Chapter 12

Food Safety and Technology: Protecting Our Food

12.1 Why Is Food Safety Important?

- Foodborne illness: illness transmitted from food or water that contains a microscopic organism, its toxic secretions, or a toxic chemical
  - 48 million Americans report foodborne illness each year (one in six)
  - 128,000 hospitalizations per year
  - 3,000 deaths per year

12.2 Government Regulators

- Food Safety and Inspection Service (FSIS)
  - Require multistep protocol called the Hazard Analysis Critical Control Point (HACCP) system
  - Designed to identify biological, chemical, and other potential food-safety hazards during distribution and sales
- Multiple government agencies are involved in ensuring the safety and quality of the food supply
  - Centers for Disease Control and Prevention (CDC)
    - Promotes/educates the public about health and safety
    - Tracks foodborne illness outbreaks
  - U.S. Department of Agriculture (USDA)
    - Oversees meat, poultry, and eggs
  - Environmental Protection Agency (EPA)
    - Regulates use of pesticides
    - Establishes water quality standards
  - Food and Drug Administration (FDA)
    - Regulates food standards for all food products (except meat, poultry, and eggs) and bottled water
    - Regulates food labeling and enforces pesticide use regulations

Table 12.1: Government Regulation Agencies

Name of Agency	Year Founded	Role in Food Regulations	Website
U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS)	1785	Oversees safety of meat, poultry, and processed egg products; also ensures accuracy of meat and poultry labeling	www.fsis.usda.gov
U.S. Food and Drug Administration (FDA)	1862	Regulates food standards of food products (except meat, poultry, and eggs) and bottled water; regulates food labeling and enforces pesticide use as established by EPA	www.fda.gov
Centers for Disease Control and Prevention (CDC)	1946	Works with public health officials to promote and educate the public about health and safety; is able to track information needed in identifying foodborne illness outbreaks	www.cdc.gov
U.S. Environmental Protection Agency (EPA)	1970	Regulates use of pesticides and which crops that can be applied to; establishes standards for water quality	www.epa.gov

12.3 Food Production – Changes over 100 years

- Has become increasingly complex
- Oversight has decreased
- More foods are mass-produced
- Ingredients come from various sources
- Contamination can occur at any point from farm to table

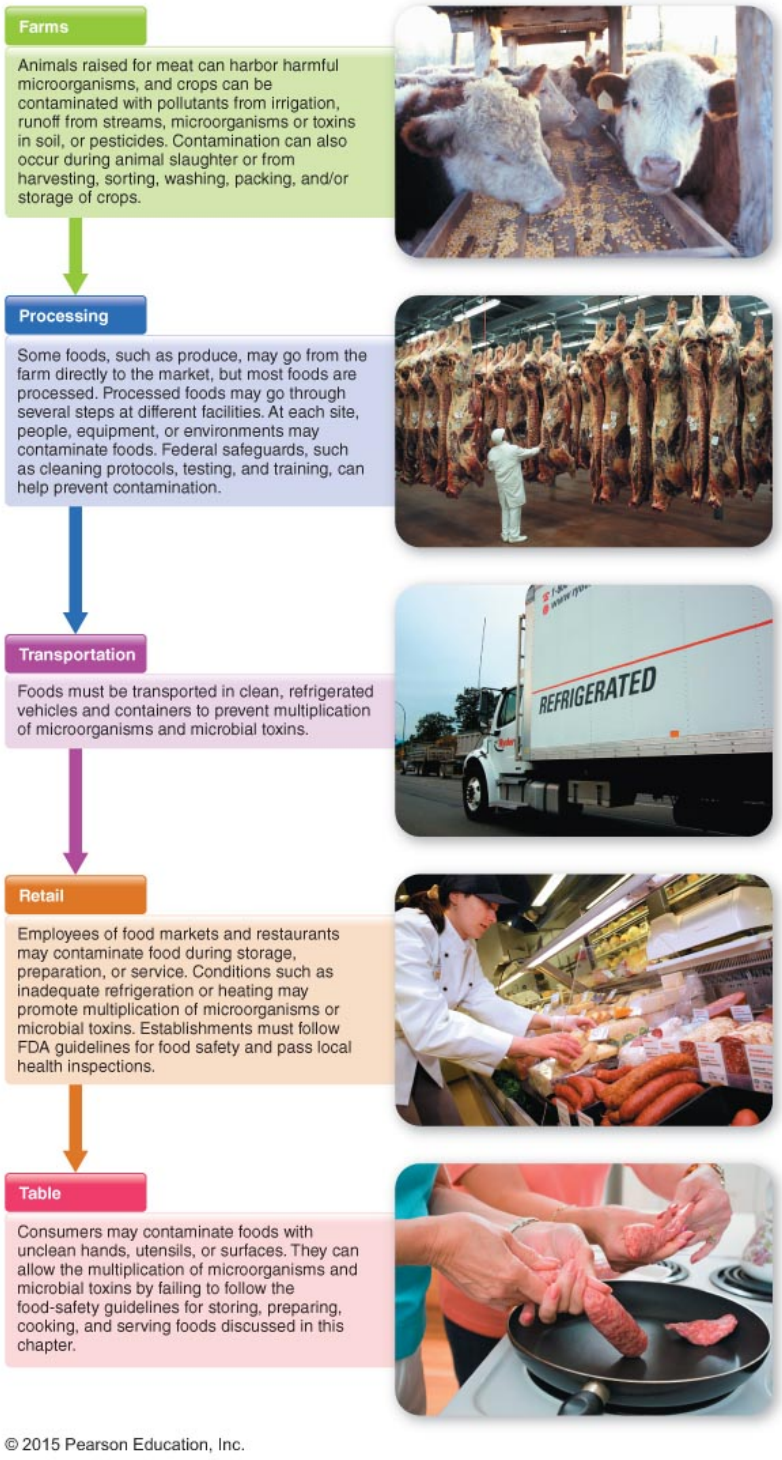

Figure 12.1: Food from Farm to Table

12.4 Causes of Foodborne Illness

- Two types of foodborne illness

  - Food infection
    * Illness resulting from eating food contaminated with living organisms
  - Food intoxication
    * Illness resulting from eating food in which microbes have secreted toxins (poisons)

