## **How does physical activity affect fluid and micronutrient needs?**

In this section, we review some of the basic functions of water and its role during exercise. (For a detailed discussion of fluid and electrolyte balance, see Chapter 7.) We also discuss changes in micronutrient needs to support vigorous physical activity.

**Dehydration and Heat-Related Illnesses**

Heat production can increase by 15 to 20 times during heavy exercise! The primary way in which we dissipate this heat is through evaporative cooling (see Figure 7.2 on page 226). When body temperature rises, more blood (which contains water) flows to the surface of the skin. Heat is carried in this way from the core of our body to the surface of our skin.

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When we sweat, the water (and body heat) leaves our body and the air around us picks up the evaporating water from our skin, cooling our body.

Heat illnesses occur because, when we exercise in the heat, our muscles and skin constantly compete for blood flow. When there is no longer enough blood flow to simultaneously provide adequate blood to both our muscles and our skin, muscle blood flow takes priority and evaporative cooling is inhibited. Exercising in heat plus humidity is especially dangerous; whereas the heat dramatically raises body temperature, the high humidity inhibits evaporative cooling--that is, the environmental air is already so saturated with water that it is unable to absorb the water in sweat. Body temperature becomes dangerously high, and heat illness is likely.

Dehydration significantly increases our risk for heat illnesses. **FIGURE 11.12** identifies the symptoms of dehydration during heavy exercise.

Heat illnesses include heat syncope, heat cramps, heat exhaustion, and heatstroke:

*-* *Heat syncope* is dizziness that occurs when people stand for too long in the heat and the blood pools in their lower extremities. It can also occur when people stop suddenly after a race or stand suddenly from a lying position.

*-* *Heat cramps* are muscle spasms that occur during exercise or several hours after strenuous exercise or manual labor in the heat. They are most commonly felt in the legs, arms, or abdomen after a person cools down.

*-* *Heat exhaustion* and *heatstroke* occur on a continuum, with unchecked heat exhaustion leading to heatstroke. Early signs of heat exhaustion include excessive sweating, cold and clammy skin, rapid but weak pulse, weakness, nausea, dizziness, headache, and difficulty concentrating. Signs that a person is progressing to heatstroke are hot, dry skin; rapid and strong pulse; vomiting; diarrhea; a body temperature greater than or equal to 104°F; hallucinations; and coma. Prompt medical care is essential to save the person's life. (For more information about heat illnesses, see Chapter 7.)

**Guidelines for Proper Fluid Replacement**

How can we prevent dehydration and heat illnesses? Obviously, adequate fluid intake is critical before, during, and after exercise. Unfortunately, our thirst mechanism cannot be relied on to signal when we need to drink. If we rely only on our feelings of thirst, we will not consume enough fluid to support exercise.

General fluid replacement recommendations are based on maintaining body weight. Athletes who are training and competing in hot environments should weigh themselves before and after the training session or event and should regain the weight lost over the subsequent 24-hour period.

[Image: Water is essential for maintaining fluid balance and preventing dehydration.]

**[Symptoms of Dehydration During Heavy Exercise:**

- Decreased exercise performance

- Increased level in perceived exertion

- Dark yellow or brown urine color

- Increased heart rate at a given exercise intensity

- Decreased appetite

- Decreased ability to concentrate

- Decreased urine output

- Fatigue and weakness

- Headache and dizziness]

**[FIGURE 11.12** Symptoms of dehydration during heavy exercise.]

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They should avoid losing more than 2% to 3 % of body weight during exercise because performance can be impaired with fluid losses as small as 1 % of body weight.

**TABLE 11.5** reviews the guidelines for proper fluid replacement. For activities lasting less than 1 hour, plain water is generally adequate to replace fluid losses. However, for training and competition lasting longer than 1 hour in any weather, sports beverages containing carbohydrates and electrolytes are recommended. These beverages are also recommended for people who will not drink enough water because they don't like the taste. If drinking these beverages will guarantee adequate hydration, they are appropriate to use. (For more specific information about sports beverages, refer to Chapter 7, page 237.)

**Inadequate Micronutrient Intake Can Diminish Health and Performance**

When people train vigorously for athletic events, their requirements for certain vitamins and minerals may be altered. It is essential to eat an adequate, varied, and balanced diet to try to meet the increased micronutrient needs associated with vigorous training.

**B-Vitamins**

The B-vitamins are directly involved in energy metabolism (see Chapter 8). There is reliable evidence that--as a population--active people may require slightly more thiamin, riboflavin, and vitamin B6 than the current RDA to support increased production of energy. However, these increased needs are easily met by consuming adequate energy and plenty of fiber-rich carbohydrates.

**[TABLE 11.5** **Guidelines for Fluid Replacement**

|  |  |  |
| --- | --- | --- |
| **Activity Level** | **Environment** | **Fluid Requirements (liters per day)** |
| Sedentary | Cool | 2-3 |
| Active | Cool | 3-6 |
| Sedentary | Warm | 3-5 |
| Active | Warm | 5-10 |

**Before Exercise or Competition**

- Drink adequate fluids during the 24 hours before event; should be able to maintain body weight.

- Slowly drink about 0.17 to 0.34 fl. oz per kg body weight of water or a sports drink in the 2 to 4 hours prior to exercise or event to achieve urine that is pale yellow in color while allowing sufficient time for excretion of excess fluid prior to exercise.

- Consuming beverages with sodium and/or small amounts of salted snacks at a meal will help stimulate thirst and retain fluids consumed.

**During Exercise or Competition**

- Amount and rate of fluid replacement depend on individual sweating rate, exercise duration, weather conditions, and opportunities to drink.

- Drink sufficient fluids during exercise to replace sweat losses such that total fluid loss is less than 2% of body weight.

**Following Exercise or Competition**

- Consume about 3 cups of fluid for each pound of body weight lost.

- Fluids after exercise should contain water to restore hydration status and sodium to support rehydration.

- Consume enough fluid to permit regular urination and to ensure the urine color is very light or light yellow in color; drinking about 125-150% of fluid loss is usually sufficient to ensure complete rehydration.

**In General**

- Products that contain fructose should be limited, as these may cause gastrointestinal distress.

- Alcohol should be avoided, as it increases urine output and reduces fluid retention.

*Source:* American College of Sports Medicine, Academy of Nutrition and Dietetics, and Dietitians of Canada. 2016. Nutrition and Athletic Performance. Joint Position Statement. *Medicine and Science in Sports and Exercise* 48(3):543-568.]

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Active people at risk for poor B-vitamin status are those who consume inadequate energy or who consume mostly refined carbohydrate foods, such as soda pop and sugary snacks. Vegan athletes and active individuals may be at risk for inadequate intake of vitamin B12; food sources enriched with this nutrient include soy and cereal products.

**Calcium**

Calcium supports proper muscle contraction and ensures bone health. Calcium intakes are inadequate for most women in the United States, including both sedentary and active women. This is most likely due to a failure to consume foods that are high in calcium, particularly dairy products. Although vigorous training does not appear to directly increase our need for calcium, we need to consume enough calcium to support bone health. If we do not, stress fractures and severe loss of bone can result.

Some female athletes suffer from a syndrome known as the *female athlete triad* (see **In Depth 11.5** immediately following this chapter). In the female athlete triad, nutritional inadequacies cause irregularities in the menstrual cycle and hormonal disturbances that lead to a significant loss of bone mass. Thus, for female athletes, consuming the recommended amounts of calcium is critical. For female athletes who are physically small and have lower energy intakes, calcium supplementation may be needed to meet current recommendations.

**Iron**

Iron is a part of the hemoglobin molecule in blood cells and is critical for the transport of oxygen to body cells and working muscles. Iron also is involved in energy production. Active individuals lose more iron in the sweat, feces, and urine than do inactive people, and endurance runners lose iron when their red blood cells break down in their feet as a consequence of the high impact of running. Female athletes and nonathletes lose more iron than male athletes because of menstrual blood losses, and females in general tend to eat less iron in their diet. Vegetarian athletes and active people may also consume less iron. Thus, many athletes and active people are at higher risk for iron deficiency. Depending on its severity, poor iron status can impair athletic performance and our ability to maintain regular physical activity.

A phenomenon known as *sports anemia* was identified in the 1960s. Sports anemia is not true anemia, but rather a transient decrease in iron stores that occurs at the start of an exercise program for some people, and it is seen in athletes who increase their training intensity. Exercise training increases the amount of water in our blood (called *plasma volume);* however, the amount of hemoglobin does not increase until later into the training period. Thus, the iron content in the blood appears to be low but instead is falsely depressed due to increases in plasma volume. Sports anemia, because it is not true anemia, does not affect performance.

In general, it appears that physically active females are at relatively high risk of suffering from the first stage of iron depletion, in which iron stores are low. Because of this, it is suggested that blood tests of iron stores and monitoring of dietary iron intake be done routinely for active people. In some cases, iron needs cannot be met through the diet, and supplementation is necessary. Iron supplementation should be done with a physician's approval and proper medical supervision.

**[recap**

Regular exercise increases fluid needs. Fluid is critical to cool our internal body temperature and prevent heat illnesses. Dehydration is a serious threat during exercise in extreme heat and high humidity. Heat illnesses include heat syncope, heat cramps, heat exhaustion, and heat stroke. Active people may need more thiamin, riboflavin, and vitamin B6 than inactive people. Exercise itself does not increase our calcium needs, but most women, including active women, do not consume enough calcium. Many active individuals require more iron, particularly female athletes and vegetarian athletes.]

[Map your walking, running, or cycling route and share it with friends--or check out dozens of fitness loops right in your neighborhood at **www.livestrong.com.** Enter "tools" into the search box, then scroll down to select "Tools" under the Livestrong Search Results heading. Then select "Loops" to get underway.]

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**LO 6** Discuss the marketing claims, performance effects, and health risks of several popular ergogenic aids.

## **Are ergogenic aids necessary for active people?**

Many competitive athletes and even some recreationally active people continually search for that something extra that will enhance their performance. **Ergogenic aids** are substances used to improve exercise and athletic performance. For example, dietary supplements can be classified as ergogenic aids, as can anabolic steroids and other pharmaceuticals. Interestingly, people report using ergogenic aids not only to enhance athletic performance but also to improve their physical appearance, prevent or treat injuries and diseases, and help them cope with stress. Some people even report using them because of peer pressure.

As you have learned in this chapter, adequate nutrition is critical to athletic performance and to regular physical activity, and products such as sports bars and beverages can help athletes maintain their competitive edge. However, as we will explore shortly, many ergogenic aids are not effective, some are dangerous, and most are very expensive. For the average consumer, it is virtually impossible to track the latest research findings for these products. In addition, many have not been adequately studied, and unsubstantiated claims surrounding them are rampant. How can you become a more educated consumer about ergogenic aids?

New ergogenic aids are available virtually every month. It is therefore not possible to discuss every product here. However, a brief review of a number of currently popular ergogenic aids is provided.

**Many Ergogenic Aids Are Said to Build Muscle Mass and Strength**

Many ergogenic aids are said to be **anabolic,** meaning that they build muscle and increase strength. Most anabolic substances promise to increase testosterone, which is the hormone associated with male sex characteristics and that increases muscle size and strength. Although some anabolic substances are effective, they are generally associated with harmful side effects.

**Anabolic Steroids**

Anabolic steroids are testosterone-based drugs known to be effective in increasing muscle size, strength, power, and speed. They have been used extensively by strength and power athletes; however, these products are illegal in the United States, and their use is banned by all major collegiate and professional sports organizations, in addition to both the U.S. and the International Olympic Committees. Proven long-term and irreversible effects of steroid use include infertility; early closure of the plates of the long bones, resulting in permanently shortened stature; shriveled testicles, enlarged breast tissue (that can be removed only surgically), and other signs of "feminization" in men; enlarged clitoris, facial hair growth, and other signs of "masculinization" in women; increased risk for certain forms of cancer; liver damage; unhealthful changes in blood lipids; hypertension; severe acne; hair thinning or baldness; and depression, delusions, sleep disturbances, and extreme anger (socalled roid rage).

**Androstenedione and Dehydroepiandrosterone**

Androstenedione ("andro") and dehydroepiandrosterone (DHEA) are precursors of testosterone. Manufacturers of these products claim that taking them will increase testosterone levels and muscle strength. Androstenedione became very popular around 20 years ago after baseball player Mark McGwire claimed he used it during the time he was breaking home run records. Contrary to popular claims, neither androstenedione nor DHEA increases testosterone levels, and early research on androstenedione has been shown to increase the risk for heart disease in men aged 35 to 65 years.15 There are no studies that support the products' claims of improving strength and increasing muscle mass.

[Image: Anabolic substances are often marketed to people striving to increase their muscle mass and strength; however, many cause harmful side effects.]

[Sidebar: **ergogenic aids** Substances used to improve exercise and athletic performance.]

[Sidebar: **anabolic** The characteristic of a substance that builds muscle and increases strength.]

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**Creatine**

Creatine, or creatine phosphate, is found in meat and fish and stored in our muscles. Because cells use creatine phosphate (CP) to regenerate ATP, it is theorized that creatine supplements make more CP available to replenish ATP, which prolongs a person's ability to train and perform in short-term, explosive activities, such as weight lifting and sprinting. Creatine does not seem to enhance performance in aerobic-type events but may increase the work performed and amount of strength gained during resistance exercise and to enhance sprint performance in swimming, running, and cycling. Side effects include acute weight gain and gastrointestinal discomfort.14

**Some Ergogenic Aids Are Said to Optimize Fuel Use**

Certain ergogenic aids are touted as increasing energy levels and improving athletic performance by optimizing the use of fat, carbohydrate, and protein. The products reviewed here are caffeine, ephedrine, carnitine, chromium, and beta-alanine.

**Caffeine**

Caffeine is a stimulant that makes us feel more alert and energetic, decreasing feelings of fatigue during exercise. In addition, caffeine has been shown to increase the use of fat as a fuel during endurance exercise, thereby sparing muscle glycogen and improving performance. Energy drinks that contain high amounts of caffeine, such as Red Bull, have become popular with athletes and many college students. These drinks should be avoided during exercise, however, because they can prompt severe dehydration due to the combination of fluid loss from exercise and increased fluid excretion from the caffeine. Research also indicates that energy drinks are associated with serious side effects in children, adolescents, and young adults, including irregularities in heart rhythm, seizures, diabetes, and mood disorders.16 It should be recognized that caffeine is a controlled or restricted drug in the athletic world, and athletes can be banned from Olympic competition if their urine levels are too high. However, the amount of caffeine that is banned is quite high, and athletes would need to consume caffeine in pill form to reach this level. Side effects of caffeine use include increased blood pressure, increased heart rate, dizziness, insomnia, headache, and gastrointestinal distress.

**Ephedrine**

Ephedrine, also known as ephedra, Chinese ephedra, and *ma huang,* is a strong stimulant marketed as a weight-loss supplement and energy enhancer. In reality, many products sold as Chinese ephedra (or herbal ephedra) contain ephedrine synthesized in a laboratory and other stimulants, such as caffeine. The use of ephedra does not appear to enhance performance, but supplements containing both caffeine and ephedra have been shown to prolong the amount of exercise that can be done until exhaustion is reached. Side effects of ephedra use include headaches, nausea, nervousness, anxiety, irregular heart rate, high blood pressure, and death. It is currently illegal to sell ephedra-containing supplements in the United States.

**Carnitine**

Carnitine is a compound made from amino acids and is found in the membranes of mitochondria in our cells. Carnitine helps shuttle fatty acids into the mitochondria, so that they can be used for energy. It has been proposed that exercise training depletes our cells of carnitine and that supplementation should restore carnitine levels, thereby enabling us to improve our use of fat as a fuel source.

