Chapter 9

Digestive System

Digestive TED-Ed
Points to ponder

• What are the digestive system structures and their functions?
• Where does carbohydrate, protein, and fat digestion and absorption occur?
• What are proteins, lipids, carbohydrates, minerals and vitamins needed for?
• What is an essential vs. a nonessential nutrient?
• What are the three accessory organs of digestion?
• What is obesity and why is it a problem?
• What is LDL and HDL?
• What are the components of a healthy diet?
• Name and explain 4 eating disorders.
What are the main steps in the digestive process?

- **Ingestion** – intake of food via the mouth
- **Digestion** – mechanically or chemically breaking down foods into their subunits
- **Movement** – food must be moved along the GI tract in order to fulfill all functions
- **Absorption** – movement of nutrients across the GI tract wall to be delivered to cells via the blood
- **Elimination** – removal of indigestible molecules
What are the four major layers that make up the wall of the GI tract?

• **Mucosa** – innermost layer that produces mucus to protect the lining and also produces digestive enzymes

• **Submucosa** – 2\(^{nd}\) layer of loose connective tissue that contains blood vessels, lymphatic vessels, and nerves

• **Muscularis** – 3\(^{rd}\) layer made of 2 layers of smooth muscle that move food along the GI tract

• **Serosa** – outer lining that is part of the peritoneum
4 layers of the GI tract

Figure 9.2  The layers of the gastrointestinal tract wall.

Lumen
central space containing food being digested

1) Mucosa
   ➢ inner mucous membrane
   ➢ Mucus
   ➢ Digestive enzymes

2) Submucosa
   ➢ broad band of loose connective tissue, nerves, blood, and lymphatic vessels

3) Muscularis
   ➢ two layers of smooth muscle

4) Serosa
   ➢ thin, outermost tissue visceral peritoneum

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9.1 Overview of Digestion

An overview of the digestive system

Figure 9.1 Organs of the GI tract and accessory structures of digestion.
What is the pathway that food follows?

mouth \downarrow
pharynx \downarrow
esophagus \downarrow
stomach \downarrow
small intestine \downarrow
large intestine \downarrow
rectum \downarrow
anus
9.2 The Mouth, Pharynx, and Esophagus

Anatomy of the mouth

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Figure 9.3a The functions of the different teeth.
Anatomy of a tooth

Figure 9.3b  A cross section of a tooth showing the crown and root.
How do we swallow food?

Figure 9.4 The process of swallowing.
9.3 The Stomach and Small Intestine

Anatomy of the stomach

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- **esophagus**
- **lower gastroesophageal sphincter**
- **pyloric sphincter**

**a. Stomach**
- **gastric pit**
- **gastric gland**
- **cells that secrete gastric juice**

**b. Gastric glands**

**c. Gastric pits in mucosa**

**d. How the stomach empties**

**c: © Dr. Fred Hossler/Visuals Unlimited**

**Figure 9.5** The layers of the stomach.
9.3 The Stomach and Small Intestine

Small intestine

- Digestion & absorption of nutrients

Figure 9.6 Absorption in the small intestine.
How are nutrients digested and transported out of the small intestine?

a. Carbohydrate digestion

- Carbohydrate
- Pancreatic amylase
- Maltase
- Glucose
- Cell of intestinal villus
- pH = basic
- Blood capillary

b. Protein digestion

- Protein
- Trypsin
- Peptides
- Peptidase
- Amino acids
- pH = basic
- Blood capillary

b. Fat digestion

- Bile salts
- Fat globules
- Emulsification droplets
- Lipase
- Monoglycerides and free fatty acids
- pH = basic
- Chylomicron
- Lymphatic capillary

Figure 9.7 Digestion and absorption of organic nutrients.
What are the major digestive enzymes?