- Viruses and bacteria are the most common microbes causing foodborne illnesses
- Other sources of contamination include parasites, fungi, and prions

12.4.1 Norovirus

Of the viruses, norovirus causes more foodborne illness than the other 30 known pathogens put together
Often referred to as "the stomach flu"
Affects 19–21 million infections per year

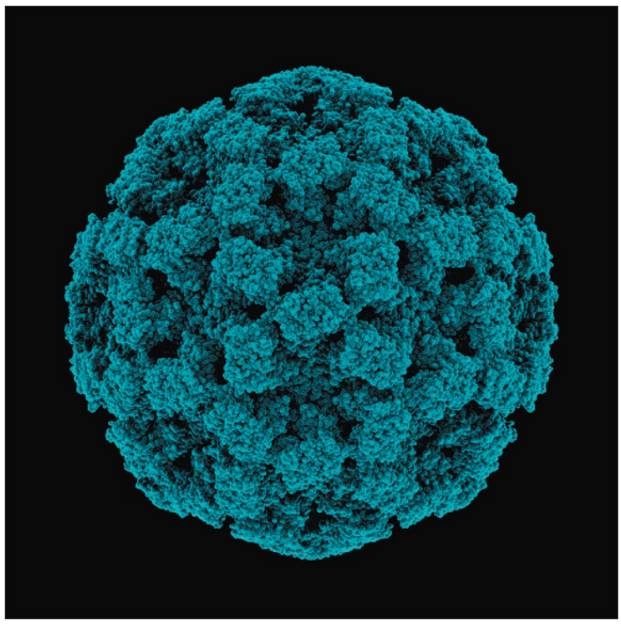

Figure 12.2: Norovirus

- The most common bacterial causes of foodborne illness are
  - Salmonella
  - Clostridium perfringens
  - Campylobacter
  - Staphylococcus aureus
  - Escherichia coli
  - Listeria monocytogenes
- The most deadly is _____

