Chapter 09
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Digestive System and Nutrition
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.
9.1 Overview of Digestion

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** – 2nd layer of loose connective tissue that contains blood vessels, lymphatic vessels, and nerves
- **Muscularis** – 3rd layer made of 2 layers of smooth muscle that move food along the GI tract
- **Serosa** – outer lining that is part of the peritoneum
Visualizing the layers of the GI tract

9.1 Overview of Digestion

Figure 9.2 The layers of the gastrointestinal tract wall.

- **Lumen**
  - central space containing food being digested

- **Mucosa**
  - inner mucous membrane layer modified according to the digestive organ

- **Submucosa**
  - broad band of loose connective tissue that contains nerves, blood, and lymphatic vessels

- **Muscularis**
  - two layers of smooth muscle

- **Serosa**
  - thin, outermost tissue that is the 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
- pharynx
- esophagus
- stomach
- small intestine
- large intestine
- rectum
- anus
The mouth

- Three pairs of salivary glands secrete salivary amylase that begins carbohydrate digestion.
- Tonsils at the back of the mouth are lymphatic tissues, important in fighting disease.
- The mouth contains teeth that begin the mechanical breakdown of food.
- The tongue is covered in taste buds and also assists in the mechanical breakdown and movement of food.
- The tongue forms a bolus (mass of chewed food) and moves it toward the pharynx.
Figure 9.3a The functions of the different teeth.
Teeth

• There are 32 teeth in adults (20 deciduous teeth in babies).

• Teeth are used for mechanical breakdown of food.

• Each tooth is made of a crown and a root.

• A hard covering of enamel and dentin covers the crown.
Teeth

• An inner pulp area has nerves and blood vessels.

• Dental caries (cavities) occurs when bacteria metabolize sugars and produce acids; limiting sugar intake and brushing teeth reduces tooth decay.
Anatomy of a tooth

Figure 9.3b A cross section of a tooth showing the crown and root.
The pharynx and esophagus

• The **pharynx** is a cavity between the mouth and esophagus that serves as a passageway for food (and air).

• The **esophagus** is a long, muscular tube that carries food to the stomach.
How do we swallow food?

• Voluntary phase
  – In the beginning, food is being swallowed from the mouth into the pharynx. It is a voluntary act.
How do we swallow food?

• Involuntary phase
  – Once the food is in the pharynx, swallowing becomes a reflex.
  – The epiglottis covers the voice box to make sure food is routed into the esophagus.
  – Food moves down the esophagus through peristalsis (rhythmic contraction).
How do we swallow food?

Figure 9.4 The process of swallowing.
Heartburn

• This occurs when acids from the stomach pass into the esophagus (acid reflux).

• There is a burning sensation in the esophagus.

• Chronic heartburn is called gastroesophageal reflux disease (GERD).
Heartburn

- The following are tips for decreasing heartburn.
  - Avoid high fat meals.
  - Do not overeat.
  - Eat several small meals rather than the standard three larger meals each day.
  - Exercise lightly.
The stomach

• It functions to store food, start digestion of proteins, and control movement of chyme into the small intestine.

• The stomach is a J-shaped organ with a thick wall.

• There are three layers of muscle in the muscularis layer of the stomach wall to help in mechanical digestion and allow it to stretch.

• The mucosa layer has deep folds called rugae, and gastric pits that lead into gastric glands that secrete gastric juice.
The stomach

- Gastric juice contains **pepsin**, an enzyme that breaks down proteins, plus HCl and mucus.

- HCl gives the stomach a pH of 2, which activates pepsin and helps kill bacteria found in food.

- A bacterium, *Helicobacter pylori*, lives in the mucus and can cause gastric ulcers.

- The stomach empties **chyme** into the small intestine after 2-6 hrs.
Figure 9.5 The layers of the stomach.
The small intestine

- The small intestine averages 6 m (18 ft) in length.