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Thus, carnitine is marketed not only as a performance-enhancing substance but also as a "fat burner." Research studies of carnitine supplementation do not support these claims, as neither the transport of fatty acids nor their oxidation appears to be enhanced with supplementation. The use of carnitine supplements has not been associated with significant side effects.

**Chromium**

Chromium is a trace mineral that enhances insulin's action of increasing the transport of amino acids into the cell. It is found in whole-grain foods, cheese, nuts, mushrooms, and asparagus. It is theorized that many people are chromium deficient and that supplementation will enhance the uptake of amino acids into muscle cells, which will increase muscle growth and strength. Like carnitine, chromium is marketed as a fat burner, with claims that its effect on insulin stimulates the brain to decrease food intake. Chromium supplements are available as chromium picolinate and chromium nicotinate. Early studies of chromium supplementation showed promise, but more recent, better-designed studies do not support any benefit of chromium supplementation on muscle mass, muscle strength, body fat, or exercise performance.

**Beta-Alanine**

Beta-alanine is a nonessential amino acid that has been identified as the limiting factor in the production of carnosine, which plays a key role in the regulation of pH in the muscle and is thought to buffer acids produced during exercise, thereby enhancing a person's ability to perform short-term, high-intensity activities. Recent evidence suggests that beta-alanine supplementation can increase muscle carnosine levels and delay the onset of muscle fatigue.17 Additionally, beta-alanine supplementation results in improved exercise performance during single or repeated high-intensity exercise bouts or maximal muscle contractions. It appears that several weeks of supplementation are needed to increase muscle carnosine levels and positively affect performance.

As this review indicates, many ergogenic aids fail to live up to their claims of enhancing athletic performance, strength, or body composition. And many have uncomfortable or even dangerous side effects. Be a savvy consumer. Before purchasing any ergogenic aid, do some homework to make sure you wouldn't be wasting your money or putting your health at risk by using it.

**[recap**

Ergogenic aids are substances used to improve exercise and athletic performance. Many claim to be anabolic, meaning that they build muscle and increase strength. Although some anabolic substances are effective, they are generally associated with harmful side effects. Certain ergogenic aids are said to increase energy levels and improving athletic performance by optimizing the use of fat, carbohydrate, and/or protein. Caffeine and beta-alanine appear to improve athletic performance. Studies do not support any ergogenic benefit of carnitine or chromium, and ephedrine is dangerous and cannot be sold in the United States.]

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## **Nutrition debate How Much Physical Activity Is Enough?**

[The first physical activity recommendations were published in 1996, when a report of the Surgeon General recommended that Americans engage in at least 30 minutes of physical activity on most days of the week.l8 Then, in 2002, the Institute of Medicine (IOM, which is now the Health and Medicine Division of the National

Academies of Sciences, Engineering, and Medicine) released a recommendation that Americans be active 60 minutes per day to optimize health.6 As this amount and frequency of physical activity was significantly higher than the Surgeon General's recommendation, it caused a great deal of confusion and controversy. For most Americans, how much physical activity is enough?

To tackle that question, let's look at the basis for the IOM's more challenging recommendation. It was derived from metabolic studies specifically examining the energy expenditure associated with maintaining a healthful body weight (defined as a BMI of 18.5 to 2 5 kg/m2). After reviewing a large number of studies that assessed energy expenditure and BMI, the IOM concluded that participating in about 60 minutes of moderately intense physical activity per day will move people to an active lifestyle and will allow them to maintain a healthful body weight.

The IOM recommendation was not based on evidence supporting the wider range of health benefits that result when a person moves from doing no physical activity to at least some level of physical activity. The growing body of evidence regarding the health benefits of physical activity clearly indicates that doing at least some physical activity is better than doing none, and doing more physical activity is better than doing less.

In 2008, the U.S. Department of Health and Human Services (HHS) released the *Physical Activity Guidelines for Americans.*5 These include guidelines for children and adolescents, adults, and older adults, with additional information for women who are pregnant; people with disabilities, type 2 diabetes, or osteoarthritis; and people who are cancer survivors. These guidelines build upon the Surgeon General's recommendation of 30 minutes per day on most, if not all, days of the week. Specifically, the 2008 HHS guidelines for adults state the following:

- Inactivity should be avoided. Participating in any amount of physical activity will provide some health benefits.

- To gain substantial health benefits, adults should do a minimum of 150 minutes per week of moderate-intensity activity, or 75 minutes per week of vigorous intensity activity, or an equivalent combination of these two intensities of activity. The activities should be aerobic in nature and performed in episodes of at least 10 minutes' duration, spread throughout the week.

- To gain additional and more extensive health benefits, adults should increase their aerobic activity level to 300 minutes per week of moderate-intensity activity, or 150 minutes per week of vigorous-intensity activity, or an equivalent combination of these two intensities.

- Adults should also participate in muscle-strengthening activities that are moderate or vigorous in intensity and involve all major muscle groups on at least 2 days per week.

Notice that these guidelines promote a *minimum* of 150 minutes per week of moderate-intensity aerobic physical activity, with additional encouragement to increase both the intensity and the duration of activity throughout the week to gain even more health benefits. Two recent studies tracking hundreds of thousands of individuals over several years support these recommendations. They found that those who exercised moderately for at least 150 minutes a week had about a 30% to 47% lower risk of dying during the study period, and that those who exercised longer (up to 450 minutes a week) or more vigorously at least occasionally during the week experienced an even greater reduction in mortality risk.19,20 This research supports the reliability of the 2008 HHS guidelines while helping to illustrate that the IOM and Surgeon General's recommendations are not really that different after all.

**CRITICAL THINKING QUESTIONS**

1. How might an overweight person gain substantial health benefits by shifting from doing no physical activity to meeting the minimum recommendation of 30 minutes per day on most days of the week?

2. Conduct a literature search using Google Scholar to identify the various benefits of regular physical activity that are not related to weight loss.

3. Based on the results of this literature search, devise a marketing campaign that could be used to encourage college students to regularly engage in physical activity.

[Image Removed]

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**[TEST YOURSELF** *ANSWERS*

**1** **T** Almost 80% of Americans do not get enough physical activity. Moreover, nearly 24% of the population report doing no leisure-time physical activity at all.

**2** **F** Evidence indicates that adequate protein intake is critical for muscle growth, and active people have higher protein needs than inactive people. However, protein supplements are not required to support muscle growth, as most Americans consume more than adequate protein from food. In contrast, weight-bearing exercise is necessary to appropriately stress the body and increase muscle mass and strength.

**3** **F** During exercise, our thirst mechanism cannot be relied upon to signal when we need to drink. If we rely solely on our feelings of thirst, we will not consume enough fluid to support exercise.]

**review questions**

**LO 1 1.** Which of the following is a benefit of regular physical activity?

a. Reduces body cells' uptake of glucose from the blood

b. Reduces the risk of nearly all forms of cancer

c. Reduces anxiety and mental stress

d. All of the above

**LO 2 2.** For achieving and maintaining cardiorespiratory fitness, the intensity range typically recommended is

a. 25% to 50% of your estimated maximal heart rate.

b. 35% to 75% of your estimated maximal heart rate.

c. 50% to 70% of your estimated maximal heart rate.

d. 75% to 95% of your estimated maximal heart rate.

**LO 3** **3.** The amount of ATP stored in a muscle cell can keep a muscle active for about

a. 1 to 3 seconds.

b. 10 to 30 seconds.

c. 1 to 3 minutes.

d. 1 to 3 hours.

**LO 3 4.** To support a long afternoon of gardening, the body predominantly uses which nutrient for energy?

a. Carbohydrate

b. Fat

c. Amino acids

d. Lactic acid

**LO 4 5.** Which of the following statements about carbohydrate loading is true?

a. Carbohydrate loading involves altering the duration and intensity of exercise and intake of carbohydrate such that the storage of fat is minimized.

b. Carbohydrate loading results in increased storage of glycogen in muscles and the liver.

c. Carbohydrate loading is beneficial for most athletes prior to most competitive events.

d. All of the above are true.

**LO 4 6.** The recommended protein intake for active people who are not competitive athletes is

a. the same as for sedentary adults, 0.8 g protein per kg body weight.

b. somewhat higher than for sedentary adults, about 1.0 to 1.2 g protein per kg body weight.

c. about twice the recommended intake for sedentary adults; that is, about 1.6 to 1.8 g protein per kg body weight.

d. two to three times the recommended intake for sedentary adults; that is, about 2.0 to 2.4 g protein per kg body weight.

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**LO 5 7.** Athletes participating in an intense athletic competition lasting more than 1 hour should

a. drink caffeinated beverages to improve their performance while maintaining their hydration.

b. drink plain warm water copiously both before and during the event in response to fluid losses from sweating and the desire to drink.

c. drink plain ice water both before and during the event in response to thirst.

d. drink a beverage containing carbohydrate and electrolytes both before and during the event in amounts that balance hydration with energy, carbohydrate, and electrolyte needs.

**LO 6 8.** Which of the following ergogenic aids has been shown in research studies to improve athletic performance?

a. androstenedione

b. chromium

c. carnitine

d. caffeine

**LO 2** 9. **True or false?** A sound fitness program overloads the body.

**LO 5 10.** **True or false?** Sports anemia is a chronic decrease in iron stores that occurs in some athletes who have been training intensely for several months to years.

**math review**

**LO 4 11.** Liz is a dance major. She participates in two 90-minute dance classes each day, 5 days a week, plus does a 60-minute strength-training workout during her lunch break twice a week. She is a vegetarian, and her current energy intake is 1,800 kcal per day. She weighs 105 pounds. After referring to Table 6.2 (page 198) she estimates that her protein intake should be 1.5 grams per kilogram of body weight, and she wants to keep her fat intake relatively low at 20% of her total daily energy intake. Based on this information, calculate how many grams of protein, fat, and carbohydrate Liz needs to consume daily to support this activity program. Does Liz's carbohydrate intake fall within the AMDR, which is 45 % to 65 % of total energy intake?

*Answers to Review Questions and Math Review are located at the back of this text and in the MasteringNutrition Study Area.*

**web links**

**www.heart.org**

American Heart Association

*The "Healthy Living" part of this site has sections on healthy eating, physical activity, weight management, and more.*

**www.acsm.org**

American College of Sports Medicine

*Click on "Public Information," then select "Brochures and Fact Sheets" to access brochures on why we eat and reducing sedentary behaviors; select the "Newsletters" section to access the ACSM's Fit Society Page newsletter.*

**www.hhs.gov**

U.S. Department of Health and Human Services

*Review this site for multiple statistics on health, exercise, and weight, as well as information on supplements, wellness, and more.*

**www.win.niddk.nih.gov**

Weight-Control Information Network

*To find out more about tips to help you get active and how to be active at any size, log onto this site and search the "WIN Health Topics A-Z" to explore these and other activity-related topics.*

**ods.od.nih.gov**

NIH Office of Dietary Supplements

*Look on this National Institutes of Health site to learn more about the health effects of specific nutritional supplements.*

**www.fnic.nal.usda.gov**

Food and Nutrition Information Center

*Visit this site, searching on "ergogenic aids," and "sports nutrition" for links to detailed information about these topics.*

**www.adultfitnesstest.org**

The President's Challenge Adult Fitness test

*Go to this site to determine you are healthy enough to exercise by completing the American Heart Association Physical Activity Readiness Questionnaire, and then complete the test to determine your fitness level.*

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# **in** **depth 11.5** **Disorders Related to Body Image, Eating, and Exercise**

***After studying this In Depth, you should be able to:***

**1** Explain how body image can affect eating and exercise patterns, as well as physical and mental health, pp. 414-416.

**2** Identify several factors that contribute to the development of disorders related to body image, eating, and exercise, pp. 416-417.

**3** Identify the most common characteristics and health risks of anorexia nervosa, bulimia nervosa, and binge-eating disorder, pp. 417-420.

**4** Describe night-eating syndrome and the female athlete triad, pp. 420-422.

**5** Discuss treatment for individuals with eating disorders, p. 422-423.]

**During the last decade, modeling agencies and fashion shows worldwide have increasingly adopted health standards for fashion models, some requiring they meet a certain BMI, and others requiring a doctor's certificate certifying that they are healthy enough to work.** At the same time, regulatory groups have been monitoring images printed in magazines and other media. For example, in both 2015 and 2016, the Advertising Standards Authority of Britain denounced advertisements for the fashion brands Yves Saint Laurent and Gucci that showed models who looked emaciated.1 Both ads were pulled.

Behind these actions are numerous deaths of severely underweight fashion models in recent decades, and longstanding concerns that images glamorizing underweight models promote an unrealistic, even dangerous standard of beauty for girls and women. Is this true? What factors are thought to contribute to body image, eating patterns, and

exercise--in both women and men? And how do abnormal eating and exercise behaviors differ from true psychiatric disorders? In the following pages, we explore **In Depth** some answers to these important questions.

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## **What is body image, and how does it influence health?**

**LO 1** Explain how body image can affect eating and exercise patterns, as well as physical and mental health.

When you look in the mirror, do you criticize aspects of your appearance--such as your facial features, complexion, body shape, muscle definition, or weight? If you do, you're not alone. Many people experience anxiety about their body image. In a recent national survey, over 25% of college students--including 17% of males and nearly 30% of females--reported that, in the past year, concerns about their personal appearance had been "very difficult to handle" or even "traumatic."2

Your **body image** is the way you perceive, feel about, and critique your body. This, in turn, can strongly influence your eating and exercise patterns. A recent study found, for example, that "feeling fat"--not necessarily being overweight according to BMI--increased unhealthful eating behaviors such as skipping meals in both adolescent boys and girls.3 And another study found an association between feelings of anxiety about being judged by others on one's appearance--known as *social physique anxiety*--and increased risk for engaging in an uncontrollable pattern of excessive exercise.4 Let's take a closer look at these relationships.

**Body Image Influences Eating Behaviors**

Body image and eating patterns both occur on a *continuum,* a spectrum that can't be divided neatly into parts. An example is a rainbow--where exactly does the red end and the orange begin? The continuum model can help us understand how a person with a preoccupation with body image can progress from relatively normal eating behaviors to a pattern that is abnormal. For example, in the study just mentioned, the adolescents who "felt fat" typically skipped breakfast, and some also skipped lunch.3

Take a moment to study the Eating Issues and Body Image Continuum **(FIGURE 1).** Which of the five columns best describes your feelings about food and your body? If you find yourself identifying with the statements on the left side of the continuum, you probably have a healthy body image and few issues with food. Most likely you accept your body size and view eating and engaging in regular physical activity as a normal part of maintaining your health. As you progress to the right side of the continuum, where body image is an overriding concern, food restriction and excessive exercise become common. The food restriction can take either of two forms:

**- Disordered eating** is a general term used to describe a variety of atypical eating behaviors that people use to achieve or maintain a lower body weight. These behaviors may be as simple as going on and off diets or as extreme as refusing to eat any fat. Such behaviors don't usually continue for long enough to make the person seriously ill, nor do they significantly disrupt the person's normal routine.

- An **eating disorder** is a psychiatric condition that involves extreme body dissatisfaction and long-term eating patterns that negatively affect body functioning. Three clinically diagnosed eating disorders are anorexia nervosa, bulimia nervosa, and binge-eating disorder. Whereas anorexia nervosa is characterized by severe food restriction, bulimia nervosa and binge-eating disorder involve extreme overeating. These disorders will be discussed in more detail shortly.