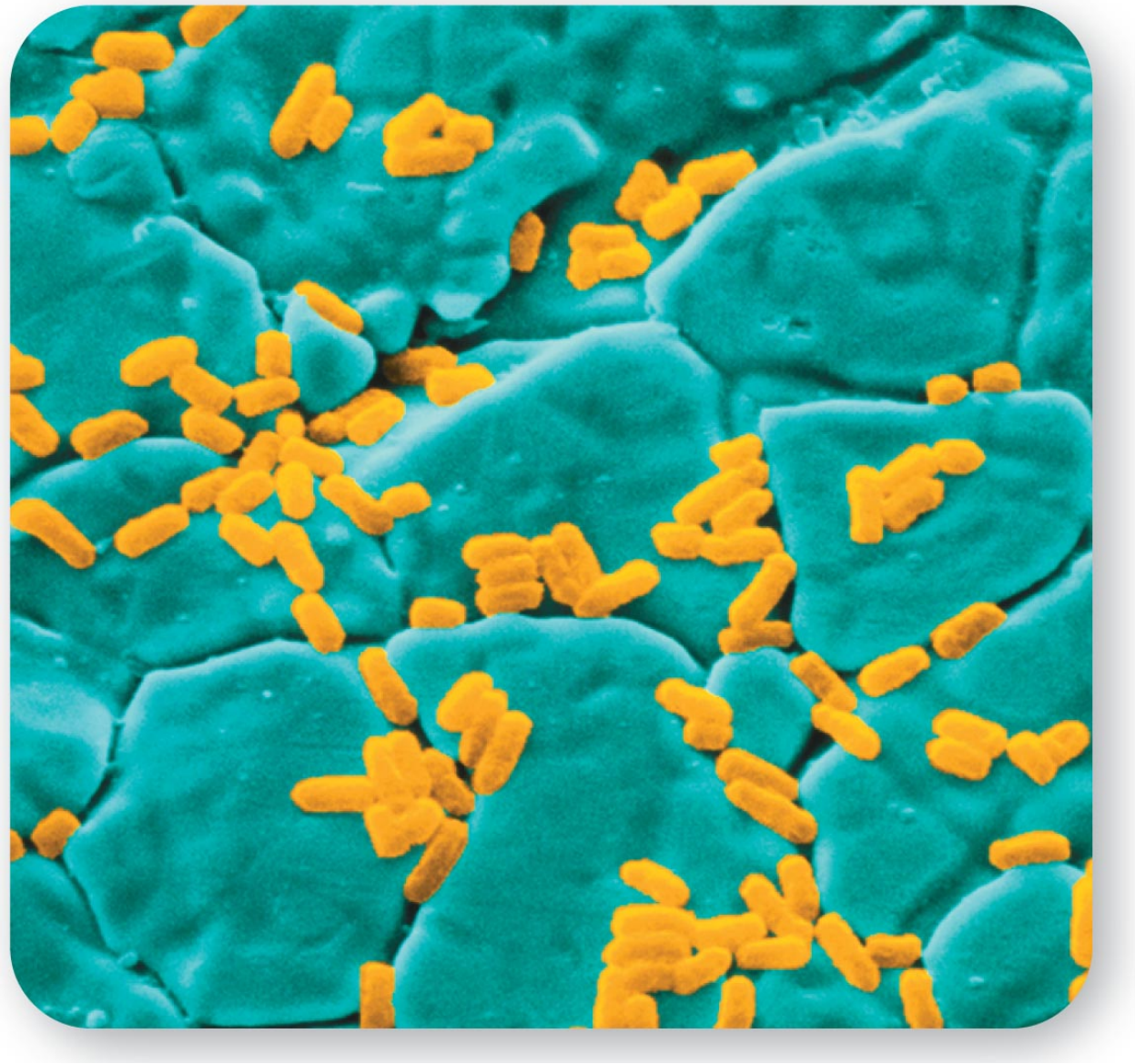

Figure 12.3: Salmonella

TABLE 12.2 Key Bacteria of Concern in Foodborne Illnesses and Deaths

Bacteria	Incubation Period	Duration	Symptoms	Foods Most Commonly Affected	Steps for Prevention
Campylobacter (several species)	1–7 days	2–10 days	Headache Diarrhea Nausea Abdominal cramps	Raw and undercooked meat, poultry, eggs Cake icing Untreated water Unpasteurized milk	Only drink pasteurized milk. Cook foods properly. Avoid cross-contamination.
Clostridium perfringens	8–22 hours	24 hours	Abdominal cramps Diarrhea Dehydration	Beef Poultry Gravies Leftovers	Cook foods thoroughly and serve hot. Refrigerate leftovers promptly. Reheat leftovers thoroughly before serving.
Escherichia coli (some strains produce an enterotoxin)	1–10 days	5–7 days	Abdominal cramps Diarrhea (often bloody) Vomiting	Water; unpasteurized milk, cheese, juice, or cider; undercooked meat; raw produce	Cook foods thoroughly. Avoid cross-contamination. Only drink pasteurized milk and juice. Practice proper handwashing and sanitizing.
Listeria monocytogenes	1–42 days	Days to weeks	Fever Muscle aches Diarrhea Sometimes headache and confusion	Meats, especially hot dogs and deli meats Vegetables Dairy products, especially raw milk and soft cheeses Smoked fish	Cook foods thoroughly and serve hot. Wash produce carefully. If pregnant, do not consume deli meats, smoked fish, or products containing raw milk.
Salmonella (more than 2,300 types)	12–24 hours	4–7 days	Nausea Diarrhea Abdominal pain Chills Fever Headache	Raw or undercooked eggs, poultry, and meat Raw milk and dairy products Seafood Fruits and vegetables	Cook foods thoroughly. Avoid cross-contamination. Only drink pasteurized milk. Practice proper handwashing and sanitizing.
Staphylococcus aureus (which produces an enterotoxin)	1–6 hours	1–2 days	Sudden, severe nausea and vomiting Abdominal cramps Diarrhea may occur	Custard- or cream-filled baked goods Ham Poultry Dressings, sauces, and gravies Eggs Potato salad	Refrigerate foods. Practice proper handwashing and sanitizing.

Sources: Data from Iowa State University Extension, Food Safety. 2015. *What Are the Most Common Foodborne Pathogens?* http://www.extension.iastate.edu/foodsafety/L1.7; U.S. Food and Drug Administration, Foodborne Illnesses: What You Need to Know, 2015, January 29. http://www.fda.gov/Food/FoodborneIllnessContaminants/FoodborneIllnessesNeedToKnow/default.htm; and U.S. Centers for Disease Control and Prevention, Foodborne Outbreak Online Database (FOOD Tool): 1998–2014. 2015, October 8. http://wwwn.cdc.gov/foodborneoutbreaks.

Figure 12.4: Bacterial Causes of Foodborne Illness

- **Parasites** – microorganisms that simultaneously derive benefit from and harm their host
  - Only responsible for about 2% of foodborne illnesses
  - Most common examples are helminths and protozoa
- Other microorganisms causing illness include
  - Viruses such as hepatitis A
  - Helminths or worms, such as tapeworms, flukes, and roundworms
  - Giardia, causing a diarrheal illness called giardiasis
  - Protozoa are most commonly the cause of waterborne illness
  - Fungi (yeast and mold), which cause food spoilage

Figure 12.5: Tapeworms

Figure 12.6: Molds

- Some microbes cause illness by secreting toxins
  - Clostridium botulinum produces botulism toxin, which blocks nerve transmissions to muscle cells
  - Toxins can be neurotoxins (damage the nervous system) or enterotoxins (damage the gastrointestinal tract)
  - Fungi produce mycotoxins
  - Toxic algae can contaminate fish and shellfish
  - A variety of plant toxins can also cause illness

Figure 12.7: Mushrooms Can Contain Dangerous Toxins

12.5 Conditions That Help Microbes Multiply

- Four factors affect the survival and reproduction of food microorganisms:
  1. Those that can cause human illness thrive in the temperature danger zone
  2. Many thrive in environments of high humidity
  3. Most have a preferred acidity range
  4. Many—though not all—depend on oxygen content to function

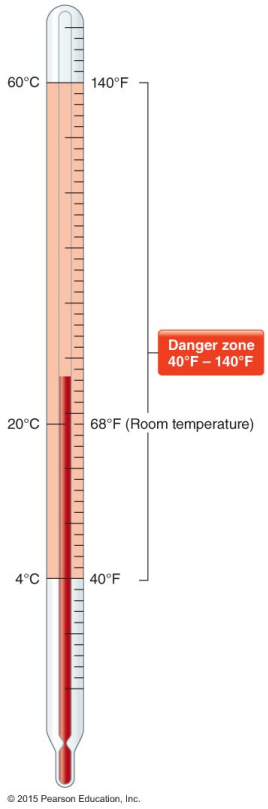

Figure 12.8: The Danger Zone

12.6 Preventing Foodborne Illness

When preparing foods at home, be sure to

- Wash hands and kitchen surfaces often
- Separate foods to prevent cross-contamination
- Chill or freeze foods to prevent microbes from growing
- Cook foods to their proper temperature