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Produced By</th>
<th>Site of Action</th>
<th>Optimum pH</th>
<th>Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbohydrate Digestion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salivary amylase</td>
<td>Salivary glands</td>
<td>Mouth</td>
<td>Neutral</td>
<td>Starch + H₂O → maltose</td>
</tr>
<tr>
<td>Pancreatic amylase</td>
<td>Pancreas</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Starch + H₂O → maltose</td>
</tr>
<tr>
<td>Maltase</td>
<td>Small intestine</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Maltose + H₂O → glucose + glucose</td>
</tr>
<tr>
<td>Lactase</td>
<td>Small intestine</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Lactose + H₂O → glucose + galactose</td>
</tr>
<tr>
<td><strong>Protein Digestion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pepsin</td>
<td>Gastric glands</td>
<td>Stomach</td>
<td>Acidic</td>
<td>Protein + H₂O → peptides</td>
</tr>
<tr>
<td>Trypsin</td>
<td>Pancreas</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Protein + H₂O → peptides</td>
</tr>
<tr>
<td>Peptidases</td>
<td>Small intestine</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Peptide + H₂O → amino acids</td>
</tr>
<tr>
<td><strong>Nucleic Acid Digestion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclease</td>
<td>Pancreas</td>
<td>Small intestine</td>
<td>Basic</td>
<td>RNA and DNA + H₂O → nucleotides</td>
</tr>
<tr>
<td>Nucleosidases</td>
<td>Small intestine</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Nucleotide + H₂O → base + sugar + phosphate</td>
</tr>
<tr>
<td><strong>Fat Digestion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipase</td>
<td>Pancreas</td>
<td>Small intestine</td>
<td>Basic</td>
<td>Fat droplet + H₂O → monoglycerides + fatty acids</td>
</tr>
</tbody>
</table>

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9.4 The Accessory Organs and Regulation of Secretions

The 3 accessory organs

- Pancreas
  - Digestive enzymes
  - Bicarbonate
  - Insulin/glucagon

- Liver
  - Filters blood (detox)
  - Removes:
    - Iron
    - Stores Vit A, D, E, K & B₁₂
    - Bile
    - Glucose ↔ glycogen

- Gallbladder
  - Store bile

Figure 9.8 Accessory organs of the digestive system.
Liver disorders

- **Hepatitis**: inflammation of the liver
  - Caused by Hepatitis A, B, C, D & E
    - Hep A (fecal/oral contamination), Hep B & C (body fluids)
    - Hep C → main cause for liver transplants
  - Can lead to liver damage, cancer, and/or death.
Liver disorders

- **Cirrhosis**
  - fatty and eventually fibrous scar tissue
  - alcoholics and obese people
  - lead to liver failure
Figure 9.9 Hormonal control and regulation of digestion.
GI Hormones

- **Gastrin**
  - Produced: stomach
  - Target: stomach
  - Increases gastric activity
GI Hormones

- **Secretin**
  - Produced: duodenum
  - Target: pancreas
  - $\text{HCO}_3^-$ release to duodenum
  - Buffers acidic chyme

- **Cholecystokinin (CCK)**
  - Produced: duodenum
  - Target: pancreas
  - Bile release from gall bladder
  - Digestive enzymes to duodenum
    - Lipase (fats)
    - Amylase (carbs)
    - Nuclease (DNA/RNA)
    - Protease (protein)

Key

- **Stimulation**
- **Inhibition**

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GI Hormones

Secretin & CCK
- inhibits gastric juices & activity
- Slows chyme delivery to duodenum

Key
- Stimulation
- Inhibition
The large intestine

Functions:
- absorb water
- absorb vitamins (B complex and K) produced by gut bacteria

Vermiform appendix: immune function

Figure 9.10 The regions of the large intestine.
Disorders of the colon and rectum

- Diarrhea
- Constipation
- Hemorrhoids
- Diverticulosis
- Irritable bowel syndrome (IBS)
- Inflammatory bowel disease/colitis (IBD)
- Polyps and cancer
An overview of the digestive system

9.1 Overview of Digestion

Figure 9.1 Organs of the GI tract and accessory structures of digestion.