**Body Image Influences Exercise Behaviors**

Disorders of body image and eating patterns are often associated with excessive exercise, because individuals with a distorted body image related to weight or shape frequently use excessive exercise as a method of purging unwanted Calories from the body.5 In the research literature, this excessive exercise is sometimes called exercise addiction6 or exercise dependence.4

How does one distinguish between healthful levels of exercise and exercise addiction? Researchers generally agree that an individual who is addicted to exercise will continue to exercise in spite of a physical injury, illness, or personal inconvenience. They will prioritize exercise above other factors in their personal lives, such as relationships, family commitments, academic studies, and work responsibilities. The exercise program also dominates their thinking, and they will experience symptoms similar to those of drug withdrawal if they cannot exercise.6 Moreover, although exercise is known to help relieve depression and anxiety, individuals who are addicted to exercise are found to have higher levels of depression and anxiety.7

Conversely, someone who is committed--but not addicted--to exercise will engage in physical activity for health, enjoyment, and to achieve sport or fitness goals, but they will not suffer withdrawal symptoms when they cannot exercise.6 These individuals have a sense of "life-balance" around physical activity.

[Sidebar: **body image** A person's perception, feelings about, and critique of his or her body's appearance and functioning.]

[Sidebar: **disordered eating** A general term used to describe a variety of abnormal or atypical eating behaviors that are used to keep or maintain a lower body weight.]

[Sidebar: **eating disorder** A clinically diagnosed psychiatric disorder characterized by severe disturbances in body image and eating behaviors.]

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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FOOD IS NOT AN ISSUE** | **CONCERNED/WELL** | **FOOD PREOCCUPIED/OBSESSED** | **DISRUPTIVE EATING** | **EATING DISORDERED** |
| - I am not concerned about what others think regarding what and how much I eat.- When I am upset or depressed I eat whatever I am hungry for without any guilt or shame.- I feel no guilt or shame no matter how much I eat or what I eat.- Food is an important part of my life but only occupies a small part of my time.- I trust my body to tell me what and how much to eat. | - I pay attention to what I eat in order to maintain a healthy body.- I may weigh more than what I like, but I enjoy eating and balance my pleasure with eating with my concern for a healthy body.- I am moderate and flexible in goals for eating well.- I try to follow Dietary Guidelines for healthy eating. | - I think about food a lot.- I feel I don't eat well most of the time.- It's hard for me to enjoy eating with others.- I feel ashamed when I eat more than others or more than what I feel I should be eating.- I am afraid of getting fat.- I wish I could change how much I want to eat and what I am hungry for. | - I have tried diet pills, laxatives, vomiting, or extra time exercising in order to lose or maintain my weight.- I have fasted or avoided eating for long periods of time in order to lose or maintain my weight.- I feel strong when I can restrict how much I eat.- Eating more than I wanted to makes me feel out of control. | - I regularly stuff myself and then exercise, vomit, or use diet pills or laxatives to get rid of the food or Calories.- My friends/family tell me I am too thin.- I am terrified of eating fat.- When I let myself eat, I have a hard time controlling the amount of food I eat.- I am afraid to eat in front of others. |
| **BODY OWNERSHIP** | **BODY ACCEPTANCE** | **BODY PREOCCUPIED/OBSESSED** | **DISTORTED BODY IMAGE** | **BODY HATE/DISASSOCIATION** |
| - Body image is not an issue for me.- My body is beautiful to me.- My feelings about my body are not influenced by society's concept of an ideal body shape.- I know that the significant others in my life will always find me attractive.- I trust my body to find the weight it needs to be at so I can move and feel confident about my physical body. | - I base my body image equally on social norms and my own self-concept.- I pay attention to my body and my appearance because it is important to me, but it only occupies a small part of my day.- I nourish my body so it has the strength and energy to achieve my physical goals.- I am able to assert myself and maintain a healthy body without losing my self-esteem. | - I spend a significant amount time viewing my body in the mirror.- I spend a significant amount of time comparing my body to others.- I have days when I feel fat.- I am preoccupied with my body.- I accept society's ideal body shape and size as the best body shape and size.- I believe that I'd be more attractive if I were thinner, more muscular, etc. | - I spend a significant amount of time exercising and dieting to change my body.- My body shape and size keep me from dating or finding someone who will treat me the way I want to be treated.- I have considered changing or have changed my body shape and size through surgical means so I can accept myself.- I wish I could change the way I look in the mirror. | - I often feel separated and distant from my body--as if it belongs to someone else.- I hate my body and I often isolate myself from others.- I don't see anything positive or even neutral about my body shape and size.- I don't believe others when they tell me I look OK.- I hate the way I look in the mirror. |

**[FIGURE 1** The Eating Issues and Body Image Continuum. The progression from normal eating (far left) to disordered eating (far right) occurs on a continuum.

*Source:* Data from Smiley, L, L. King, and H. Avery. University of Arizona Campus Health Service. Original Continuum, C. Shlaalak. Preventive Medicine and Public Health. Copyright © 1997 Arizona Board of Regents.]

**Body Dysmorphic Disorder Is a Psychiatric Diagnosis**

A psychiatric disorder of body image that typically involves disordered eating and excessive exercise is **body dysmorphic disorder (BDD).** It is estimated to affect as much as 2.4% of the population8 and is about equally common in males and females.9 In medicine, a *dysmorphica* is an abnormality of structure; in BDD, the individual obsesses over a perceived defect--real or imaginary--in his or her appearance.

[Sidebar: **body dysmorphic disorder (BDD)** A clinically diagnosed psychiatric disorder characterized by a disabling preoccupation with perceived defects in appearance.]

[Image: Men are more likely than women to exercise excessively in an effort to control their weight.]

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A common form of BDD is *muscle dysmorphia,* a pathological pursuit of increased muscularity that causes individuals--usually men--to engage in highly disordered eating behaviors and excessive exercise, typically strength training. Men with muscle dysmorphia perceive themselves as small and frail even though they may actually be quite large and muscular. As a result, they spend long hours lifting weights and follow a meticulous diet, often consisting of excessive high-protein foods and dietary supplements. They may also abuse anabolic steroids.9,10

Muscle dysmorphia shares several characteristics with other body image and eating disorders. For instance, individuals report "feeling fat" and express significant discomfort with the idea of having to expose their body to others (e.g., take off their clothes in the locker room). They also have increased rates of other psychiatric illnesses, including anxiety and depression.11

**What factors contribute to disorders related to body image, eating, and exercise?**

**LO 2** Identify several factors that contribute to the development of disorders related to body image, eating, and exercise.

The factors that contribute to the development of body image disorders, excessive exercise, and eating disorders in any particular individual are very complex.

**Influence of Genetic Factors**

Overall, the diagnosis of BDD and eating disorders is more common in siblings and other blood relatives who also have the diagnosis than in the general population.12,13 Data derived from studies examining twins estimate that genetic factors account for 43% of the variance in BDD,12 and 50% to 83% of the variance in eating disorders.13 These observations might suggest that one or more genes contribute to these disorders; however, it is difficult to separate the contribution of genetic and environmental factors within families.

**Influence of Family**

Research suggests that the family environment, including high levels of conflict, lack of cohesion, negative communication patterns, inappropriate modeling of attitudes toward weight and shape, poor-quality parent-child relationships, and low family expressiveness can all influence the development and maintenance of an eating disorder.14 Compared to families without a member with an eating disorder, families of a person with an eating disorder tend to share three traits:15

*-* *Anxiety.* Within families, anxiety can be contagious and can maintain or even exacerbate a pattern of disordered eating. For example, parents may display a high level of anxiety in response to a child's disordered eating behaviors. The child senses this anxiety and responds by intensifying the behavior.

*-* *Compulsivity.* The families of individuals who develop eating disorders are typically characterized by inflexibility, rigidity, and the need for order. Thus, when the family experiences an unpredictable event, the individual may turn to compulsive behaviors-- such as refusing food or obsessively exercising--to adapt.

*-* *Abnormal eating behavior in one family member.* A pattern of disordered eating may already be present within the family, leading other family members to view this behavior as normal or acceptable.

**Influence of Media**

Media, including social media, can play an important role in the formation of body image in both males and females, and can create unrealistic expectations for body weight and shape.9,16,17

[Image: Photos of models and celebrities are routinely air-brushed or altered to "enhance" physical appearance. Unfortunately, many young people believe these portrayals are accurate and, hence, strive to meet unrealistic physical goals.]

[Think that eating disorders develop only in teenage girls? Or that the individual's mother is always to blame? Guess again. Visit the National Institute of Mental Health at **www.nimh.nih.gov** and type in the search bar "eating disorders myths" to find a series of short videos busting nine myths about disordered eating.]

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Most adults understand that computer-enhanced images of lean, beautiful women and muscular men are unrealistic, but adolescents, who are still developing a sense of their identity and body image, may lack the same ability to distance themselves from what they see.18 Because body image influences eating behaviors, it is likely that this barrage of unrealistic media models may contribute to eating disorders.19,20 However, scientific evidence demonstrating that media *causes* eating disorders does not exist.

**Influence of Social and Cultural Values**

Eating disorders are significantly more common in white females in Western societies than in other women worldwide.13 This may be due in part to the white Western culture's association of slenderness with attractiveness, wealth, and high fashion. In contrast, until recently, the prevailing view in developing societies has been that excess body fat is desirable as a sign of health and material abundance.

The members of society with whom we most often interact--our family members, friends, classmates, and coworkers--also influence the way we see ourselves. Their comments related to our appearance can be particularly hurtful--enough so to contribute to BDD9 or disordered eating.13 Peer relationships also appear to be highly influential in the development of an eating disorder. Research shows that frequent comparison of one's body to peers can contribute to the developed of body dissatisfaction and disordered eating.21 For example, a 2011 study from the London School of Economics concluded that anorexia is primarily socially induced. The higher the BMI of one's peers, the lower the risk of developing anorexia.22

**Comorbidity with Other Psychological Disorders**

Individuals with body image or eating disorders often have comorbidity with other psychological disorders such as obsessive-compulsive disorder (OCD).8,9,23 In one study, over 60% of individuals with BDD were classified as having a lifetime history of anxiety disorder, including OCD.8 The OCD may manifest, for example, as compulsive checking and counting of foods eaten, Calories, body weight, waist or other measurements, or aspects of their exercise program.8,9,23

Eating disorders are also associated with perfectionism, low self-esteem, moodiness, and interpersonal difficulties.20,24 Individuals with anorexia nervosa may also experience excessive anxiety over unfamiliar or unpredictable situations or events. They have a high need for control; thus, they find it difficult to complete tasks, since nothing is ever quite good enough or done well enough.25 Conversely, those with bulimia nervosa may demonstrate more impulsivity and respond more negatively or erratically to challenges.20 These negative moods may trigger overeating.13,26

## **What psychiatric eating disorders are recognized?**

**LO 3** Identify the most common characteristics and health risks of anorexia nervosa, bulimia nervosa, and binge-eating disorder.

Recall that eating disorders are psychiatric conditions. The clinical manual of the American Psychiatric Association, which is the world's largest psychiatric organization, recognizes three such eating disorders. These are anorexia nervosa, bulimia nervosa, and binge-eating disorder.24

All three of these eating disorders occur in males as well as females; however, the signs and symptoms may differ. Females may focus more on the desire to be thin, while males may focus more on muscularity.27 That is, males may be less concerned with actual body weight (scale weight) and more concerned with body composition (percentage of muscle mass compared to fat mass).5

The methods that males and females use to achieve weight loss also appear to differ. Males are more likely to use excessive exercise, whereas females tend to use severe energy restriction, vomiting, and laxative abuse. These differences may stem from sociocultural biases; that is, dieting is considered to be more acceptable for women, whereas the overwhelming sociocultural belief is that eating disorders are "not masculine."28

**Anorexia Nervosa**

**Anorexia nervosa** is a potentially life-threatening eating disorder that is characterized by an extremely low body weight achieved through self-starvation, which eventually leads to a severe nutrient deficiency. According to the National Eating Disorders Association, 20 million women and 10 million men suffer from a clinically significant eating disorder at some time in their life.29 Approximately 0.5% to 3.7% of American females develop anorexia, and 20 % of these women will die prematurely from complications related to their disorder, including suicide and heart problems.30 These statistics make anorexia nervosa the most common and most deadly psychiatric disorder diagnosed in women and one of the leading causes of death in females between the ages of 15 and 24.30 As the statistics indicate, anorexia nervosa also occurs in males, but the prevalence is much lower than it is in females.27,30

**Signs and Symptoms of Anorexia Nervosa**

The classic sign of anorexia nervosa is an extremely restrictive eating pattern that leads to self-starvation. People with this disorder may fast completely, restrict energy intake to only a few kilocalories per day, or eliminate all but one or

[Sidebar: **anorexia nervosa** A serious, potentially life-threatening eating disorder that is characterized by self-starvation, which eventually leads to a deficiency in the energy and essential nutrients required by the body to function normally.]

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[Image: People with anorexia nervosa experience an extreme drive for thinness, resulting in potentially fatal weight loss.]

two food groups from their diet. They also have an intense fear of weight gain, and even small amounts (e.g., 1 to 2 pounds) trigger high stress and anxiety.

In females, **amenorrhea** (the condition of having no menstrual periods for at least 3 continuous months) is a common feature of anorexia nervosa. It occurs when a young woman consumes insufficient energy to maintain normal body functions.

The American Psychiatric Association identifies the following conditions of anorexia nervosa.24,31

- Refusal to maintain body weight at or above a minimally normal weight for age and height

- Intense fear of gaining weight or becoming fat, even though considered underweight by all medical criteria

- Disturbance in the way in which one's body weight or shape is experienced, undue influence of body weight or shape on self-evaluation, or denial of the seriousness of the current low body weight

**Health Risks of Anorexia Nervosa**

Left untreated, anorexia nervosa eventually leads to a deficiency in energy and nutrients that are required by the body to function normally **(FIGURE 2).** The body will then use stored fat and lean tissue (e.g., organ and muscle tissue) as an energy source to maintain brain tissue and vital body functions. The body will also shut down or reduce nonvital body functions to conserve energy. Electrolyte imbalances can lead to heart failure and death. The best chance for recovery is when an individual receives intensive treatment early.

**Bulimia Nervosa**

**Bulimia nervosa** is characterized by repeated episodes of binge eating and purging. Unlike individuals with anorexia nervosa, those with bulimia nervosa can be normal weight; however, they either fear gaining weight or are extremely unhappy with their body size and want to lose weight.30,32 According to the National Institutes of Mental Health (NIMH), the lifetime rate for bulimia nervosa is 0.5% for women and 0.1 % for men.32 Thus, women are at a much higher risk for bulimia nervosa than men.

The following behaviors characterize bulimia nervosa:

**-** **Binge eating** is usually defined as consumption of a quantity of food that is large for the person and for the amount of time in which it is eaten. For example, a person may eat a dozen brownies with 2 quarts of ice cream in a period of just 30 minutes. While binge eating, the person feels a loss of self-control, including an inability to end the binge once it has started.24,33 At the same time, the person feels a sense of euphoria not unlike a drug-induced high.

**-** **Purging** is a compensatory behavior used to prevent weight gain. Methods of purging include vomiting, laxative or diuretic abuse, enemas, fasting, and excessive exercise.

Men who participate in "thin-build" sports, such as jockeys, have a higher risk for bulimia nervosa than men who do not.]

[Sidebar: **amenorrhea** The absence of menstruation. In females who had previously been menstruating, it is defined as the absence of menstrual periods for 3 or more continuous months.]

[Sidebar: **bulimia nervosa** A serious eating disorder characterized by recurrent episodes of binge eating and recurrent inappropriate compensatory behaviors in order to prevent weight gain, such as self-induced vomiting, fasting, excessive exercise, or misuse of laxatives, diuretics, enemas, or other medications.]

[Sidebar: **binge eating** Consumption of a large amount of food in a short period of time, usually accompanied by a feeling of loss of self-control.]

[Sidebar: **purging** An attempt to rid the body of unwanted food by vomiting or other compensatory means, such as excessive exercise, fasting, or laxative abuse.]