Figure 12.9: Reducing Foodborne Illness

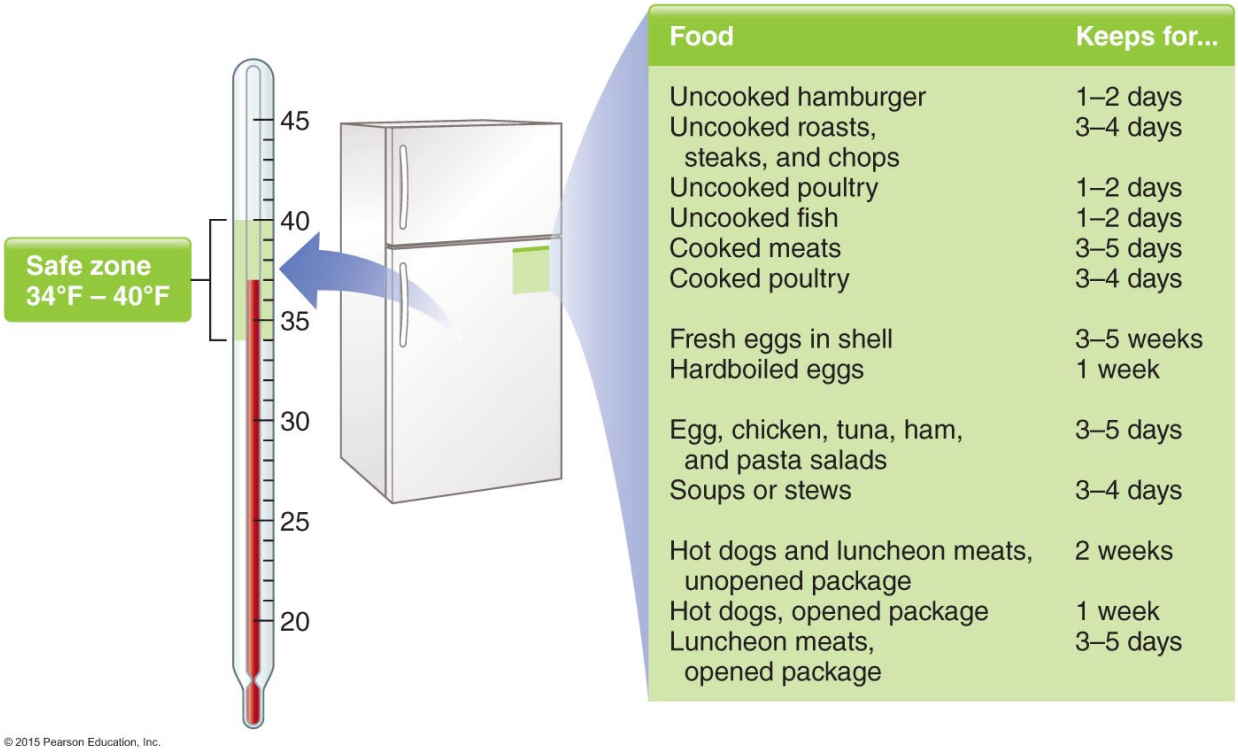

Figure 12.10: Keeping Foods Refrigerated

- Foods should be cooked thoroughly to kill microbes
- Leftovers should be stored in the refrigerator for a limited period of time
- Food should be thawed slowly in the refrigerator
- When shopping, purchase refrigerated and frozen foods last