**Liver**
- Major metabolic organ;
- Processes and stores nutrients;
- Produces bile for emulsification of fats

**Gallbladder**
- Stores bile from liver; sends it to the small intestine

**Pancreas**
- Produces pancreatic juice; contains digestive enzymes, and sends it to the small intestine; produces insulin and secretes it into the blood after eating

**Digestive tract organs**
- **Mouth**
  - Teeth chew food; tongue tastes and pushes food for chewing and swallowing
- **Pharynx**
  - Passageway where food is swallowed
- **Esophagus**
  - Passageway where peristalsis pushes food to stomach
- **Stomach**
  - Secretes acid and digestive enzyme for protein; churns, mixing food with secretions, and sends chyme to small intestine
- **Small intestine**
  - Mixes chyme with digestive enzymes for final breakdown; absorbs nutrient molecules into body; secretes digestive hormones into blood
- **Large intestine**
  - Absorbs water and salt to form feces
- **Rectum**
  - Stores and regulates elimination of feces
- **Anus**
Transport of glucose into body cells and storage of glucose as glycogen

Breakdown of glycogen and release of glucose into blood

Homeostasis: 70–110 mg glucose/100 mL blood

Pancreas secretes insulin.

Stimulus: Blood glucose level rises after eating.

Stimulus: Blood glucose level drops below set point.

Pancreas secretes glucagon.

Hormones: Insulin and glucagon (Review)
Other GI Hormones

- **Ghrelin**
  - Produced: stomach
  - Target: brain
  - Increases appetite & fat storage

- **Leptin**
  - Produced: adipose tissue
  - Target: brain
  - Suppresses food intake & inducing weight loss
Digestive system schematic: secretions and absorption

- Veins to heart
- Hepatic portal vein
- Lymphatic system
- Absorbed food (except lipids)
- Absorbed water

Secretions:
- From salivary glands
- From gastric glands
- From liver
- From pancreas

Locations:
- Mouth
- Stomach
- Esophagus
- Small intestine
- Large intestine
- Rectum
- Anus
- Liver
What is obesity? What is BMI?

- When an individual is grossly overweight and has a body mass index (BMI) $\geq 30$, he or she is obese.

- BMI is a general guide to estimate how much of a person’s weight is due to adipose tissue.

- It does not take into account gender, fitness, or bone structure.
What is your BMI?

Source: U.S. Department of Agriculture: Dietary Guidelines for Americans, 2005

Figure 9.11 The body mass index chart.
To understand weight and nutrition, we first have to understand nutrients

- **Nutrients** are components of food that are needed to perform physiological body functions.

- Nutrients include
  - carbohydrates.
  - proteins.
  - lipids.
  - minerals.
  - vitamins.
Carbohydrates

- Simple sugars → primary energy source

- Refined grains → fiber and vitamins are removed
  - white bread, cake, and cookies

- Complex carbohydrates
  - beans, whole-grain products, nuts, and fruits

- Refined sugars & fructose sweeteners may contribute to obesity.
  - Increases insulin secretion → insulin resistance
    - Type 2 diabetes and increased fat metabolism.
    - Increase fat deposition may increase the risk of coronary heart disease, liver diseases, and certain cancers
How can you reduce high-glycemic index carbohydrates?

<table>
<thead>
<tr>
<th>Table 9.3</th>
<th>Reducing High-Glycemic-Index Carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To Reduce Dietary Sugar</strong></td>
<td></td>
</tr>
<tr>
<td>1. Eat fewer sweets, such as candy, soft drinks, ice cream, and pastries.</td>
<td></td>
</tr>
<tr>
<td>2. Eat fresh fruits or fruits canned without heavy syrup.</td>
<td></td>
</tr>
<tr>
<td>3. Use less sugar—white, brown, or raw—and less honey and syrups.</td>
<td></td>
</tr>
<tr>
<td>4. Avoid sweetened breakfast cereals.</td>
<td></td>
</tr>
<tr>
<td>5. Eat less jelly, jam, and preserves.</td>
<td></td>
</tr>
<tr>
<td>6. Eat fresh fruit; especially avoid artificial fruit juices.</td>
<td></td>
</tr>
<tr>
<td>7. When cooking, use spices, such as cinnamon, instead of sugar to flavor foods.</td>
<td></td>
</tr>
<tr>
<td>8. Do not put sugar in tea or coffee.</td>
<td></td>
</tr>
<tr>
<td>9. Avoid processed foods made from refined carbohydrates, such as white bread, rice, and pasta, and limit potato intake.</td>
<td></td>
</tr>
</tbody>
</table>
Proteins