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[**Skin/hair/nails:**

- Hair becomes thin, dry, and brittle; hair loss occurs

- Skin is dry, easily bruised, and discolored

- Nails turn brittle

**Blood and immune system:**

- Anemia

- Compromised immune system increases risk of infection

**Kidneys:**

- Dehydration

- Electrolyte abnormalities that can be life-threatening

- Chronic renal failure

**Reproductive function:**

- Disruption of sex hormone production, resulting in menstrual dysfunction and amenorrhea in females

- Infertility

**Muscle:**

- Loss of muscle tissue as the body uses the muscles as an energy source

**Brain:**

- Altered levels of serotonin and other neurotransmitters

- Alteration in glucose metabolism

- Mood changes

**Thyroid gland:**

- Abnormal thyroid levels due to starvation

**Heart:**

- Low blood pressure and abnormal heart rate contribute to dizziness and fainting

- Abnormal electrocardiogram (ECG)

- Sudden death due to ventricular arrhythmias

**Gastrointestinal system:**

- Abdominal pain and bloating caused by slowed gastric emptying and intestinal motility

- Acute pancreatitis

- Constipation

**Bone:**

- Decreased bone mineral density (osteopenia)

- Decreased ability to absorb calcium due to low estrogen levels

- Decreased intake of bone-building nutrients due to starvation

- Increased loss of bone due to elevated Cortisol levels]

**[FIGURE 2** The impact of anorexia nervosa on the body.]

For example, after a binge, a runner may increase her daily mileage to equal the "calculated" energy content of the binge.

**Signs and Symptoms of Bulimia Nervosa**

The American Psychiatric Association has identified the following criteria for diagnosis of bulimia nervosa:31

- Recurrent episodes of binge eating (e.g., eating a large amount of food in a short period, such as within 2 hours).

- Recurrent inappropriate compensatory behavior in order to prevent weight gain, such as self-induced vomiting; misuse of laxatives, diuretics, enemas, or other medications; fasting; or excessive exercise.

- Binge eating occurs on average at least twice a week for 3 months.

- Body shape and weight unduly influence self-evaluation.

- The disturbance does not occur exclusively during episodes of anorexia nervosa. Some individuals will have periods of binge eating and then periods of starvation, which makes classification of their disorder difficult.

Moreover, an individual with bulimia nervosa typically purges after most episodes but not necessarily on every occasion. Weight gain as a result of binge eating can therefore be significant.

How can you tell if someone has bulimia nervosa? In addition to the recurrent and frequent binge-eating and purging episodes, the National Institutes of Health have identified the following signs and symptoms:34

- Chronically inflamed and sore throat

- Swollen glands in the neck and below the jaw

- Worn tooth enamel and increasingly sensitive and decaying teeth as a result of exposure to stomach acids

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- Gastroesophageal reflux disorder

- Intestinal distress and irritation from laxative abuse

- Kidney problems from diuretic abuse

- Severe dehydration from purging of fluids

**Health Risks of Bulimia Nervosa**

The destructive behaviors of bulimia nervosa can lead to illness and even death. The most common health consequences associated with bulimia nervosa are:

*-* *Electrolyte imbalance:* typically caused by dehydration and the loss of potassium and sodium from the body with frequent vomiting. This can lead to irregular heartbeat and even heart failure and death.

*-* *Gastrointestinal problems:* inflammation, ulceration, and possible rupture of the esophagus and stomach from frequent bingeing and vomiting. Chronic irregular bowel movements and constipation may result in people with bulimia who chronically abuse laxatives.

*-* *Dental problems:* tooth decay and staining from stomach acids released during frequent vomiting

As with anorexia nervosa, the chance of recovery from bulimia nervosa increases, and the negative effects on health decrease, if the disorder is detected at an early stage. Familiarity with the warning signs of bulimia nervosa can help you identify friends and family members who might be at risk.

**Binge-Eating Disorder**

When was the last time a friend or relative confessed to you about "going on an eating binge"? Most likely, he or she explained that the behavior followed some sort of stressful event, such as a problem at work, the breakup of a relationship, or a poor grade on an exam. Many people have one or two binge episodes every year or so, in response to stress. But in people with **binge-eating disorder,** the behavior occurs frequently. Because it is not usually followed by purging, the person tends to gain a lot of weight. This lack of compensation for the binge distinguishes binge-eating disorder from bulimia nervosa.

The prevalence of binge-eating disorder is estimated to be 3% to 5% of the adult female and 2% of the adult male population, most of whom are overweight or obese.30 Our current food environment, which offers an abundance of good-tasting, cheap food any time of the day, makes it difficult for people with binge-eating disorder to avoid food triggers.

Again, the increased energy intake associated with binge eating significantly increases a person's risk of being overweight or obese. In addition, the types of foods typically consumed during a binge episode are high in fat and sugar, which can increase blood lipids. Finally, the stress associated with binge eating can have psychological consequences, such as low self-esteem, avoidance of social contact, depression, and negative thoughts related to body size.

## **What syndromes of disordered eating are recognized?**

**LO 4** Describe night-eating syndrome and the female athlete triad.

A *syndrome* is a type of disorder characterized by the presence of two or more distinct health problems that tend to occur together. Two syndromes involving disordered eating behaviors are night-eating syndrome and the female athlete triad.

**Night-Eating Syndrome**

**Night-eating syndrome** was first described in a group of patients who were not hungry in the morning but spent the evening and night eating and reported insomnia. Like binge-eating disorder, it is associated with obesity because, although night eaters don't binge, they do consume significant energy in their frequent snacks, and they don't compensate for the excess energy intake.

The distinguishing characteristic of night-eating syndrome is the time during which most of the day's energy intake occurs. Night eaters have a daily pattern of significantly increasing their energy intake in the evening and/or at nighttime and not being hungry at breakfast time. Thus, night-eating syndrome is diagnosed by one or both of the following criteria.35

- Eating at least 25% of daily food intake after the evening meal

- Experiencing at least two episodes per week of night eating; that is, getting up to eat after going to bed

Night eating is also characterized by a depressed mood and insomnia.36 In short, this syndrome combines three unique disorders: an eating disorder, a sleep disorder, and a mood disorder.36

[Sidebar: **binge-eating disorder** A disorder characterized by binge eating an average of twice a week or more, typically without compensatory purging.]

[Sidebar: **night-eating syndrome** Disorder characterized by intake of the majority of the day's energy between 8:00 PM and 6:00 AM. Individuals with this disorder also experience mood and sleep disorders.]

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[Image: People with night-eating syndrome consume most of their daily energy between 8 PM and 6 AM.]

Many night eaters are obese, and many experience anxiety or engage in substance abuse. Some engage in other disordered eating behaviors.

Night-eating syndrome is important clinically because of its association with obesity, which increases the risk for several chronic diseases, including heart disease, high blood pressure, stroke, type 2 diabetes, and arthritis. Obesity also increases the risk for sleep apnea, which can further disrupt the night eater's already abnormal sleeping pattern.

**The Female Athlete Triad**

The **female athlete triad** is part of a larger syndrome called *relative energy deficiency in sport (REDS),* which encompasses numerous health problems associated with inadequate energy consumption to meet the energy needs of active men and women. These health-related issues can impair many aspects of physiological functioning, including BMR, immunity, protein synthesis, and bone, reproductive, and cardiovascular health.37

The female athlete triad itself consists of the following three clinical conditions in physically active females **(FIGURE 3):**38

- Low energy availability (such as inadequate energy intake to maintain menstrual function or to cover energy expended in exercise) with or without eating disorders

- Menstrual dysfunction, such as amenorrhea

- Low bone density

Certain sports that strongly emphasize leanness or a thin body build may place a young girl or a woman at risk for the female athlete triad.

**FIGURE 3** The female athlete triad is a syndrome composed of three coexisting disorders: low energy availability (with or without eating disorders), menstrual dysfunction (such as amenorrhea), and low bone density (such as osteoporosis). Energy availability is defined as dietary energy intake minus exercise energy expenditure.]

These sports typically include figure skating, gymnastics, and diving; classical ballet dancers are also at increased risk for the disorder.

Active women experience the general social and cultural demands placed on women to be thin, as well as pressure from their coach, teammates, judges, and/or spectators to meet weight standards or body-size expectations for their sport. Failure to meet these standards can result in severe consequences, such as being cut from the team or losing an athletic scholarship.

As the pressure to be thin mounts, active women may restrict their energy intake, typically by engaging in disordered eating behaviors. Energy restriction combined with high levels of physical activity can disrupt the menstrual cycle and result in amenorrhea. Menstrual dysfunction can also occur in active women who are not dieting and don't have an eating disorder. These women are just not eating enough to cover the energy costs of their exercise training and all the other energy demands of the body and daily living. Female athletes with menstrual dysfunction, regardless of the cause, typically have reduced levels of the reproductive hormones estrogen and progesterone.

[Sidebar: **female athlete triad** A syndrome that consists of three clinical conditions in some physically active females: low energy availability (with or without eating disorders), menstrual dysfunction, and low bone density.]

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When estrogen levels in the body are low, it is difficult for bone to retain calcium, and gradual loss of bone mass occurs. Thus, many female athletes develop premature bone loss (osteoporosis) and are at increased risk for fractures.

Recognition of an athlete with one or more of the components of the female athlete triad can be difficult, especially if the athlete is reluctant to be honest when questioned about her eating behaviors and symptoms. For this reason, familiarity with the early warning signs is critical. These include excessive dieting and/or weight loss, excessive exercise, stress fractures, and comments suggesting that self-esteem appears to be dictated by body weight and shape.

## **nutri-case LIZ**

"I used to dance with a really cool modern company, where everybody looked sort of healthy and 'real.' No waifs! When they folded after Christmas, I was really bummed, but this spring, I'm planning to audition for the City Ballet. My best friend dances with them, and she told me that they won't even look at anybody over 100 pounds. So I've just put myself on a strict diet. Most days, I come in under 1,200 Calories, though some days I cheat and then I feel so out of control. Last week, my dance teacher stopped me after class and asked me whether or not I was menstruating. I thought that was a pretty weird question, so I just said sure, but then when I thought about it, I realized that I've been so focused and stressed out lately that I really don't know! The audition is only a week away, so I'm going on a juice fast this weekend. I've just got to make it into the City Ballet!"

What factors increase Liz's risk for the female athlete triad? What, if anything, do you think Liz's dance teacher should do? Is intervention even necessary, since the audition is only a week away?

## **How are eating disorders treated?**

**LO 5** Discuss treatment for individuals with eating disorders.

As with any health problem, prevention is best: People with concerns about their body image and body weight need help before the issues develop into something more serious.

Patients who are severely underweight, display signs of malnutrition, are medically unstable, or are suicidal may require immediate hospitalization. The goals of nutritional therapies are to restore the individual to a healthy body weight and normal eating patterns, teach the individual to identify hunger and satiety cues, and resolve the nutrition-related health issues.39 For stable hospitalized patients, the expected weight gain ranges from 2 to 3 pounds per week. For outpatient settings, the expected weight gain is much lower (0.5 to 1 pound/week).

Nutrition counseling is an important aspect of inpatient treatment, especially to deal with the body image issues that occur as weight is regained. Once the patient reaches an acceptable body weight, nutrition counseling will address issues such as the acceptability of certain foods; dealing with food situations, such as family gatherings and eating out; and learning to put together a healthful food plan for weight maintenance.

Patients with an eating disorder who are underweight but medically stable, normal weight, or overweight may be able to enter an outpatient program designed to meet their specific needs. Some outpatient programs are extremely intensive, requiring patients to come in each day for treatment. Others are less rigorous, requiring only weekly visits for nutrition counseling to identify and manage events and feelings that trigger food restriction, binge eating, or purging. Another goal is to establish structured eating behaviors that can enable the patient to maintain a healthful body weight. In addition, nutrition counseling will address factors specific to the individual, such as negative feelings about foods or fears associated with uncontrolled binge eating.

If you're concerned about a friend's eating behaviors, raising the subject can be difficult. Before you do, learn as much as you can about eating disorders. Make sure you know the difference between the facts and myths. Locate a health professional specializing in eating disorders to whom you can refer your friend, and be ready to go with your friend if he or she does not want to go alone. If you are at a university or college, check with your campus health center to see if it has an eating disorder specialist or team or can recommend someone to you.

When it's time to talk, what exactly should you say? **The Quick** Tips on the next page are sensible steps you can take when discussing disordered eating with a friend.

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**Talking with a Loved One About Disordered Eating**

**Set aside a time and place to talk.** Find a private place where you can share your concerns openly and honestly in a caring and supportive way without distractions. Allow enough time--after classes or on the weekend is best.

**Share your observations.** Mention specific times when you felt concerned about your friend's behaviors related to body image, eating, purging, or excessive exercise. Tell your friend that you're mentioning these things because you believe they might indicate that he or she needs professional help.

**Avoid accusing and oversimplifying.** Do not accuse the person of poor behavior or offer simplistic solutions such as, "You just need to eat more." Instead, focus on communicating what you've observed and how it makes you feel. For example, "When you only eat an apple for lunch, I worry about your health."

**Ask your friend to consult the health care professional you've identified as knowledgeable about eating issues.** If you wish, offer to help your friend make an appointment. You could even offer to go with your friend to the appointment.

**Avoid arguments.** If your friend doesn't agree that there is any reason for concern, try repeating your key points, but don't insist on being right.

**Assure your friend that you care.**

Say that you're available to listen if he or she would like to talk about it in future.

**Consider your own needs.** Especially if your friend declines your help, consider meeting with a health care professional to share your concerns and get some support.

*Source:* Adapted from National Eating Disorders Association (NEDA). (2016, September). What Should I Say? www.nationaleatingdisorders.org]

**web links**

**www.bddfoundation.org**

Body Dysmorphic Disorder Foundation

*Visit this site to find information, assessment tools, and support.*

**www.nimh.nih.gov**

National Institute of Mental Health (NIMH) Office of Communications and Public Liaison

*Search this site for "disordered eating" or "eating disorders" to find numerous articles on the subject.*

**www.anad.org**

National Association of Anorexia Nervosa and Associated Disorders

*Visit this site for information and resources about eating disorders.*

**www.nationaleatingdisorders.org**

National Eating Disorders Association

*This site is dedicated to expanding public understanding of eating disorders and promoting access to treatment for those affected and support for their families.*

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**[test yourself**

**1.** **T F** Each year, about 1 million Americans are sickened as a result of eating food contaminated with germs or their toxins.

**2.** **T F** Freezing destroys any microorganisms that might be lurking in your food.

**3**. **T F** In the United States, the primary reason that crops are genetically modified is to increase their tolerance to weed killers.

*Test Yourself answers are located in the Study Plan at the end of this chapter.*]

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# **CHAPTER 12** **Food Safety and Technology Protecting our food**

***After studying this chapter, you should be able to:***

**1** Explain what foodborne illness is and why it is of concern, pp. 426-428.

**2** Identify the microorganisms and toxins responsible for most foodborne illness and the conditions that encourage them to multiply, pp. 429-434.

**3** Discuss strategies for preventing foodborne illness at home and while eating out, pp. 434-439.

**4** Compare and contrast the various methods manufacturers use to preserve foods, p. 440.

**5** Debate the safety of food additives, including the role of the GRAS list, pp. 441-442.

**6** Describe the processes, uses, benefits, and concerns of genetic modification of foods, pp. 443-445.

**7** Discuss the health concerns associated with food residues, and the key characteristics of organic foods, pp. 446-450.]

**In 2015, at least 600 people across the United States became seriously ill and dozens had to be hospitalized after eating at a Chipotle's restaurant.** In the weeks following the outbreaks, many food-safety failures were identified, including failing to maintain foods at the proper temperatures to discourage the growth of microbes, and failing to send employees home when they were sick. But astonishingly for a national restaurant chain that promised its customers "food with integrity," some Chipotle's managers also failed to insist on the most fundamental step in food safety: handwashing. Although alarms in the restaurants went off hourly to remind workers to wash their hands, the alarms were routinely ignored. Late in 2015, Chipotle's began implementing a massive new food-safety program. One of its initiatives? Managers must ensure that all employees wash their hands for at least 20 seconds, followed by using a hand sanitizer, at least once an hour.