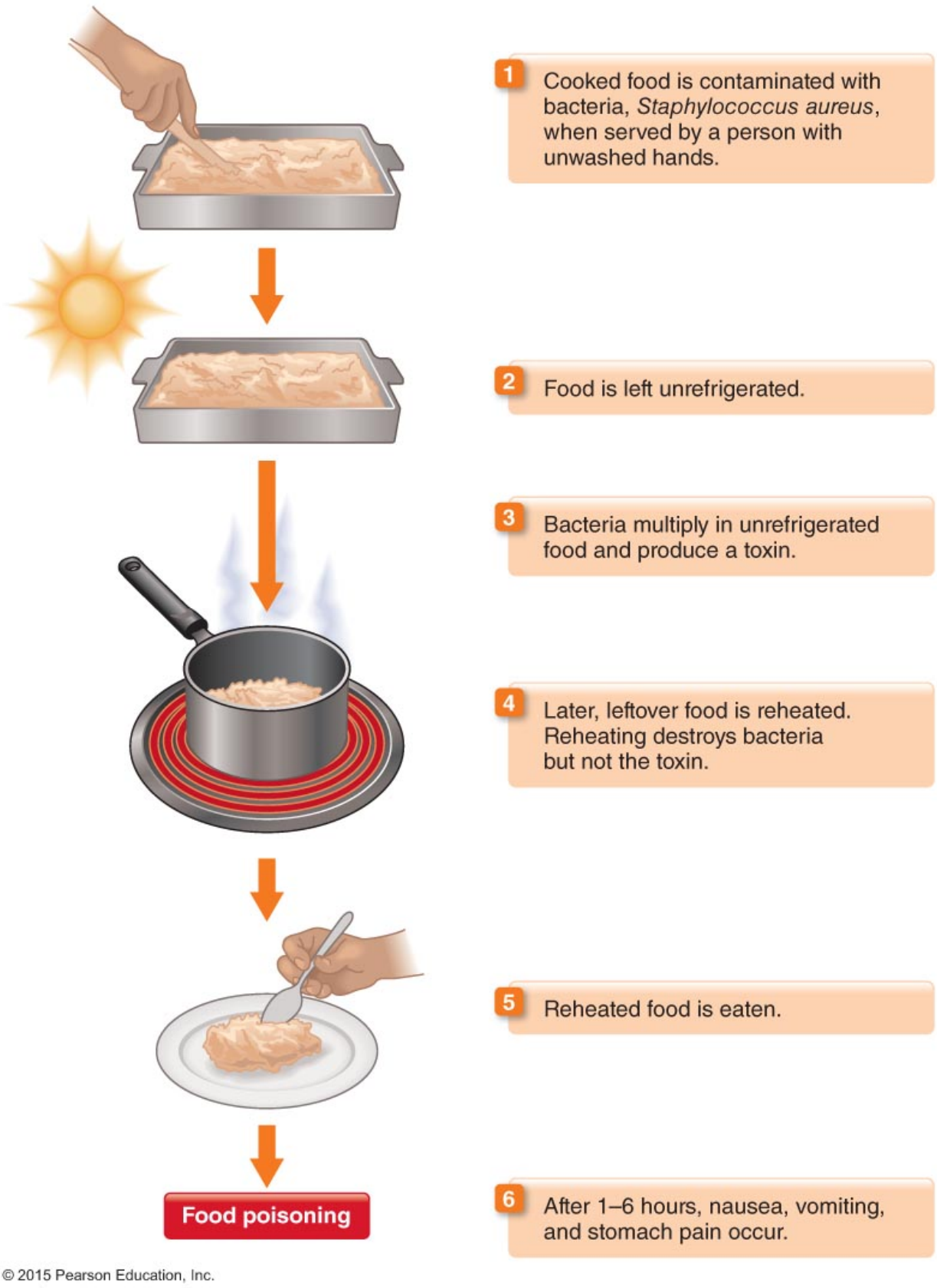

Figure 12.11: Food Contamination

- When eating out:
  - Eat at restaurants that look clean
  - Insist that food be cooked thoroughly
- When traveling:
  - Avoid raw foods, salads, unpasteurized milk, and uncooked fruits and vegetables
  - Select beverages carefully
  - Use a waterless antibacterial hand cleanser frequently

12.7 Preventing Food Spoilage

- Spoilage can be prevented by many natural techniques
  - Salting or sugaring
  - Drying
  - Smoking
  - Cooling
- More modern techniques of preventing spoilage include
  - Canning
  - Pasteurization
  - Irradiation
  - Aseptic packaging
  - Modified atmosphere packaging
  - High-pressure processing

Figure 12.12: The USDA's Radura

12.8 Food Additives

- Food additives are chemicals that do not occur naturally in the food but are added to enhance the food in some way – can include:
  - Nutrients and preservatives
  - Flavorings
  - Colorings
  - Other agents
- More than 3,000 food additives are used in the United States

TABLE 12.3 Examples of Common Food Additives

Food Additive	Foods Found in
Coloring Agents	
Beet extract	Beverages, candies, ice cream
Beta-carotene	Beverages, sauces, soups, baked goods, candies, macaroni and cheese mixes
Caramel	Beverages, sauces, soups, baked goods
Tartrazine	Beverages, cakes and cookies, ice cream
Preservatives	
Alpha-tocopherol (vitamin E)	Vegetable oils
Ascorbic acid (vitamin C)	Breakfast cereals, cured meats, fruit drinks
BHA	Breakfast cereals, chewing gum, oils, potato chips
BHT	Breakfast cereals, chewing gum, oils, potato chips
Calcium proprionate/sodium proprionate	Bread, cakes, pies, rolls
EDTA	Beverages, canned shellfish, margarine, mayonnaise, processed fruits and vegetables, sandwich spreads
Propyl gallate	Mayonnaise, chewing gum, chicken soup base, vegetable oils, meat products, potato products, fruits, ice cream
Sodium benzoate	Carbonated beverages, fruit juice, pickles, preserves
Sodium chloride (salt)	Most processed foods
Sodium nitrate/sodium nitrite	Bacon, corned beef, lunch meats, smoked fish
Sorbic acid/potassium sorbate	Cakes, cheese, dried fruits, jellies, syrups, wine
Sulfites (sodium bisulfite, sulfur dioxide)	Dried fruits, processed potatoes, wine
Texturizers, Emulsifiers, and Stabilizers	
Calcium chloride	Canned fruits and vegetables
Carageenan/pectin	Ice cream, chocolate milk, soy milk, frostings, jams, jellies, cheese, salad dressings, sour cream, puddings, syrups
Cellulose gum/guar gum/gum arabic/ locust gum/xanthan gum	Soups and sauces, gravies, sour cream, ricotta cheese, ice cream, syrups
Gelatin	Desserts, canned meats
Lecithin	Mayonnaise, ice cream
Humectants	
Glycerin	Chewing gum, marshmallows, shredded coconut
Propylene glycol	Chewing gum, gummy candies

Figure 12.13: Common Food Additives

- Sulfates and nitrites are preservatives that have raised health concerns

- Before a new additive can be used in food, the producer must demonstrate its safety to the FDA
- Substances already recognized as safe and exempt from stringent testing are referred to as generally recognized as safe (GRAS)

12.9 Genetic Modification in Food Production

- In genetic modification, the DNA of an organism is altered to bring about changes in its seeds or offspring
  - Recombinant DNA technology is a type of genetic modification in which DNA from different sources is combined
  - An increasing number and quantity of food crops have been genetically modified