- Enzymes secreted by the pancreas into the small intestine digest carbohydrates, proteins, and fats.

- Bile is secreted by the gallbladder into the small intestine to emulsify fats.
The small intestine

- The absorption of digested food depends on the large surface area created by numerous villi (finger-like projections) and microvilli.

- Amino acids and sugars enter the capillaries while fatty acids and glycerol enter the lacteals (small lymph vessels).
Anatomy of the small intestine

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
  - pH = basic
  - Cell of intestinal villus
  - Blood capillary

b. Protein digestion

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

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

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

<table>
<thead>
<tr>
<th>Table 9.1</th>
<th>Major Digestive Enzymes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enzyme</strong></td>
<td><strong>Produced By</strong></td>
</tr>
<tr>
<td><strong>Carbohydrate Digestion</strong></td>
<td></td>
</tr>
<tr>
<td>Salivary amylase</td>
<td>Salivary glands</td>
</tr>
<tr>
<td>Pancreatic amylase</td>
<td>Pancreas</td>
</tr>
<tr>
<td>Maltase</td>
<td>Small intestine</td>
</tr>
<tr>
<td>Lactase</td>
<td>Small intestine</td>
</tr>
<tr>
<td><strong>Protein Digestion</strong></td>
<td></td>
</tr>
<tr>
<td>Pepsin</td>
<td>Gastric glands</td>
</tr>
<tr>
<td>Trypsin</td>
<td>Pancreas</td>
</tr>
<tr>
<td>Peptidases</td>
<td>Small intestine</td>
</tr>
<tr>
<td><strong>Nucleic Acid Digestion</strong></td>
<td></td>
</tr>
<tr>
<td>Nuclease</td>
<td>Pancreas</td>
</tr>
<tr>
<td>Nucleosidases</td>
<td>Small intestine</td>
</tr>
<tr>
<td><strong>Fat Digestion</strong></td>
<td></td>
</tr>
<tr>
<td>Lipase</td>
<td>Pancreas</td>
</tr>
</tbody>
</table>
9.4 The Accessory Organs and Regulation of Secretions

The 3 accessory organs

- Pancreas
- Liver
- Gallbladder

Figure 9.8 Accessory organs of the digestive system.
The pancreas

• Fish-shaped spongy organ behind the stomach

• Functions of the pancreas
  1. Secretes enzymes into the small intestine
     • Trypsin digests proteins.
     • Lipase digests fats.
     • Pancreatic amylase digests carbohydrates.
  2. Secretes bicarbonate into the small intestine to neutralize stomach acids
  3. Secretes insulin into the blood to keep blood sugar levels under control
The liver and gallbladder

- The liver is a large metabolic organ that lies under the diaphragm and is made of 100,000 lobules.
- It filters blood from the GI tract, thus acting to remove poisons and detoxify the blood.
- The liver removes iron, vitamins A, D, E, K, and B₁₂ from the blood and stores them.
- It stores glucose as glycogen and breaks it down to help retain blood glucose levels.
The liver and gallbladder

- The liver makes plasma proteins and helps regulate cholesterol levels by making bile salts.

- It makes **bile** that is then stored in the **gallbladder** to be secreted into the small intestine to emulsify fats.

- The liver also breaks down hemoglobin.
Liver disorders

• Hepatitis
  – Hepatitis is inflammation of the liver.
  – It is caused by Hepatitis A, B, and C.
  – This disease can lead to liver damage, cancer, and/or death.
Liver disorders

• Cirrhosis
  – The liver becomes fatty and eventually the liver tissue is replaced by fibrous scar tissue.
  – It is seen in alcoholics and obese people.
  – Cirrhosis can lead to liver failure in which the liver cannot regenerate as fast as it is being damaged.
How do hormones control digestive gland secretions?