In the food-illness outbreaks linked to Chipotle's, three different pathogenic (disease-causing) microorganisms (microscopic organisms) were involved: norovirus, which spread from workers to foods, surfaces, and customers; *E. coli,* a bacterium that may have colonized undercooked meats; and *Salmonella,* a bacterium that contaminated fresh produce. These are just 3 of the 31 microorganisms known to cause foodborne illness.1

How do pathogenic microorganisms enter foods and beverages, and how can we protect ourselves from them? What makes foods spoil, and what techniques help keep foods fresh longer? And do technologies like genetic modification or the use of pesticides also pose a risk? We explore these and other questions in this chapter.

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**LO 1** Explain what foodborne illness is and why it is of concern.

## **What is foodborne illness and why is it a critical concern?**

**Foodborne illness** is a term used to encompass any symptom or disorder that arises from ingesting food or water contaminated with pathogenic microorganisms, their toxic secretions, or pollutants like mercury and other industrial chemicals. It is commonly referred to as *food poisoning.*

**Ingestion of Contaminants Prompts Acute Illness**

The human immune system has evolved to handle most cases of foodborne illness effectively. Many foodborne contaminants are killed in the mouth by first-line defenses such as antimicrobial enzymes in saliva or hydrochloric acid in the stomach. Any that survive these chemical assaults usually trigger acute vomiting and/or diarrhea as the gastrointestinal tract attempts to expel them. Simultaneously, a defensive response by the white blood cells of the immune system causes nausea, fatigue, fever, and muscle aches.

The U.S. Centers for Disease Control and Prevention (CDC) estimates that, each year, about 48 million Americans--one in six--experience symptoms of foodborne illness.1 Most cases resolve within hours or days as vomiting and diarrhea rid the body of the offending agent and the immune response ends. However, depending on the status of one's health, the pathogen involved, and the "dose" ingested, symptoms can be severe. Each year, an estimated 128,000 Americans are hospitalized with foodborne illness, and 3,000 die.1 At highest risk for hospitalization or death are people with reduced immunity, including:

- Developing fetuses, infants, and young children, as their immune system is immature.

- People with compromised immunity, including pregnant women, the very old, the very ill, and people with acquired immunodeficiency syndrome (AIDS).

- People who are receiving immune system-suppressing drugs, such as transplant recipients and cancer patients.

**Reducing Foodborne Illness Is a Challenge**

Foodborne illness has emerged as a major public health threat in recent years. A key reason is that federal oversight of food safety reflects at least 30 different laws administered among 15 different agencies.2 One of the most important of these is the CDC, mentioned earlier, which monitors reports from state public health agencies for indications of outbreaks of foodborne illness and assists in investigating and controlling such outbreaks.

The two agencies primarily responsible for preventing foodborne illness are the Food Safety and Inspection Service (FSIS) of the United States Department of Agriculture (USDA) and the Food and Drug Administration (FDA). These agencies require certain food producers to follow a multistep protocol called the Hazard Analysis Critical Control Point (HACCP) system to identify biological, chemical, and other potential food-safety hazards and to control these hazards at each step from cultivation through processing to distribution and sales.3 Initially developed for NASA to prevent contamination of food sent on space flights, the HACCP is mandatory for producers of certain high-risk foods such as meats, fish, and juices, and encouraged for use by producers of other foods as well as by restaurants and other food retailers.

The Environmental Protection Agency (EPA) also plays a role in food safety by regulating the use of pesticides, water quality, and other environmental concerns. The roles of these agencies are identified in **TABLE 12.1.**

In 2009, President Barack Obama announced the creation of an interagency Food Safety Working Group to coordinate the food-safety efforts of these and other federal agencies; however, the group met for only two years.

[Sidebar: **foodborne illness** An illness transmitted by food or water contaminated by a pathogenic microorganism, its toxic secretions, or a toxic chemical.]

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**TABLE 12.1 Government Agencies That Regulate Food Safety**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 they can be applied to; establishes standards for water quality | www.epa.gov |

In 2015, the president proposed consolidating food-safety responsibilities into a new agency, but as of 2016, this consolidation has not yet been achieved.2

In January 2011, the U.S. Congress passed into law a new food-safety bill, the Food Safety Modernization Act. This bill provided for increased federal inspections of food-production facilities, new regulations to prevent contamination of foods, and more robust enforcement tools. It may be too soon to judge the effectiveness of these provisions; however, the most recent food-safety progress report from the CDC shows no change or an increase in foodborne illness incidents involving four of six major pathogens, and modest progress (22-32% decline) in incidents involving the remaining two.4

The CDC reports that contaminated seafood, chicken, and dairy are responsible for the greatest percentage of foodborne illness outbreaks.5 However, beef, pork, fresh fruits and vegetables, and even nuts and seeds are also commonly involved. Raw vegetables are a common source of illness: in 2016, 15 people in eight states were hospitalized and 1 died after consuming a packaged fresh salad mix contaminated with a bacterium called *Listeria monocytogenes.* Many mixed foods can be unsafe, especially when they include a combination of ingredients from a variety of fields, feedlots, and processing facilities. These various sources can remain hidden not only to consumers, but even to the food companies using the ingredients. Contamination can occur at any point from farm to table **(FIGURE 12.1)** (page 428), and thus is often difficult to trace.

Among outbreaks associated with a single known setting, restaurants are implicated in about 60% of cases, another 14% involve caterers or banquet facilities, and about 12% occur in homes.5 Later in this chapter we'll explore ways to reduce your risks.

**[recap**

Foodborne illness arises from the ingestion of food or water - contaminated with pathogenic microorganisms, their toxins, or environmental pollutants. It affects 48 million Americans a year, but because the human immune system has evolved effective defenses against it, most cases resolve quickly. Still, each year, about 128,000 Americans require hospitalization for foodborne illness, and about 3,000 die. Contamination can occur at any point from farm to table. Responsibilities for maintaining a safe food supply are currently shared among 15 different federal agencies. The Hazard Analysis Critical Control Point (HACCP) system is required by the FDA and USDA to identify potential food-safety hazards and the critical control points at which these hazards can be prevented. The Food Safety Modernization Act of 2011 increased the inspection and regulation of food production facilities; however, the most recent progress report from the CDC shows either no reduction or an increase in foodborne illness from four of six major pathogens tracked.]

[Image: Mixed foods can become contaminated with microbial pathogens at any point from the farm to the packaging center.]

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[**FIGURE 12.1** Food is at risk for contamination at any of the five stages from farm to table, but following food-safety guidelines can reduce the risks.]

**[Farms**

Animals raised for meat can harbor harmful microorganisms, and crops can be contaminated with pollutants from irrigation, runoff from streams, microorganisms or toxins in soil, or pesticides. Contamination can also occur during animal slaughter or from harvesting, sorting, washing, packing, and/or storage of crops.

↓

**Processing**

Some foods, such as produce, may go from the farm directly to the market, but most foods are processed. Processed foods may go through several steps at different facilities. At each site, people, equipment, or environments may contaminate foods. Federal safeguards, such as cleaning protocols, testing, and training, can help prevent contamination.

↓

**Transportation**

Foods must be transported in clean, refrigerated vehicles and containers to prevent multiplication of microorganisms and microbial toxins.

↓

**Retail**

Employees of food markets and restaurants may contaminate food during storage, preparation, or service. Conditions such as inadequate refrigeration or heating may promote multiplication of microorganisms or microbial toxins. Establishments must follow FDA guidelines for food safety and pass local health inspections.

**↓**

**Table**

Consumers may contaminate foods with unclean hands, utensils, or surfaces. They can allow the multiplication of microorganisms and microbial toxins by failing to follow the food-safety guidelines for storing, preparing, cooking, and serving foods discussed in this chapter.]

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**LO 2** Identify the microorganisms and toxins responsible for most foodborne illness and the conditions that encourage them to multiply.

## **What causes most foodborne illness?**

The consumption of food containing pathogenic microorganisms--those capable of causing disease--results in food infections. In contrast, food intoxications result from consuming food in which microorganisms have secreted harmful substances called **toxins.** Naturally occurring plant and marine toxins also contaminate food. Finally, chemical residues in foods, such as heavy metals, pesticides, and packaging residues, can cause illness. Residues are discussed later in this chapter.

**Several Types of Microorganisms Contaminate Foods**

The microorganisms that most commonly cause food infections are viruses and bacteria.

**Viruses Involved in Foodborne Illness**

**Viruses** are extremely tiny noncellular agents that can survive only by infecting living cells. Just one type, norovirus, causes an average of 19 to 21 million infections, well over 50,000 hospitalizations, and up to 800 deaths annually in the United States.6 In fact, norovirus is behind more than half of all cases of foodborne illness in the United States **(FIGURE 12.2).**1

Norovirus is so common and contagious that many people refer to it simply as "the stomach flu"; however, it is not a strain of influenza. Symptoms of infection typically come on suddenly and include stomach cramps as well as both vomiting and diarrhea. Because the vomiting begins abruptly, the person is likely to be in a social setting. Because it is forceful, anyone nearby is likely to become contaminated. Another characteristic that makes norovirus so contagious is that, whereas most viruses perish quickly in a dry environment, norovirus is able to survive on dry surfaces and objects, from countertops to utensils, for days or even weeks. Also, ingestion of even a few "particles" of norovirus can result in full-blown illness.6

Healthcare facilities, cruise ships, restaurants, catered events, and college campuses commonly report outbreaks. The best way to prevent the spread of norovirus is to wash your hands, kitchen surfaces, and utensils with warm, soapy water. Alcohol-based hand sanitizers may be used in addition to handwashing, but not as a substitute.6 If you experience vomiting or diarrhea, immediately clean and disinfect all nearby surfaces and remove and wash laundry thoroughly.

Whereas norovirus infects millions of Americans annually, hepatitis A virus (HAV) infects about 3,500.7 Like norovirus, HAV can be transmitted person-to-person or via contaminated food and water. The term *hepatitis* means inflammation of the liver. This causes jaundice (a yellowish skin tone), a common sign of HAV infection.7 Typically, the symptoms of HAV infection include a mild fever, abdominal pain, and nausea and vomiting that lasts a few weeks. Rarely, in elderly patients and those with preexisting liver disease, HAV infection can lead to liver failure and even death.

**Bacteria Involved in Foodborne Illness**

In contrast to viruses, **bacteria** are cellular microorganisms and are able to reproduce independently, either by dividing in two or by forming reproductive spores. Whereas our resident GI flora contribute to our health and functioning, pathogenic bacteria can cause mild to severe disease.

Foodborne bacterial illness commonly occurs when we ingest pathogenic bacteria living in or on undercooked or raw foods or fluids. These bacteria, which often come from human or animal feces, can damage our cells and tissues either directly or by secreting a destructive toxin. The species of bacteria causing the most illness, hospitalization, and/or death are identified in **TABLE 12.2.** Of these, *Salmonella* is the bacterium responsible for the greatest number of illnesses--nearly 2,600 in 2014. Moreover, of all pathogens, including norovirus, *Salmonella* causes the greatest number of hospitalizations and deaths **(FIGURE 12.3)** (page 430).1,8

**[FIGURE 12.2** Norovirus is responsible for more than half of all cases of foodborne illness in the United States. Infection typically produces a mild illness; however, because it affects so many people, it is the fourth leading cause of foodborne deaths.]

[To learn more about norovirus infection and how to protect yourself, watch a short video from the CDC at **www.cdc.gov/ norovirus/.**]

[Sidebar: **toxin** Any harmful substance; in microbiology, a harmful chemical secretion of a microorganism.]

[Sidebar: **viruses** A group of infectious agents that are much smaller than bacteria, lack independent metabolism, and are incapable of growth or reproduction outside of living cells.]

[Sidebar: **bacteria** Cellular microorganisms that lack a true nucleus and reproduce by cell division or by spore formation.]

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**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 | HeadacheDiarrheaNauseaAbdominal 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 crampsDiarrheaDehydration | 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 andsanitizing. |
| *Listeria**monocytogenes* | 1-42 days | Days to weeks | FeverMuscle aches Diarrhea Sometimes headache and confusion | Meats, especially hot dogs and deli meats VegetablesDairy 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 | NauseaDiarrheaAbdominal painChillsFeverHeadache | Raw or undercooked eggs, poultry, and meat Raw milk and dairy products SeafoodFruits 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 vomitingAbdominal cramps Diarrhea may occur | Custard- or cream-filledbaked goodsHamPoultryDressings, sauces, andgraviesEggsPotato 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/FoodbornelllnessContaminants/FoodbornelllnessesNeedToKnow/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.

*Listeria monocytogenes,* mentioned earlier, causes far fewer illnesses than *Salmonella*--just 55 in 2014. However, *Listeria* infections tend to be more severe. In 2014, over 90% of infections required hospitalization, and nearly 24% resulted in death.8 Infection is particularly severe in older adults and pregnant women. These populations are advised to avoid soft cheeses or other foods or beverages made with unpasteurized milk, hot dogs and deli meats unless served steaming hot, and refrigerated smoked seafood, because these foods are more likely to harbor *Listeria.* They should also wash their hands, kitchen surfaces, and foods thoroughly as described shortly.

**Other Microorganisms Involved in Foodborne Illness**

**Parasites** are microorganisms that simultaneously derive benefit from and harm their host. They are responsible for only about 2% of foodborne illnesses. The most common culprits are helminths and protozoa:

**- Helminths** are multicellular worms, such as tapeworms **(FIGURE 12.4),** flukes, and roundworms. They reproduce by releasing their eggs into vegetation or water. When animals consume the contaminated matter, the eggs hatch inside their host. Larvae develop in the host's tissue, where they can survive long after the animal is killed for food. People who eat the food either raw or undercooked consume the larvae, which then mature into adult worms in their small intestine.

**[FIGURE 12.3** *Salmonella* is the second leading cause of foodborne illness, after norovirus, and the primary cause of foodborne infections requiring hospitalization or resulting in death. Infection can cause fever, diarrhea, and abdominal cramps, and cells of some strains can perforate the intestines and invade the blood.]

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Some worms cause mild symptoms, such as nausea and diarrhea, whereas others can cause intestinal obstruction or even death. Thoroughly cooking beef, pork, or fish destroys the larvae.

**- Protozoa** are single-celled organisms. One of these, *Toxoplasma gondii,* is one of the top five pathogens responsible for hospitalizations and deaths due to foodborne illness.1 People typically become infected by eating undercooked, contaminated meat, or by ingesting minute amounts after handling raw meat and then failing to wash their hands.9 Another protozoan parasite common worldwide is *Giardia,* which lives in the intestines of infected animals and humans and is passed into the environment from their stools. People typically consume *Giardia* by swallowing contaminated water (in lakes, rivers, and so on) or by eating contaminated food. A week or more following ingestion, the person experiences a diarrheal illness, which usually resolves within 2 to 6 weeks.10

**Fungi** are plantlike, spore-forming organisms that can grow as either single cells or multicellular colonies. Three common types are yeasts, which are globular; molds, which are long and thin; and the familiar mushrooms. Very few species of fungi cause serious disease in people with healthy immune systems, and those that do cause disease in humans are not typically foodborne. In addition, unlike bacterial growth, which is invisible and often tasteless, fungal growth typically makes food look and taste so unappealing that we immediately discard it **(FIGURE 12.5).**

A rare but fatal neurological disease called *variant Creutzfeldt-Jakob disease (vCJD)* can occur in people who consume beef or other meat contaminated by **prions,** animal proteins that misfold and become infectious. Over many years, prions destroy normal proteins until the loss of functional nerve tissue progresses to cause neurological disease and eventually death. More than 200 people have died from vCJD, the great majority in Europe before new standards were adopted for animal feeding and surveillance. In the United States, three people have died from vCJD.11

**Some Foodborne Illness Is Due to Toxins**

The microorganisms just discussed cause illness by directly infecting and destroying body cells. In contrast, other bacteria and fungi secrete toxins that bind to body cells and cause a variety of symptoms. Toxins can be categorized according to the type of cell they bind to; neurotoxins damage the nervous system and can cause paralysis, and enterotoxins target the gastrointestinal system and generally cause severe diarrhea and vomiting.