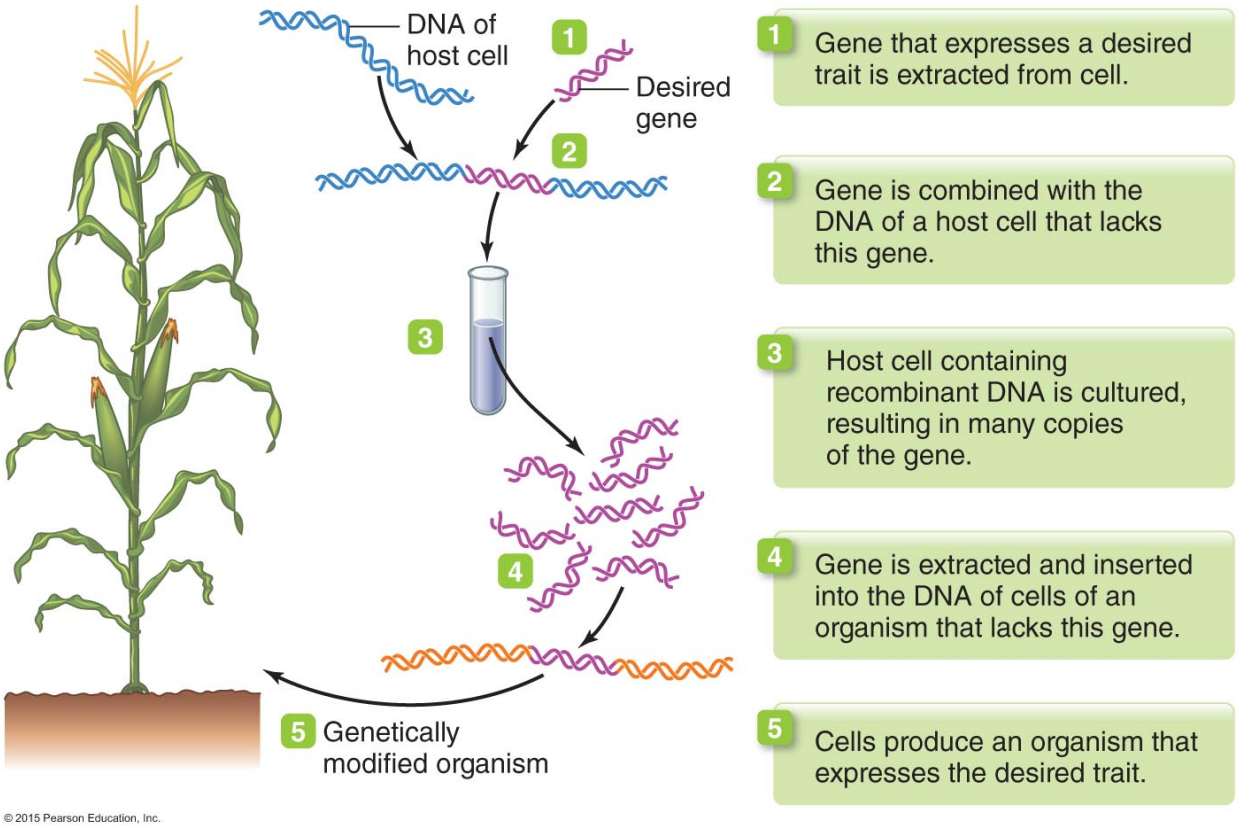

Figure 12.14: Recombinant DNA Technology

12.10 Benefits to Genetic Modification

- GM crops grow faster and have a higher yield

- Drought-resistant crops help to conserve water
- Reduced energy use to grow, pesticides, emissions from greenhouse gases, and increased soil preservation
- GM crops can be produced with higher nutrient contents
- Improved farmer profits benefit the economy
- Health risks
  - **Allergenicity** – genes transferred from common allergen foods could affect those with allergies
    - No currently reports however
  - Consuming crops that are antimicrobial could potential hard the cells of our body or our microbial flora in the GI tract
  - Genes from GM crops have migrated to conventional crops miles away
  - Possible link to cancer
- Environmental risks
  - Loss of biodiversity
  - Generation of superweeds
  - Threats to other species
- Economic instability

12.11 Should We Label GM Foods?

- Labeling would allow consumers to know if their food contained GM products
- The European Union has long required that GM foods are labeled clearly
- In 2016 the FDA did not require such labeling
- GM crops have been used in the United States for 20 years without labeling

12.12 Residues on Foods

- Various chemicals can persist and even accumulate in foods
- These residues can include
  - Persistent organic pollutants
  - Insecticides, herbicides, and fungicides
  - Growth hormone

12.13 Persistent Organic Pollutants

- Persistent organic pollutants (POPs): chemicals released into the atmosphere from industry, agriculture, automobiles, and waste disposal
  - Found in virtually all categories of foods
  - Include
    - Mercury and lead, which are nerve toxins
    - Dioxins, which increase risk of cancer and other disorders