Figure 9.9  Hormonal control and regulation of digestion.
The large intestine

- The **large intestine** includes the cecum, colon, rectum, and anal canal.
- It is larger in diameter but shorter than the small intestine.
- The cecum has a projection known as the **appendix** that may play a role in fighting infections.
The large intestine

• Functions to
  – absorb water to prevent dehydration.
  – absorb vitamins (B complex and K) produced by intestinal flora.
  – form and rid the body of feces through the anus.
The large intestine

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

- **Diarrhea** – increased peristalsis and failure to reabsorb water, due to either an infection or nervous stimulation
- **Constipation** – feces are dry and hard; condition may be controlled with water and fiber
- **Hemorrhoids** – enlarged and inflamed blood vessels of the anus due to chronic constipation, pregnancy, aging, or anal intercourse
- **Diverticulosis** – occurrence of pouches of mucosa from weak spots in the muscularis layer that can become infected; often occur in the descending colon
Disorders of the colon and rectum

- **Irritable bowel syndrome (IBS)** – muscularis layer contracts with power, but without its normal coordination; characterized by chronic diarrhea and abdominal pain

- **Inflammatory bowel disease/colitis (IBD)** – a group of inflammatory disorders such as ulcerative colitis or Crohn’s disease

- **Polyps and cancer** – small growths found in the epithelial lining that can be benign or cancerous
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.
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, and 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
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

- Carbohydrates are sugars or polysaccharides that are digested into the simple sugars which are an important energy source.

- Refined grains should be minimized in the diet because fiber and vitamins are removed (i.e., white bread, cake, and cookies).

- Complex carbohydrates are recommended as a good source of vitamins and minerals (i.e., beans, whole-grain products, nuts, and fruits).
Can carbohydrates be harmful?

- Refined sugars and fructose sweeteners may contribute to obesity.

- These foods may cause the pancreas to secrete large amounts of insulin which can lead to insulin resistance seen in type 2 diabetes and increased fat metabolism.

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

• Proteins are digested into 20 different amino acids which are used to produce cellular proteins.

• Essential amino acids are the 8 amino acids that must be attained through diet.

• Complete proteins that have all essential amino acids are usually derived from animals such as meat and dairy.

• Nonanimal sources of complete proteins are tofu, soymilk, and other processed food from soybeans.
Proteins

- Incomplete proteins are ones that lack at least one essential amino acid (i.e., legumes, nuts, grains, etc.) and need to be combined with another incomplete protein to allow all amino acids to be used in the body.

- Amino acids cannot be stored in the body, thus small amounts (2 meat servings) need to be ingested on a daily basis.
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 9.4 Reducing Certain Lipids

<table>
<thead>
<tr>
<th>To Reduce Saturated Fats and Trans Fats in the Diet</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To Reduce Dietary Cholesterol</th>
</tr>
</thead>
<tbody>
<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>
Minerals

• The body contains > 5g of each major mineral and < 5g of each trace mineral.

• Major minerals make up components of cells, body fluids, and tissues (i.e., calcium).

• Minor minerals are components of larger molecules (i.e., iron in hemoglobin).

• A varied and complete diet usually provides necessary minerals.
Calcium

- **Calcium** is needed to make bone, nerve impulse conduction, and muscle contraction.

- 1,000 mg/day are recommended to keep bones healthy early in life and 1,300 mg/day after menopausal age.

- Vitamin D is needed with calcium to prevent bone loss (**osteoporosis**).
Sodium

• Sodium is needed for regulating water balance.

• 500 mg/day is the recommended amount (on average each American takes in 4,000 – 4,700 mg/day).

• Sodium can increase hypertension in people who already have it.
# A summary of minerals

9.6 Nutrition and Weight Control

<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.
# 9.6 Nutrition and Weight Control

## Fat-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 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.
A guide to daily food recommendations

Figure 9.15 MyPlate.
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
Eating disorders are associated with body image

Figure 9.16 The characteristics of different eating disorders.

9.6 Nutrition and Weight Control

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