**[FIGURE 12.4** Tapeworms have long bodies with hooks and suckers, which they use to attach to a host's tissue.]

[Sidebar: **parasite** A microorganism that simultaneously derives benefit from and harms its host.]

[Sidebar: **helminth** A multicellular microscopic worm.]

[Sidebar: **protozoa** Single-celled, mobile parasites.]

[Sidebar: **fungi** Plantlike, spore-forming organisms that have a true nucleus and can grow as either single cells or multicellular colonies.]

[Sidebar: **prion** A protein that misfolds and becomes infectious and destructive; prions are not living cellular organisms or viruses.]

**[FIGURE 12.5** Molds rarely cause foodborne illness, in part because they look so unappealing that we throw the food away.]

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[**FIGURE 12.6** Some mushrooms, such as this fly agaric, contain fungal toxins that can cause illness or even death.]

**Bacterial Toxins**

One of the most common foodborne toxins is produced by the bacterium *Staphylococcus aureus* (see Table 12.2). Although the vomiting it typically provokes is severe, it tends to resolve quickly. In contrast, the neurotoxin produced by the bacterium *Clostridium botulinum* is deadly. This botulism toxin blocks nerve transmission to muscle cells, paralyzing the muscles, including those required for breathing. A common source of contamination is food from a damaged (split, pierced, or bulging) can. If you spot damaged canned goods while shopping, notify the store manager. If you inadvertently purchase food in a damaged can or find that the container spurts liquid when you open it, wash your hands, put on gloves, wrap the can in a sealed plastic bag, and throw it in the trash. Then clean all surfaces with a diluted bleach solution. *Never taste the food, as even a microscopic amount of botulism toxin can be fatal.*12 Other common sources of *C. botulinum* are foods improperly canned at home, raw honey, oils infused with garlic or herbs, and potatoes baked in foil.

Some strains of *E.* *coli,* including those involved in the outbreaks mentioned at Chipotle's, produce an enterotoxin toxin called *Shiga toxin.* These types are referred to as *Shiga toxin-producing E. coli,* or STEC. The most common STEC is E. *coli* 0157. STECs are likely to require hospitalization because infection can result in bloody diarrhea and kidney failure. In vulnerable populations they can be fatal.1,8

Eating spoiled fish--commonly tuna or mackerel--is unwise because the bacteria responsible for the spoilage release toxins into the fish. The result is *scombrotoxic fish poisoning,* which causes headache, vomiting, a rash, sweating, and flushing within a few minutes to 2 hours after consumption. Symptoms usually resolve within a few hours in healthy people.13

**Fungal Toxins**

Some fungi produce poisonous chemicals called *mycotoxins.* (The prefix *myco-* means "fungus.") These toxins are typically found in grains stored in moist environments. In some instances, moist conditions in the field encourage fungi to reproduce and release their toxins on the surface of growing crops. Long-term consumption of mycotoxins can cause organ damage or cancer.

A highly visible fungus that causes food intoxication is the poisonous mushroom. Most mushrooms are not toxic, but a few, such as the deathcap mushroom *(Amanita phalloides)*, can be fatal. Some poisonous mushrooms are quite colorful **(FIGURE 12.6),** a fact that helps explain why the victims of mushroom poisoning are often children.14

**Toxic Algae**

You may have seen signs warning of a "red tide" along a stretch of coastline. Shellfish beds are closed during a red tide to protect the public from a foodborne illness called *paralytic shellfish poisoning* (PSP).13 Red tides are caused by the excessive production of certain species of toxic algae, whose bloom turns ocean waters purple, pink, or red. Mussels, clams, and other shellfish consume the toxic algae. When people consume the affected seafood--which typically looks, smells, and tastes normal--PSP results. Symptoms, which typically arise within an hour, range from numbness and tingling to paralysis and respiratory failure.13

*Ciguatoxins* are marine toxins commonly found in large finfish from tropical regions, including grouper, sea bass, and snapper. Symptoms of ciguatoxin poisoning include nausea, vomiting, diarrhea, itching, and blurred vision, but typically resolve within days to several weeks.13

**Plant Toxins**

A variety of plants contain toxins that, if consumed, can cause illness. As humans evolved, we learned to avoid such plants. However, one plant toxin is still commonly found in kitchens. Potatoes that have turned green contain the toxin *solanine,* which forms, along with the harmless green pigment chlorophyll, when the potatoes are exposed to light.

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Solanine is very toxic even in small amounts, and potatoes that appear green beneath the skin should be thrown away. Toxicity causes vomiting, diarrhea, fever, headache, and other symptoms and can progress to shock. Rarely, the poisoning can be fatal.15

You can avoid the greening of potatoes by storing them for only short periods in a dark cupboard or brown paper bag in a cool area. Wash the potato to expose its color, and throw it away if it has turned green.

**Certain Conditions Help Microorganisms Multiply in Foods**

Given the correct environmental conditions, microorganisms can thrive in many types of food. Four factors affect the survival and reproduction of food microorganisms:

*-* *Temperature.* Many microorganisms capable of causing human illness thrive at warm temperatures, from about 40°F to 140°F (4°C to 60°C). You can think of this range of temperatures as the **danger zone (FIGURE 12.7).** These microorganisms can be destroyed by thoroughly heating or cooking foods, and their reproduction can be slowed by refrigeration and freezing. Safe cooking and food-storage temperatures are identified later in this chapter.

*-* *Humidity.* Many microorganisms require a high level of moisture; thus, foods such as boxed dried pasta do not make suitable microbial homes, although cooked pasta left at room temperature would prove hospitable.

*-* *Acidity.* Most microorganisms have a preferred pH range in which they thrive. Pathogenic bacteria prefer a pH range from slightly acidic to neutral--about 4.6 to 7.0. However, there are exceptions. *Clostridium botulinum,* for example, thrives in alkaline environments, such as fish and most vegetables.

*-* *Oxygen content.* Many microorganisms require oxygen to function; thus, food-preservation techniques that remove oxygen, such as industrial canning and bottling, keep foods safe for consumption. In contrast, C. *botulinum* thrives in an oxygen-free environment. For this reason, the canning process heats foods to a temperature high enough to destroy this deadly microorganism.

In addition, microorganisms need an entryway into a food. Just as skin protects the body from microbial invasion, the peels, rinds, and shells of many foods seal off access to the nutrients within. Eggshells are a good example of a natural food barrier. Once such a barrier is pierced or removed, however, the food loses its primary defense against contamination. Slicing through an unwashed melon, for example, can contaminate the edible interior.

## **Nutri-case THEO**

"I got really sick yesterday after eating lunch in the cafeteria. I had a turkey sandwich, potato salad, and a cola. A few hours later, in the middle of basketball practice, I started to shake and sweat. I felt really nauseated and barely made it to the bathroom before vomiting. Then I went back to my dorm room and crawled into bed. This morning I still feel a little sick to my stomach, and sort of weak. I asked a couple of my friends who ate in the cafeteria yesterday if they got sick, and neither of them did, but I still think it was the food. I'm going off-campus for lunch from now on!"

Do you think that Theo's illness was foodborne? If so, what food(s) do you most suspect? What do you think of his plan to go off-campus for lunch from now on?

**[FIGURE 12.7** The danger zone is a temperature range within which many pathogenic microorganisms thrive. Notice that "room temperature" (about 68°F) is within the danger zone!]

[Sidebar: **danger zone** The range of temperature (about 40°F to 140°F, or 4°C to 60°C) at which many microorganisms capable of causing human disease thrive.]

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Food infections result from the consumption of food containing living microorganisms, such as bacteria, whereas food intoxications result from consuming food containing toxins. The top cause of foodborne illness is norovirus. Second in line is the bacterium *Salmonella,* which is also responsible for the greatest number of hospitalizations and deaths. The parasite *Toxoplasma gondii* is one of the top five pathogens responsible for hospitalizations and deaths due to foodborne illness. Prions are self-replicating particles that can contaminate and destroy nerve tissue. *Clostridium botulinum,* "STEC" species of *E. coli,* and other bacteria can produce toxins capable of causing severe illness and even death. Mushrooms, seafood, and potatoes may also contain toxins. In order to reproduce in foods, microorganisms require a precise range of temperature, humidity, acidity, and oxygen content.]

**LO 3** Discuss strategies for preventing foodborne illness at home and while eating out.

## **How can you prevent foodborne illness?**

The U.S. Department of Health and Human Services' Foodsafety.gov is the nation's gateway to federal food-safety information. Foodsafety.gov identifies four basic rules for food safety **(FIGURE 12.8).**

**Clean: Wash Your Hands and Kitchen Surfaces Often**

One of the easiest and most effective ways to prevent foodborne illness is to consistently wash your hands before and after handling food. Most college students believe they know how to wash their hands, but a recent study discovered that they don't! After washing their hands, 58% of students participating in the study still had colonies of microorganisms--some pathogenic--populating their hands!16

What's the right way to wash? Remove any rings or bracelets before you begin, because jewelry can harbor bacteria. Scrub for at least 20 seconds with a mild soap, being sure to wash underneath your fingernails and between your fingers. Rinse under warm, running water. Although you should wash dishes in hot water, it's too harsh for handwashing: It causes the surface layer of the skin to break down, increasing the risk that microorganisms will be able to penetrate your skin. Dry your hands on a clean towel or fresh paper towel.

Thoroughly wash utensils, containers, and cutting boards with soap and hot water, either in a dishwasher, or by hand, wearing gloves. You can sanitize cutting boards with a solution of 1 tablespoon of chlorine bleach to 1 gallon of water. Flood the surface with the bleach solution and allow it to air dry. Also wash countertops with soap and hot water.

Wash fruits and vegetables thoroughly under running water just before eating, cutting, or cooking them. Prewashed and bagged salad greens clearly marked as ready-to-eat do not need to be washed again. Washing fruits and vegetables with soap or detergent, or using commercial produce washes, is not recommended. Also, do not wash meat, poultry, or fish, as doing so can spread contaminants. Microorganisms in these foods will be destroyed when you thoroughly cook them.17

**Separate: Don't Cross-Contaminate**

**Cross-contamination** is the spread of microorganisms from one food to another. This commonly occurs when raw foods, such as chicken and vegetables, are cut using the same knife or cutting board, or stored or carried to the table on the same plate.18 Invest in a set of cutting boards of different colors, and reserve one for fresh breads, one for produce, and one for meat, fish, and poultry.

[To learn "Clean" tips for preventing foodborne illness, watch a video at **www.foodsafety.gov.** From the home page, click on the "Clean" logo to find it.]

**[FIGURE 12.8** This food-safety logo from Foodsafety.gov can help you remember the four steps for reducing your risk of foodborne illness.]

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In the refrigerator, keep raw meat, poultry, eggs, and seafood and their juices away from ready-to-eat food. Keep them wrapped in plastic on the lowest shelf of your refrigerator.

When preparing meals with a marinade, reserve some of the fresh marinade in a clean container; then add the raw ingredients to the remainder. In this way, some uncontaminated marinade will be available if needed later in the cooking process. While marinating raw food, keep it in the refrigerator.18

Prevent cross-contamination while food shopping. Keep raw meat, poultry, and seafood away from other foods in your cart, and make sure they're wrapped in plastic at the checkout, so their juices won't contaminate other foods. Inspect eggs before putting them in your cart. If a carton has a broken egg, bring it to the store manager. Also, watch out for unsafe practices in the store. For example, the displaying of food products such as cooked shrimp on the same bed of ice as raw seafood is not safe, nor is slicing cold cuts with the same knife used to trim raw meat. Report such practices to your local health authorities.

**Chill: Store Foods in the Refrigerator or Freezer**

The third rule for keeping food safe from bacteria is to promptly refrigerate or freeze it. Remember the danger zone: microorganisms that cause foodborne illness can reproduce in temperatures above 40°F. To keep them from multiplying in your food, keep it cold. Refrigeration (between 32°F and 40°F) and freezing (at or below 0°F)19 do not kill all microorganisms, but cold temperatures diminish their ability to reproduce in quantities large enough to cause illness. Also, many naturally occurring enzymes that cause food spoilage are deactivated at cold temperatures.

**Shopping for Perishable Foods**

When choosing perishable foods, check the "sell by" or "best used by" date on the label. The "sell by" date indicates the last day a product can be sold and still maintain its quality during normal home storage and consumption. The "best used by" date tells you how long a product will maintain best flavor and quality before eating.20 The "use by" date indicates the last day recommended to consume the food. No matter the type, if the stamped date has passed, don't purchase the item and notify the store manager. These foods should be promptly removed from the shelves.

When shopping for food, purchase refrigerated and frozen foods last. After you check out, get perishable foods home and into the refrigerator or freezer within 1 hour. If your trip home will be longer than an hour, take along a cooler to transport them.

**Refrigerating Foods at Home**

As soon as you get home from shopping, put meats, eggs, cheeses, milk, and any other perishable foods in the refrigerator. Store meat, poultry, and seafood in the back of the refrigerator away from the door, so that they stay cold, and on the lowest shelf, so that their juices do not drip onto any other foods. If you are not going to use raw poultry, fish, or ground beef within 2 days of purchase, store it in the freezer. A guide for refrigerating foods is provided in **FIGURE 12**.9 on page 436.

After a meal, refrigerate leftovers promptly--even if still hot--to discourage microbial growth. The standard rule is to refrigerate leftovers within 2 hours of serving. If the ambient temperature is 90°F or higher, such as at a picnic, foods should be refrigerated within 1 hour.19 A larger quantity of food takes longer to cool, so divide and conquer: separate leftovers into shallow containers for quicker cooling.19 Finally, avoid keeping leftovers for more than a few days (see Figure 12.9). If you don't plan to finish a dish within the recommended time frame, freeze it.

[Image: The "sell by" date tells the store how long to display the product for sale.]

[Sidebar: **cross-contamination** Contamination of one food by another via the unintended transfer of microorganisms through physical contact.]

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[**FIGURE 12.9** While it's important to keep a well-stocked refrigerator, it's also important to know how long foods will keep.

*Source*: Data from U.S. Department of Agriculture, Food Safety and Inspection Service. 2015, March. Food safety information. Refrigeration and food safety. www.fsis.usda.gov.]

|  |  |
| --- | --- |
| **Food** | **Keeps for...** |
| Uncooked hamburger | 1-2 days |
| Uncooked roasts, steaks, and chops | 3-5 days |
| Uncooked poultry | 1-2 days |
| Uncooked fish | 1-2 days |
| Cooked meats, poultry, and fish | 3-4 days |
| Fresh eggs in shell | 3-5 weeks |
| Hardboiled eggs | 1 week |
| Egg, chicken, tuna, ham, and pasta salads | 3-5 days |
| Soups or stews | 3-4 days |
| Hot dogs and luncheon meats, unopened package | 2 weeks |
| Hot dogs, opened package | 1 week |
| Luncheon meats, opened package | 3-5 days |

Leftovers are great for lunch the next day, of course, but how do you keep them safe if you pack a lunch at 8 AM and eat it on campus or at work several hours later? Find food-safety strategies for packed lunches in the **Quick Tips** feature on this page.