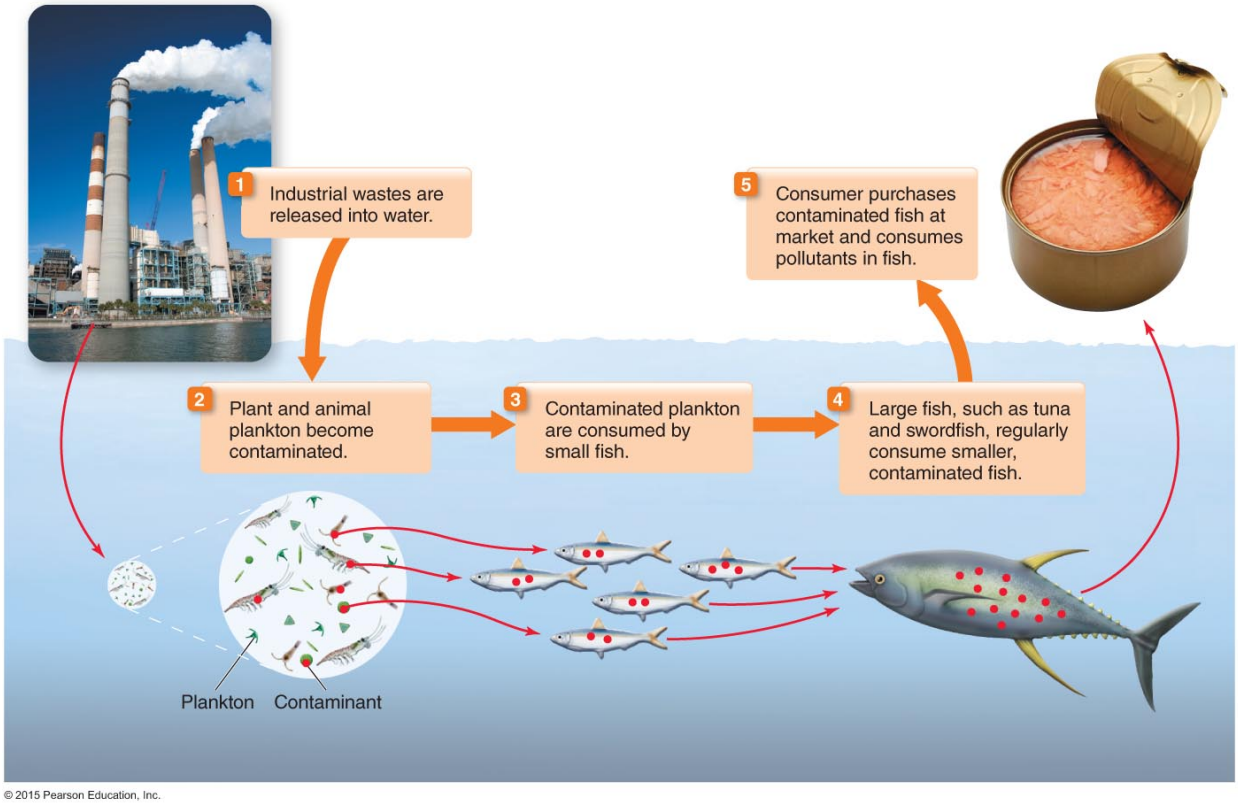

Figure 12.15: Biomagnification of POPs

12.14 Pesticides

- Pesticides are used to help protect against crop losses, reduce the incidence of disease, and increase crop yields
  - Most common are insecticides, herbicides, and fungicides
  - Can be natural or synthetic
  - Can remain as toxins on foods
  - Regulated by the EPA

12.15 Growth Hormones and Antibiotics

- Recombinant bovine growth hormone (rBGH) is a genetically engineered growth hormone given to cows
  - Increases muscle mass; decreases fat
  - Increases milk production
  - One-third of all U.S. dairy cows receive rBGH
  - Risks to humans are still being studied
- Antibiotics are routinely given to animals raised for food to reduce the number of disease outbreaks
  - Risks to humans are still being studied
  - May be developing significant reservoirs for antibiotic-resistant strains of bacteria, or "superbugs"
- Exposure to growth hormones and antibiotics can be reduced by selecting organic foods, free-range meats, and vegetarian meals

12.16 Organic Foods

- Organic foods are grown without the use of synthetic pesticides
  - Standards for organic production are regulated by the USDA

100% organic: only organic ingredients

Organic: 95% of ingredients are organic

Made with organic ingredients: 70% or more of ingredients are organic

Figure 12.16: USDA Organic Seal

12.17 In Depth: Supplements

- Supplements, according to the FDA, are a product containing ingredients like vitamins, minerals, herms, amino acids, or enzymes
- In 2014 sales of dietary supplements reached nearly $37 billion
- Are supplements safe?
  - In 2015, 14 U.S. Attorneys General signed a letter to congress requesting for an investigation of the dietary supplement industry
  - This comes after an audit for DNA testing of ingredients found they did not contain ingredients listed, but did contain heavy metals