- **8 essential amino acids**
  - must be attained through diet
- **Complete proteins** have all essential amino acids
  - animals such as meat and dairy
  - Nonanimal sources: tofu, soymilk, and other processed food from soybeans
- **Incomplete proteins** lack at least one essential AA
  - legumes, nuts, grains

**Diagram:**
- Essential amino acids for adults
  - Methionine
  - Valine
  - Threonine
  - Phenylalanine
  - Leucine
  - Isoleucine
  - Tryptophan
  - Lysine
- Corn (maize) and other grains
- Beans and other legumes
Can proteins be harmful?

- An overabundance of protein can result in dehydration during exercise and sweating.

- An overabundance of proteins can lead to calcium loss in urine which can lead to kidney stones.

- Eating red meat as a source of protein is high in saturated fats that can lead to CVD.
Lipids

- **Lipids** include fats, oils, and cholesterol.

- Saturated fats (usually of animal origin) are usually solid at room temperature, while unsaturated fats are usually liquid at room temperature.

- **Essential fatty acids** are ones that must be ingested; they include linoleic acid and linolenic acid (these can only be found in polyunsaturated oils such as corn and safflower).
Lipids

• Olive and canola oil contain more monounsaturated fats.

• Omega-3 fatty acids, thought to ward off heart disease, are found in some fish (salmon, sardines, and trout) as well as some plants (flaxseed oil).
Choosing the most healthy fat and oil

Figure 9.14
Saturated and unsaturated fatty acids.
Can lipids be harmful?

- CVD is often a result of arteries blocked by plaque made of cholesterol and saturated fats.
- Low density lipoprotein (LDL) is the “bad” cholesterol because it carries cholesterol from the liver to the cells.
- LDL is increased by saturated fats and decreased by unsaturated fats.
Can lipids be harmful?

- High density lipoprotein (HDL) is the “good” cholesterol because it carries cholesterol to the liver where it is converted to bile salts.

- Trans-fatty acids are made by hydrogenation of unsaturated fatty acids for commercial products and may reduce the ability of cells to clear cholesterol from the bloodstream.
How can you reduce “bad” fats and cholesterol in your diet?

<table>
<thead>
<tr>
<th>Table 9.4 Reducing Certain Lipids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To Reduce Saturated Fats and Trans Fats in the Diet</strong></td>
</tr>
<tr>
<td>1. Choose poultry, fish, or dry beans and peas as a protein source.</td>
</tr>
<tr>
<td>2. Remove skin from poultry, and trim fat from red meats before cooking; place on a rack, so that fat drains off.</td>
</tr>
<tr>
<td>3. Broil, boil, or bake rather than fry.</td>
</tr>
<tr>
<td>4. Limit your intake of butter, cream, trans fats, shortenings, and tropical oils (coconut and palm oils).</td>
</tr>
<tr>
<td>5. Use herbs and spices to season vegetables instead of butter, margarine, or sauces. Use lemon juice instead of salad dressing.</td>
</tr>
<tr>
<td>6. Drink skim milk instead of whole milk, and use skim milk in cooking and baking.</td>
</tr>
<tr>
<td><strong>To Reduce Dietary Cholesterol</strong></td>
</tr>
<tr>
<td>1. Avoid cheese, egg yolks, liver, and certain shellfish (shrimp and lobster). Preferably, eat white fish and poultry.</td>
</tr>
<tr>
<td>2. Substitute egg whites for egg yolks in both cooking and eating.</td>
</tr>
<tr>
<td>3. Include soluble fiber in the diet. Oat bran; oatmeal; beans; corn; and fruits, such as apples, citrus fruits, and cranberries, are high in soluble fiber.</td>
</tr>
</tbody>
</table>
# 9.6 Nutrition and Weight Control