**Freezing and Thawing Foods**

The temperature in your freezer should be set at or below 0°F. Use a thermometer and check it periodically. If your electricity goes out, avoid opening the freezer until the power is restored. When the power does come back on, check the temperature. If it is at or below 40°F, or if the food contains ice crystals, the food should still be safe to eat, or refreeze.21

As with refrigeration, smaller packages will freeze more quickly. Rather than attempting to freeze an entire casserole, divide the food into multiple, small portions in freezer-safe containers; then freeze.

**Quick Tips**

**[Packing a Food-Safe Lunch**

**Insulate**. Invest in an insulated lunch box or soft-sided case.

**Keep it cold.** When packing meat or any other perishable, include a freezer pack as well as another ice source. A frozen juice box or small bottle of water works well, and should make a refreshing drink by lunchtime.

**Pack it hot.** For leftovers, soups, and other hot foods, use a thermos: Fill it with boiling water. Let it stand while you heat the food until it's piping hot. When it's ready, drain the water and fill the thermos.

**Wash and** **wipe.** When it's time for lunch, wash your hands before eating. Pack disposable wipes and, once you've finished eating, discard used food wraps and wipe out the lunch box--as well as your hands. At home, wash reusable containers, thermos, utensils, and the lunch box with hot water and soap.

*Source:* Data from FoodSafety.gov. Back to School.

www.foodsafety.gov/keep/events/backtoschool/]

[Image: Freeze a 100% juice box overnight, then tuck it into your packed lunch with your perishable foods. By noontime, you'll have a cold, nutritious drink--and a safer lunch.]

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Sufficient thawing will ensure adequate cooking throughout, which is essential to preventing foodborne illness. The safest way to thaw meat, poultry, and seafood is to place the frozen package on the bottom shelf of the refrigerator, on a large plate or in a large bowl to catch its juices. It should be ready to cook within 24 hours. Never thaw frozen meat, poultry, or seafood on a kitchen counter or in a basin of warm water. Room temperatures allow the growth of bacteria on the surface of food. You can also thaw foods in your microwave, following the manufacturer's instructions. Another option is to cook the food without first thawing it. Just allow for a cooking time about 50% longer than usual.19

**Dealing with Molds in Refrigerated Foods**

Some molds like cool temperatures. Mold spores are common in the atmosphere, and they randomly land on food in open containers. If the temperature and acidity of the food are hospitable, they will grow.

If the surface of a small portion of a firm, solid food, such as hard cheese, becomes moldy, it is generally safe to cut off that section down to about an inch and eat the unspoiled portion. However, if soft cheese, sour cream, tomato sauce, a leftover casserole, or another soft or fluid product becomes moldy, discard it entirely, as foods with a high moisture content may be contaminated below the surface.22

**Cook: Heat Foods Thoroughly**

Thoroughly cooking food is a sure way to kill the intestinal worms discussed earlier and many other microorganisms. Color and texture are unreliable indicators of safety. Use a food thermometer to ensure that you have cooked food to a safe minimum internal temperature to destroy any harmful bacteria. The minimum temperatures vary for the type of food:23

- Beef, pork, veal, lamb steaks, roasts, and chops: 145°F with a 3-minute rest time before serving

- Fish: 145°F

- Ground beef: 160°F

- Egg dishes: 160°F

- Poultry, whole, pieces, and ground: 165°F

Place the thermometer in the thickest part of the food, away from bone, fat, or gristle.

It's end of term and you're planning a lakeside barbecue! To keep it food-safe, check out the **Quick Tips** on transporting, cooking, and serving grilled and cold foods on page 438.

Microwave cooking is convenient, but you need to be sure your food is thoroughly and evenly cooked and that there are no cold spots in the food where bacteria can thrive. For best results, cover food, stir often, and rotate for even cooking. Raw and semi-raw (such as marinated or partly cooked) fish delicacies, including sushi and sashimi, may be tempting, but their safety cannot be guaranteed. Always cook fish thoroughly. When done, fish should be opaque and flake easily with a fork. If you're wondering how sushi restaurants can guarantee the safety of their food, the short answer is they can't. All fish to be used for sushi must be frozen using a method that effectively kills any parasites that are in the fish, but it does not necessarily kill bacteria or viruses. Another myth is that hot sauce can kill microbes in raw foods. It can't.

You may have fond memories of licking cake or brownie batter off a spoon when you were a kid, but such practices are no longer considered safe. That's because most cake batter contains raw eggs, one of the most common sources of *Salmonella.* Cook eggs until they are firm.

**Protect Yourself from Toxins in Foods**

Killing microorganisms with heat is an important step in keeping food safe, but it won't protect you from their toxins.

[To learn how to use a food thermometer, watch the video at **www.foodsafety.gov.** From the home page, click on the "Cook" logo to find it.]

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**[Staying Food-Safe at a Barbecue**

**Keep foods cold--and separate--during transport.** Use small coolers with ice or frozen gel packs to keep food at or below 40°F. Put beverages in one cooler, washed fruits and vegetables and containers of potato salad in another, and wrapped, frozen meat, poultry, and seafood in another. Keep coolers in an air-conditioned part of your car.

**Wash your hands, utensils, and food-preparation surfaces.**

Take along a water jug, some soap, and paper towels or a box of moist, disposable towelettes. Keep all utensils and platters clean when preparing foods.

**Grill foods thoroughly.** Use a food thermometer. Burgers should reach 160°F and chicken at least 165°F.

**Avoid contaminating cooked foods.** When taking food from the grill to the table, never use the same platter or utensils that previously held raw meat or seafood.

**Keep grilled food hot.** Move it to the side of the grill, just away from the coals, so that it stays at or above 140°F. If grilled food isn't going to be eaten right away, wrap it well and place it in an insulated container.

**Keep perishable foods on ice.**

Drain off water as the ice melts and replace the ice frequently. Don't let any perishable food sit out longer than 2 hours. In temperatures above 90°F, that drops to 1 hour.

*Source:* Data from U.S. Food and Drug Administration. 2015, November 20. Barbecue basics: Tips to prevent foodborne illness. http://www.fda.gov/forconsumers/ucm094562.htm]

That's because many toxins are unaffected by heat and are capable of causing severe illness even when the microorganisms that produced them have been destroyed.

For example, let's say you prepare a casserole for a team picnic. Too bad you forget to wash your hands before serving it to your teammates, because you contaminate the casserole with the bacterium *Staphylococcus aureus,* which is commonly found on skin. You and your friends go off and play soccer, leaving the food in the sun, and a few hours later you take the rest of the casserole home. At supper, you heat the leftovers thoroughly, thinking that this will kill any bacteria that multiplied while it was left out. That night you experience nausea, severe vomiting, and abdominal pain. What happened? While your food was left out, *Staphylococcus* multiplied in the casserole and produced a toxin **(FIGURE 12.10).** When you reheated the food, you killed the microorganisms, but their toxin was unaffected. When you then ate the food, the toxin made you sick.

**Be Choosy When Eating Out--Close to Home or Far Away**

When choosing a place to eat out, avoid restaurants that don't look clean. Grimy tabletops and dirty restrooms indicate indifference to hygiene. Pay attention to the food service workers, too. If they appear to be ill, or their hands don't look clean, or they're handling both raw and ready-to-eat foods, go elsewhere. Although public health inspectors randomly visit and inspect the food-preparation areas of all businesses that serve food, these inspections don't guarantee safety the day of your visit.

Another way to protect yourself when dining out is by ordering foods to be cooked thoroughly. If you order a hamburger and it arrives pink in the middle, or scrambled eggs and they arrive runny, send the food back.

[Image: At a barbecue, it's essential to heat foods to the proper temperature.]

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[**1** Cooked food is contaminated with bacteria, *Staphylococcus aureus,* when served by a person with unwashed hands.

**2** Food is left unrefrigerated.

**3** Bacteria multiply in unrefrigerated food and produce a toxin.

**4** Later, leftover food is reheated. Reheating destroys bacteria but not the toxin.

**5** Reheated food is eaten.

**6** After 1-6 hours, nausea, vomiting, and stomach pain occur.]

**[FIGURE 12.10** Food contamination can occur long after the microorganism itself has been destroyed.]

If you order potato, egg, tuna, or chicken salad or a dish with a cream sauce, and it arrives looking somewhat congealed or simply less than fresh, it may have been left out too long. Send it back.

When planning a trip, tell your physician your travel plans and ask about vaccinations you need or any medications you should take along in case you get sick. Pack a waterless antibacterial hand cleanser and use it frequently. When dining, choose cooked foods and bottled and canned beverages or tea or coffee made with boiling water (see Chapter 3). All raw food has the potential for contamination.

**[recap**

Foodborne illness can be prevented at home by following four tips: **(1)** Clean: wash your hands and kitchen surfaces often. **(2)** Separate: isolate foods to prevent cross-contamination. **(3)** Chill: store foods in the refrigerator or freezer. **(4)** Cook: heat foods long enough and at the correct temperatures to ensure proper cooking. When eating out, avoid restaurants with areas that don't look clean or workers who appear ill or indifferent to hygiene, and ask that all food be cooked thoroughly.]

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**LO 4** Compare and contrast the various methods manufacturers use to preserve foods.

## **How is food spoilage prevented?**

Any food that has been harvested and that people aren't ready to eat must be preserved in some way or, before long, it will degrade enzymatically and become home to a variety of microorganisms. Even processed foods--foods that are manipulated mechanically or chemically--have the potential to spoil.

The most ancient methods of preserving foods are salting, sugaring, drying, and smoking, all of which draw the water out of plant or animal cells. By dehydrating the food, these methods make it inhospitable to microorganisms and dramatically slow the action of enzymes that would otherwise degrade the food. We still use many of these methods today to preserve and prepare foods and meats, such as salted or smoked fish ham.

Natural methods of cooling have also been used for centuries, including storing foods in underground cellars, caves, running streams, and even "cold pantries"-- north-facing rooms of the house that were kept dark and unheated, often stocked with ice. The forerunner of the modern refrigerator--the miniature icehouse, or icebox-- was developed in the early 1800s, and in cities and towns a local iceman would make rounds delivering ice to homes.

More recently, technological advances have helped food producers preserve the integrity of their products for months and even years between harvesting and consumption. These include the addition of preservatives such as vitamins C and E, as well as the following:

*-* *Canning.* Developed in the late 1700s, canning involves washing and blanching food, placing it in cans, siphoning out the air, sealing the cans, and then heating them to a very high temperature. Canned food has an average shelf life of at least 2 years from the date of purchase.

*-* *Pasteurization.* The technique called **pasteurization** exposes a beverage or other food to heat high enough to destroy microorganisms, but for a short enough period of time that the taste and quality of the food are not affected. For example, in flash pasteurization, milk or other liquids are heated to 162°F (72 °C) for

15 seconds.

*-* *Aseptic packaging.* You probably know aseptic packaging best as "juice boxes." Food and beverages are first heated, then cooled, then placed in sterile containers. The process uses less energy and materials than traditional canning, and the average shelf life is about 6 months.

*-* *Modified atmosphere packaging.* In this process, the oxygen in a package of food is replaced with an inert gas, such as nitrogen or carbon dioxide. This prevents a number of chemical reactions that spoil food, and it slows the growth of bacteria that require oxygen. The process can be used with a variety of foods, including meats, fish, vegetables, and fruits.

*-* *High-pressure processing.* In this technique, the food to be preserved is subjected to an extremely high pressure, which inactivates most bacteria while retaining the food's quality and freshness.

*-* *Irradiation.* This process exposes foods to gamma rays from radioactive metals. Energy from the rays penetrates food and its packaging, killing or disabling microorganisms in the food. The process does not cause foods to become radioactive! A few nutrients, including thiamin and vitamins A, E, and K, are lost, but these losses are also incurred in conventional processing and preparation. Although irradiated food has been shown to be safe, the FDA requires that all irradiated foods be labeled with a Radura symbol and a caution against irradiating the food again **(FIGURE 12.11).**

**[recap**

Salting, sugaring, drying, smoking, and cooling have been used for centuries to preserve food. Preservatives such as vitamin C and E may be added to foods produced today. In addition, canning, pasteurization, irradiation, and several packaging techniques are used to preserve a variety of foods during shipping, as well as on grocer and consumer shelves.

Before the modern refrigerator, an iceman would deliver ice to homes and businesses.]

**[FIGURE 12.11** The U.S. Food and Drug Administration requires the Radura--the international symbol of irradiated food--to be displayed on all irradiated food sold in the United States.]

[Sidebar: **pasteurization** A form of sterilization using high temperatures for short periods of time.]

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**LO 5** Debate the safety of food additives, including the role of the GRAS list.

## **What are food additives, and are they safe?**

Have you ever picked up a loaf of bread and started reading its ingredients? You'd expect to see flour, yeast, water, and some sugar, but what are all those other items? They are collectively called *food additives,* and they are in almost every processed food. Food additives are not foods in themselves but, rather, natural or synthetic chemicals added to foods to enhance them in some way. More than 3,000 different food additives are currently used in the United States. **TABLE 12.3** identifies only a few of the most common.

**Food Additives Include Nutrients and Preservatives**

Vitamins and minerals are added to foods as nutrients and as preservatives. As just noted, vitamin E is usually added to fat-based products to keep them from going rancid, and vitamin C is used as an antioxidant in many foods.

**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 |

[Sidebar: **food additive** A substance or mixture of substances intentionally put into food to enhance its appearance, safety, palatability, and quality.]

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Iodine is added to table salt to help decrease the incidence of goiter and birth defects related to iodine deficiency. Vitamin D is added to milk, and calcium is added to milk alternatives and some juices to help preserve healthy bone. Folate is added to cereals, breads, and other foods to help prevent birth defects, and many cereals and breads are also fortified with iron. The following two preservatives have raised health concerns:

*-* *Sulfites.* A small segment of the population is sensitive to sulfites, preservatives used in many beers and wines and sometimes on grapes and other fresh foods. Consuming sulfites can prompt asthma, headaches, or other symptoms in sensitive people.

*-* *Nitrites.* Commonly used to preserve processed meats, nitrites can be converted to nitrosamines during the cooking process. Nitrosamines have been found to be carcinogenic in animals, so the FDA has required all foods with nitrites to contain additional antioxidants to decrease the formation of nitrosamines.

**Other Food Additives Include Flavorings, Colorings, and Texturizers**

Flavoring agents are used to replace the natural flavors lost during food processing. In contrast, *flavor enhancers* have little or no flavor of their own but accentuate the natural flavor of foods. One of the most common flavor enhancers is monosodium glutamate (MSG). In some people, MSG causes symptoms such as headaches, difficulty breathing, and heart palpitations.

Common food *colorings* include beet extract, which imparts a red color; beta-carotene, which gives a yellow color; and caramel, which adds brown color. The coloring tartrazine (FD&C Yellow #5) causes an allergic reaction in some people, and its use must be indicated on the product packaging.

*Texturizers* are added to foods to improve their texture. *Emulsifiers* help keep fats evenly dispersed within foods. *Stabilizers* give foods "body" and help them maintain a desired texture or color. *Humectants* keep foods such as marshmallows, chewing gum, and shredded coconut moist and stretchy. *Desiccants* prevent the absorption of moisture from the air; for example, they are used to prevent table salt from forming clumps.24

## **Are Food Additives Safe?**

Federal legislation was passed in 1958 to regulate food additives. Before a new additive can be used in food, the producer of the additive must submit data to the FDA demonstrating its safety. The FDA then determines the additive's safety based on these data. Also in 1958, the U.S. Congress recognized that many substances added to foods do not require stringent testing, as their safety has been established through long-term use or has been recognized by qualified experts through scientific studies. These additives are referred to as **Generally Recognized as Safe (GRAS).** The GRAS list identifies substances that either have been tested and determined by the FDA to be safe and approved for use in the food industry, or are deemed safe as a result of consensus among experts.