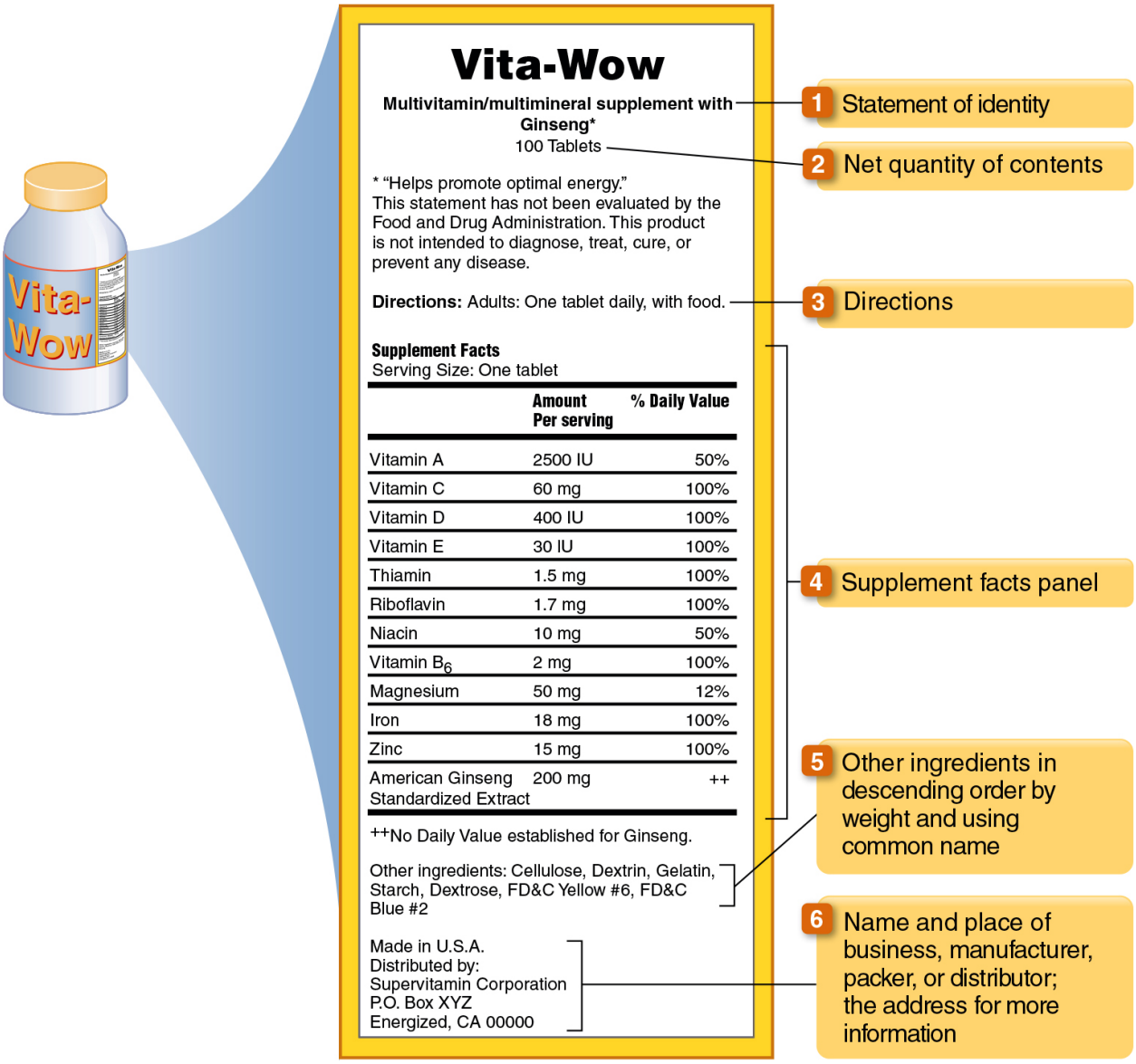

Figure 12.17: Supplements

- The FDA does not have the authority to review safety and efficacy of supplements
- It is the responsibility of the manufacturer to prove the safety of supplements
- Manufacturers do not have to tell the FDA they have added an ingredient
- The FDA does not regulate practices to ensure the purity

12.17.1 Herbal supplements

- The plant or part of the plant that is used to flavor, scent, and/or potential health-related properties

- The National Center for Complimentary and Integrative Health (NCCIH)
- Consult a healthcare provider before beginning a supplement

TABLE 1 Potentially Harmful Herbal Supplements

Herb	Potential Risks
Bitter orange	Increased blood pressure and heart rate; heart attack; stroke
Ephedra (also known as *ma huang,* Chinese ephedra, and epitonin)	High blood pressure, irregular heartbeat, nerve damage, insomnia, tremors, headaches, seizures, heart attack, stroke, possible death
Kava (also known as *kava kava*)	Liver damage; death
Licorice root	High blood pressure, fluid retention, hypokalemia
Noni	Liver damage
Thunder god vine	Diarrhea, nausea, skin rash, headache, hair loss, menstrual changes, male infertility; can be fatal if improperly extracted
Willow bark	Reye's syndrome (a potentially fatal reaction that may occur when children take aspirin), allergic reaction in adults
Yohimbe	High blood pressure, increased heart rate, headache, anxiety, dizziness, nausea, vomiting, tremors, insomnia

Source: Data from National Center for Complementary and Integrative Health (NCCIH). 2016. *Herbs at a Glance.* https://nccih.nih.gov/health/herbsataglance.htm

Figure 12.18: Potentially Harmful Herbal Supplements

- Surveys show that 67% of Americans use a vitamin or mineral supplement

- 35% use "specialty" supplements
- 23% use botanicals
- 17% use sports supplements

TABLE 2 Individuals Who May Benefit from Micronutrient Supplementation

Type of Individual	Specific Supplements That May Help
Newborns	Routinely given a single dose of vitamin K at birth
Infants	Depends on age and nutrition; may need iron, vitamin D, or other nutrients
Children not drinking fluoridated water	Fluoride supplements
Children with poor eating habits or overweight children on an energy-restricted diet	Multivitamin and multimineral supplement that does not exceed the RDA for the nutrients it contains
Pregnant teenagers	Iron and folic acid; other nutrients may be necessary if diet is very poor
Women who may become pregnant	Multivitamin or multivitamin and multimineral supplement that contains 0.4 mg of folic acid
Pregnant or lactating women	Multivitamin and multimineral supplement that contains iron, folic acid, zinc, copper, calcium, vitamin B_6, vitamin C, and vitamin D
People on prolonged or highly calorically restrictive weight-reduction diets	Multivitamin and multimineral supplement
People recovering from serious illness or surgery	Multivitamin and multimineral supplement
People with HIV/AIDS or other wasting diseases; people addicted to drugs or alcohol	Multivitamin and multimineral supplement or single-nutrient supplements
People who do not consume adequate calcium	Calcium should be consumed in whole foods and beverages; however, for some populations, supplements may be prescribed
People with low exposure to sunlight	Vitamin D
People eating a vegan diet	Vitamin B_{12}, riboflavin, calcium, vitamin D, iron, and zinc
People who have had portions of their intestinal tract removed; people who have a malabsorptive disease	Depends on the exact condition; may include various fat-soluble and/or water-soluble vitamins and other nutrients
Elderly people	Multivitamin and multimineral supplement, vitamin B_{12}

Figure 12.19: Individuals Who May Benefit from Micronutrient Supplementation