## A summary of minerals

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Functions</th>
<th>Food Sources</th>
<th>Deficiency</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major (More Than 100 mg/Day Needed)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (Ca(^{2+}))</td>
<td>Strong bones and teeth, nerve conduction, muscle contraction, blood clotting</td>
<td>Dairy products, leafy green vegetables</td>
<td>Stunted growth in children, low bone density in adults</td>
<td>Kidney stones, interferes with iron and zinc absorption</td>
</tr>
<tr>
<td>Phosphorus (PO(_4^{3-}))</td>
<td>Bone and soft tissue growth; part of phospholipids, ATP, and nucleic acids</td>
<td>Meat, dairy products, sunflower seeds, food additives</td>
<td>Weakness, confusion, pain in bones and joints</td>
<td>Low blood and bone calcium levels</td>
</tr>
<tr>
<td>Potassium (K(^+))</td>
<td>Nerve conduction, muscle contraction</td>
<td>Many fruits and vegetables, bran</td>
<td>Paralysis, irregular heartbeat, eventual death</td>
<td>Vomiting, heart attack, death</td>
</tr>
<tr>
<td>Sulfur (S(^{2-}))</td>
<td>Stabilizes protein shape, neutralizes toxic substances</td>
<td>Meat, dairy products, legumes</td>
<td>Not likely</td>
<td>In animals, depresses growth</td>
</tr>
<tr>
<td>Sodium (Na(^+))</td>
<td>Nerve conduction, pH and water balance</td>
<td>Table salt</td>
<td>Lethargy, muscle cramps, loss of appetite</td>
<td>Edema, high blood pressure</td>
</tr>
<tr>
<td>Chloride (Cl(^-))</td>
<td>Water balance</td>
<td>Table salt</td>
<td>Not likely</td>
<td>Vomiting, dehydration</td>
</tr>
<tr>
<td>Magnesium (Mg(^{2+}))</td>
<td>Part of various enzymes for nerve and muscle contraction, protein synthesis</td>
<td>Whole grains, leafy green vegetables</td>
<td>Muscle spasm, irregular heartbeat, convulsions, confusion, personality changes</td>
<td>Diarrhea</td>
</tr>
<tr>
<td><strong>Trace (Less Than 100 mg/Day Needed)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc (Zn(^{2+}))</td>
<td>Protein synthesis, wound healing, fetal development and growth, immune function</td>
<td>Meats, legumes, whole grains</td>
<td>Delayed wound healing, stunted growth, diarrhea, mental lethargy</td>
<td>Anemia, diarrhea, vomiting, renal failure, abnormal cholesterol levels</td>
</tr>
<tr>
<td>Iron (Fe(^{2+}))</td>
<td>Hemoglobin synthesis</td>
<td>Whole grains, meats, prune juice</td>
<td>Anemia, physical and mental sluggishness</td>
<td>Iron toxicity disease, organ failure, eventual death</td>
</tr>
<tr>
<td>Copper (Cu(^{2+}))</td>
<td>Hemoglobin synthesis</td>
<td>Meat, nuts, legumes</td>
<td>Anemia, stunted growth in children</td>
<td>Damage to internal organs if not excreted</td>
</tr>
<tr>
<td>Iodine (I(^{-}))</td>
<td>Thyroid hormone synthesis</td>
<td>Iodized table salt, seafood</td>
<td>Thyroid deficiency</td>
<td>Depressed thyroid function, anxiety</td>
</tr>
<tr>
<td>Selenium (SeO(_4^{2-}))</td>
<td>Part of antioxidant enzyme</td>
<td>Seafood, meats, eggs</td>
<td>Vascular collapse, possible cancer development</td>
<td>Hair and fingernail loss, discolored skin</td>
</tr>
<tr>
<td>Manganese (Mn(^{2+}))</td>
<td>Part of enzymes</td>
<td>Nuts, legumes, green vegetables</td>
<td>Weakness and confusion</td>
<td>Confusion, coma, death</td>
</tr>
</tbody>
</table>
Vitamins

• Organic compounds (not including proteins, fats, or carbohydrates) are used for metabolism but not produced in high enough quantities by the body.

• Vitamins are often enzyme helpers (coenzymes).

• There is a total of 13 vitamins in two groups: fat soluble and water soluble.
Fat-soluble vitamins

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Functions</th>
<th>Food Sources</th>
<th>Deficiency</th>
<th>Health Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>Antioxidant synthesized from beta-carotene; needed for healthy eyes, skin, hair, and mucous membranes and for proper bone growth</td>
<td>Deep yellow/orange and leafy, dark green vegetables; fruits; cheese; whole milk; butter; eggs</td>
<td>Night blindness, impaired growth of bones and teeth</td>
<td>Headache, dizziness, nausea, hair loss, abnormal development of fetus</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Group of steroids needed for development and maintenance of bones and teeth and for absorption of calcium</td>
<td>Milk fortified with vitamin D, fish liver oil; also made in the skin when exposed to sunlight</td>
<td>Rickets, decalcification and weakening of bones</td>
<td>Calcification of soft tissues, diarrhea, possible renal damage</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Antioxidant that prevents oxidation of vitamin A and polyunsaturated fatty acids</td>
<td>Leafy green vegetables, fruits, vegetable oils, nuts, whole-grain breads and cereals</td>
<td>Unknown</td>
<td>Diarrhea, nausea, headaches, fatigue, muscle weakness</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Needed for synthesis of substances active in clotting of blood</td>
<td>Leafy green vegetables, cabbage, cauliflower</td>
<td>Easy bruising and bleeding</td>
<td>Can interfere with anticoagulant medication</td>
</tr>
</tbody>
</table>
### Water-soluble vitamins

#### Table 9.8 Water-Soluble Vitamins

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Functions</th>
<th>Food Sources</th>
<th>Deficiency</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C</td>
<td>Antioxidant; needed for forming collagen; helps maintain capillaries, bones, and teeth</td>
<td>Citrus fruits, leafy green vegetables, tomatoes, potatoes, cabbage</td>
<td>Scurvy, delayed wound healing, infections</td>
<td>Gout, kidney stones, diarrhea, decreased copper</td>
</tr>
<tr>
<td>Thiamine (vitamin B₁)</td>
<td>Part of coenzyme needed for cellular respiration; also promotes activity of the nervous system</td>
<td>Whole-grain cereals, dried beans and peas, sunflower seeds, nuts</td>
<td>Beriberi, muscular weakness, enlarged heart</td>
<td>Can interfere with absorption of other vitamins</td>
</tr>
<tr>
<td>Riboflavin (vitamin B₂)</td>
<td>Part of coenzymes, such as FAD*, aids cellular respiration, including oxidation of protein and fat</td>
<td>Nuts, dairy products, whole-grain cereals, poultry, leafy green vegetables</td>
<td>Dermatitis, blurred vision, growth failure</td>
<td>Unknown</td>
</tr>
<tr>
<td>Niacin (nicotinic acid)</td>
<td>Part of coenzyme NAD⁺; needed for cellular respiration, including oxidation of protein and fat</td>
<td>Peanuts, poultry, whole-grain cereals, leafy green vegetables, beans</td>
<td>Pellagra, diarrhea, mental disorders</td>
<td>High blood sugar and uric acid, vasodilation, etc.</td>
</tr>
<tr>
<td>Folacin (folic acid)</td>
<td>Coenzyme needed for production of hemoglobin and formation of DNA</td>
<td>Dark, leafy green vegetables; nuts; beans; whole-grain cereals</td>
<td>Megaloblastic anemia, spina bifida</td>
<td>May mask B₁₂ deficiency</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>Coenzyme needed for synthesis of hormones and hemoglobin; CNS control</td>
<td>Whole-grain cereals, bananas, beans, poultry, nuts, leafy green vegetables</td>
<td>Rarely, convulsions, vomiting, seborrhea, muscular weakness</td>
<td>Insomnia, neuropathy</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>Part of coenzyme A needed for oxidation of carbohydrates and fats; aids in the formation of hormones and certain neurotransmitters</td>
<td>Nuts, beans, dark green vegetables, poultry, fruits, milk</td>
<td>Rarely, loss of appetite, mental depression, numbness</td>
<td>Unknown</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Complex, cobalt-containing compound; part of the coenzyme needed for synthesis of nucleic acids and myelin</td>
<td>Dairy products, fish, poultry, eggs, fortified cereals</td>
<td>Pernicious anemia</td>
<td>Unknown</td>
</tr>
<tr>
<td>Biotin</td>
<td>Coenzyme needed for metabolism of amino acids and fatty acids</td>
<td>Generally in foods, especially eggs</td>
<td>Skin rash, nausea, fatigue</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

*FAD = flavin adenine dinucleotide
*NAD = nicotinamide adenine dinucleotide
Antioxidants

• Antioxidants are chemicals that decrease the rate of oxidation or transfer of electrons.

• Vitamin C, E, and A are considered antioxidants because they are thought to defend the body against free radicals that can transfer electrons and damage cells and DNA.

• The vitamins are common in fruits and vegetables.
Why should we be concerned with obesity?

• Obesity has doubled in the US in the last 20 years.

• In the US, ~1/3 of adults are obese and it is now prevalent in children and adolescents.

• Obesity tends to increase with an increase in income.
Why should we be concerned with obesity?

- It is associated with:
  - an increased risk of premature death
  - type 2 diabetes
  - Hypertension
  - CVD
  - Stroke
  - gallbladder disease
  - respiratory dysfunction
  - Osteoarthritis
  - certain cancers.
Searching for the magic weight-loss bullet

• Trendy diet programs
  ➢ Pritikin diet: high carbohydrate and fiber diet through whole grains and vegetables
  ➢ Atkins: low-carbohydrate, and high protein and fat diet
  ➢ Zone and South beach diets: low carbohydrate diets that are high in protein and “healthy” fats
  ➢ Caveman, or Paleo, Diet: mimics the diets of humans prior to agricultural pursuits

• Prescription drugs
Searching for the magic weight-loss bullet

• Surgical procedures
  ➢ Gastroplasty: stapling or partitioning of a small portion of the stomach
  ➢ Gastric bypass: attaching the lower part of the small intestine to the stomach so most of the food bypasses the stomach and small intestine
  ➢ Gastric banding: a constriction band is used to reduce stomach size
  ➢ Liposuction: removal of fat cells; best used for overweight people that are not obese or morbidly obese
Eating disorders are associated with body image

Figure 9.16 The characteristics of different eating disorders.

a. Anorexia nervosa
b. Bulimia nervosa
c. Muscle dysmorphia

a: © Ted Foxx/Alamy RF; b: © Donna Day/Stone/Getty Images; c: © Corbis RF
Eating disorders

- **Anorexia nervosa** – psychological disorder due to fear of getting fat; it usually results in self-induced starvation, high physical activity, and may include purging.

- **Bulimia nervosa** – disorder in which people eat large amounts of high-calorie food (binge-eating) followed by purging to avoid weight gain, often more than once a day.
Eating disorders

• **Binge-eating disorder** – obese people are afflicted; overeating is not followed by purging, and this can lead to depression, anger, anxiety, and more binges

• **Muscle dysmorphia** – characterized by people that think their bodies are underdeveloped and are often preoccupied with body-building activities and diet