In 1985, the FDA established the Adverse Reaction Monitoring System (ARMS). Under this system, the FDA investigates complaints from consumers, physicians, and food companies about food additives.

The GRAS list is not static; in 2015, for example, the FDA determined that partially hydrogenated oils (PHOs), the main source of *trans* fatty acids in the U.S. diet, are no longer GRAS. Food companies were given until June 2018 to comply, after which time they will no longer be allowed to produce foods containing PHOs.

**[recap**

Food additives are chemicals intentionally added to foods to enhance their color, flavor, texture, nutrient density, moisture level, or shelf life. Although there is continuing controversy over food additives in the United States, the FDA regulates additives used in our food supply and considers safe those it approves. The GRAS list identifies substances that either have been tested and determined by the FDA to be safe or are deemed safe as a result of consensus among experts.]

[Image: Many foods, such as ice cream, contain colorings.]

[Sidebar: **Generally Recognized as Safe (GRAS)** A list of substances approved for use in food production because they have been determined safe for consumption based on a history of long-term use or on the consensus of qualified research experts.]

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**LO 6** Describe the processes, uses, benefits, and concerns of genetic modification of foods.

**How is genetic modification used in food production, and is it safe?**

In **genetic modification,** also referred to as *genetic engineering,* the genetic material, or DNA, of an organism is altered to bring about specific changes in its seeds or offspring.

**Genetic Modification Includes Selective Breeding and Recombinant DNA Technology**

Selective breeding is one example of genetic modification; for example, Brahman cattle, which have poor-quality meat but high resistance to heat and humidity, are bred with English shorthorn cattle, which have good meat but low resistance to heat and humidity. The outcome of this selective breeding process is Santa Gertrudis cattle, which have the desired characteristics of higher-quality meat and resistance to heat and humidity. Although selective breeding is effective, it is a relatively slow process because a great deal of trial and error typically occurs before the desired characteristics are achieved.

Advances in biotechnology have moved genetic modification beyond selective breeding to include the manipulation of the DNA of living cells of one organism to produce the desired characteristics of a different organism. Called **recombinant DNA technology,** the process commonly begins when scientists isolate from an animal, a plant, or a microbial cell a particular segment of DNA--one or more genes--that codes for a protein conferring a desirable trait, such as drought tolerance or increased nutrients **(FIGURE 12.12).** Scientists then splice the DNA into a "host cell," usually a microorganism. The cell is cultured to produce many copies--a *gene library*--of the beneficial gene. Then, many scientists can readily obtain the gene to modify other organisms that lack the desired trait. The modified DNA causes the plant's cells to build the protein of interest, and the plant expresses the desired trait. The term *genetically modified organism (GMO)* refers to any organism in which the DNA has been altered using recombinant DNA technology.

Cultivation of GMO food crops began in 1996. In the United States, the most common genetic modification in food crops induces tolerance to herbicides, chemicals that kill weeds.25 Herbicide-tolerant GM crops (HT GMOs) can be sprayed liberally with chemicals that previously would have destroyed the crops themselves.

**[1** Gene that expresses a desired trait is extracted from a cell.

**2** Gene is combined with the DNA of a host cell that lacks this gene.

**3** Host cell containing recombinant DNA is cultured, resulting in many copies of the gene.

**4** Gene is extracted and inserted into the DNA of cells of an organism that lacks this gene.

**5** Cells produce an organism that expresses the desired trait.]

**[FIGURE 12.12** Recombinant DNA technology involves producing plants and other organisms that contain modified DNA, which enables them to express desirable traits that are not present in the original organism.]

[Sidebar: **genetic modification** The process of changing an organism by manipulating its genetic material.]

[Sidebar: **recombinant DNA technology** A type of genetic modification in which scientists combine DNA from different sources to produce a transgenic organism that expresses a desired trait.]

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[Image: Corn is one of the most widely cultivated genetically modified crops.]

The second most common modification induces insect resistance by inserting the gene from the soil bacterium Bt (*Bacillus thuringiensis)*.25 The Bt gene codes for the assembly of a protein that is toxic to specific insects, protecting the plant throughout its life span. The most common GM crops are corn and soybeans. The USDA reports that, in 2015, 89% of all corn crops and 94% of all soybean crops grown in the United States were HT GMOs, and a great majority of these crops were Bt modified as well.25

**Genetic Modification Has Many Benefits**

In 2014, nearly 450 million acres of GM crops were grown in 28 countries worldwide.26 Many agricultural experts cite numerous benefits resulting from the global adoption of GM technology:26-28

- GM crops grow faster and have average yields 22 % higher than conventional crops. Crops have been engineered for drought-tolerance, salt-tolerance, and other characteristics that enable them to thrive in challenging climates. As a result, food security for countries struggling to maintain adequate food supplies has increased.

- Cultivation of GM crops has had some environmentally responsible outcomes. These include conservation of water due largely to the development of drought-tolerant species of corn, reduced use of pesticides, reduced energy use, reduced emissions of greenhouse gases, and increased soil conservation due to higher productivity.

- GM crops can be produced with enhanced nutrients, improved digestibility, and lower levels of carcinogens, thereby improving public health.

- Farmer profits have increased by an average of 50 % in both developed and developing countries, on both corporate and family farms, the majority owned by resource-poor farmers.

**Genetic Modification Poses Certain Risks**

As the use of genetic modification increases, however, some public health experts and environmental scientists have become concerned about evidence of its risks. These are discussed here.

**Potential Health Risks**

The World Health Organization (WHO) has identified several potential health concerns of GM foods:28-30

*-* *Allergenicity.* Theoretically, the transfer of genes from organisms with commonly allergenic proteins--such as fractions of wheat or soy--to nonallergenic organisms could occur. The WHO has not, however, found allergic effects from GM foods currently on the market.

*-* *Antimicrobial properties.* It is possible that consumption of GM foods containing antibiotic-resistance genes could harm human body cells or the beneficial microbial flora in the GI tract. Although the WHO encourages the use of gene transfer techniques that do not involve antibiotic-resistance genes, the risk remains.

*-* *Indirect effects on food safety and loss of diversity.* Genes have migrated from GM crops to conventional food crops several miles away (e.g., via wind, birds, or insects).

*-* *Link to cancer.* In 2015, the International Agency for Research on Cancer (IARC), an agency of the WHO, classified the herbicide glyphosate, commercially known as Roundup, and the herbicide in greatest use in GM crops, as a probable carcinogen. The IARC linked glyphosate specifically to an increased risk for non-Hodgkin lymphoma, a leading cause of cancer death.

**Environmental Risks**

Environmental scientists have become increasingly concerned about the effects of GM crops on local and global ecologies. We focus on three such concerns here.28,31-33

*-* *Loss of biodiversity.* As already noted, unintentional transfer of genes from one crop to another has occurred. Studies have yielded evidence of transgenes in maize (corn), wheat, and other plants miles away.

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But even the intentional planting of GM crops promotes the spread of monocultures (genetically identical plants, such as the same variety of wheat or rice), which reduce nutrient and phytochemical variety in our diets, and increase those crops' vulnerability to plant diseases and climate events.

*-* *Generation of superweeds.* There is no question that the adoption of HT GMOs--and the liberal application of glyphosate--has led to the generation of *superweeds;* that is, weeds that have evolved a tolerance to herbicides. Superweeds can grow faster, taller, and tougher than typical weeds, requiring farmers to apply more toxic pesticides. These weeds have appeared in 66 countries, including in 22 states in the United States. In 2014, the EPA released new regulations to combat the problem of superweeds, but environmental advocacy groups say they do not go far enough to address the crisis.

*-* *Threats to other species.* Ecologists have associated the rise in GM crops to the decline in populations of certain species of birds, insects, and other creatures. One of the most commonly cited examples is the 80% decline in the population of monarch butterflies since 1997. Although climate change and other factors contribute, researchers point out that the butterfly larvae feed on milkweed, which has greatly declined with the increased use of glyphosate in conjunction with increased planting of HT-GMO crops.

**Economic Instability**

Critics also charge that GMOs have introduced the potential for only a few companies, including Monsanto, the world's largest agricultural biotechnology corporation, to control the majority of world food production. For example, the seed industry has become increasingly dominated by Monsanto, which has bought up smaller seed companies, impeding competition and leading to increased seed prices.

**Should GM Foods Be Labeled?**

Many who oppose genetic engineering--and some who do not--agree that all GM foods should be labeled, so that consumers know what they are purchasing. The European Union (EU) has long required that GM foods be clearly labeled as such. In contrast, as of 2016, the U.S. Food and Drug Administration did not require such labeling. Thus, the only way for consumers to avoid GM foods is to purchase organic foods (discussed shortly).

In contrast, many GM supporters argue that labeling a food as genetically modified would raise consumer concerns about unconfirmed health risks. Globally, most nations, including the United States, perform rigorous assessments of the quality and safety of GM foods.29 As the WHO notes, similar evaluations are generally not performed for conventional foods. Thus, consumer beliefs that conventional foods are safer than GM foods are not necessarily correct.

Twenty years have now passed since the introduction of GM foods into the marketplace. As more and more of the world's food supply depends on GM crops, the need for rigorous research into their risks, and the development of effective safeguards to reduce those risks, continues to grow as well.

**[recap**

In genetic modification, the genetic material, or DNA, of an organism is altered to enhance certain qualities. The process is called recombinant DNA technology. In U.S. agriculture, genetic modification is most often used to induce herbicide tolerance and insect resistance. It may also be used to boost a crop's yield, nutrients, protection from disease, or ability to grow in challenging conditions. GM technology has increased the global food supply and has certain beneficial environmental and economic effects. Concerns include the potential for negative health effects, loss of biodiversity, generation of superweeds, and monopolization of world food production. Many health and consumer groups advocate labeling of all GM foods.]

[Image: The increased use of glyphosate on HT-GMO corn and soybeans is one factor associated with an 80% decline in the population of monarch butterflies.]

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**LO 7** Discuss the health concerns associated with food residues, and the key characteristics of organic foods.

**How do residues harm our food supply?**

**Food residues** are chemicals that remain in foods despite cleaning and processing. Residues of global concern include persistent organic pollutants, pesticides, and the hormones and antibiotics used in animals. The health concerns related to residues prompt many consumers to choose organic foods.

**Persistent Organic Pollutants Can Cause Illness**

Some chemicals released into the atmosphere as a result of industry, agriculture, automobile emissions, and improper waste disposal can persist in soil or water for years or even decades. These chemicals, collectively referred to as **persistent organic pollutants (POPs),** can travel thousands of miles in gases or as airborne particles, in rain, snow, rivers, and oceans, eventually entering the food supply through the soil or water.34 If a pollutant gets into the soil, a plant can absorb the chemical into its structure and pass it on as part of the food chain. Animals can also absorb the pollutant into their tissues or consume it when feeding on plants growing in the polluted soil. Fat-soluble pollutants are especially problematic, as they tend to accumulate in the animal's body tissues in ever-greater concentrations as they move up the food chain. This process is called **biomagnification.** The POPs are then absorbed by humans when the animal is used as a food source **(FIGURE 12.13).**

POP residues have been found in virtually all categories of foods, including baked goods, fruit, vegetables, meat, poultry, fish, and dairy products. Significant levels have been detected all over the Earth, even in pristine regions of the Arctic thousands of miles from any known source.34

[Sidebar: **food residues** Chemicals that remain in foods despite cleaning and processing.]

[Sidebar: **persistent organic pollutants (POPs)** Chemicals released as a result of human activity into the environment, where they persist for years or decades.]

[Sidebar: **biomagnification** The process by which persistent organic pollutants become more concentrated in animal tissues as they move from one creature to another through the food chain.]

**[1** Industrial wastes are released into water.

**2** Plant and animal plankton become contaminated.

**3** Contaminated plankton are consumed by small fish.

**4** Large fish, such as tuna P and swordfish, regularly consume smaller, contaminated fish.

**5** Consumer purchases contaminated fish at market and consumes pollutants in fish.]

**[FIGURE 12.13** Biomagnification of persistent organic pollutants in the food supply.]

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**Health Risks of POPs**

POPs are a health concern because of their range of harmful effects on the body. Some are neurotoxins. Many others are carcinogens. Still others act as *endocrine disruptors,* chemicals thought to interfere with the body's endocrine glands and their production of hormones. As you know, hormones play roles in a vast number of body processes, but endocrine disruptors are particularly associated with developmental problems, reproductive system disorders, nerve disorders, and impaired immune function.34 They disrupt normal body processes by blocking the binding sites for natural hormones on body cells; mimicking natural hormones and thereby augmenting their actions; or altering the synthesis or metabolism of natural hormones.34

Some pesticides leave residues that qualify as POPs. Pesticides are discussed shortly.

**Heavy Metals**

Mercury, a naturally occurring heavy metal element, is found in soil, rocks, and water. It is also released into the air by industry and the burning of garbage and fossil fuels. As mercury falls from the air, it finds its way to rivers, lakes, and the ocean, where it accumulates. Fish absorb mercury as they feed on aquatic organisms, and this mercury is passed on to us when we consume the fish. As mercury accumulates in the body, it has a toxic effect on the nervous system, prompting memory loss and mood swings, as well as impaired vision, hearing, speech, and movement.35

Large predatory fish, such as swordfish, shark, king mackerel, and tilefish tend to contain the highest levels of mercury.35 Because mercury is especially toxic to the developing nervous system of fetuses and growing children, pregnant and breastfeeding women and young children are advised to entirely avoid eating these types of fish. Other fish and shellfish are lower in mercury. The FDA and EPA recommend that pregnant women and young children eat no more than two servings (12 oz) per week of low-mercury fish.35

Lead is another heavy metal of concern. You may have heard of the 2015 lead contamination of municipal tap water in Flint, Michigan, and the increased risks to the residents exposed: In children, lead exposure can cause decreased IQ, serious learning and behavioral disorders, and hearing impairment. Adults can experience decreased fertility, nerve disorders, and cardiovascular and kidney disease.36 Lead is an industrial waste from leaded gasoline, lead-based paints, and lead-soldered cans, now outlawed but decomposing in landfills. Some older homes also have high levels of lead paint dust, or the lead paint may be peeling in chips, which young children may put it their mouths. Some old ceramic mugs and other dishes are fired with lead-based glaze, allowing residues to build up in foods. No amount of lead is safe.

**Plasticizers**

Chemicals added to paint, varnish, cements, and plastics to increase their workability are collectively known as plasticizers. Two plasticizers found in plastic food containers can leach into foods and act as endocrine disruptors. A chemical called *bisphenol A (BPA)* is routinely used in the linings of canned foods and in some plastic food packaging. BPA is a form of synthetic estrogen, a female reproductive hormone, and research has linked it most conclusively to reproductive and developmental disorders.37 *Phthalates* are a large group of plasticizers that are found in plastic food packaging, shampoos, carpeting and vinyl flooring, pesticides, and many other products, as well as in animal-based foods and drinking water. Phthalates have also been linked to reproductive and developmental disorders.37,38

To limit your exposure to BPA and phthalates:39

- Reduce your consumption of canned foods.

- Avoid purchasing food in plastic containers with the recycling codes 3 or 7, as these may contain BPA or phthalates. Do not microwave foods in these containers or use them to hold hot foods or beverages. They are more likely to leach endocrine disruptors when they become heated.

- Whenever possible, choose glass, porcelain, or stainless-steel containers.

[Download a free safe-seafood app from the Monterey Bay Aquarium by clicking the link under "What Consumers Can Do" at **http://www.seafoodwatch.org**.]

[Image: Antique porcelain is often coated with lead-based glaze.]

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**Dioxins**

Dioxins are both carcinogens and endocrine disruptors. These industrial pollutants are typically formed as a result of combustion processes, such as waste incineration or the burning of wood, coal, or oil. Dioxins enter the soil and can persist in the environment for many years. There is concern that long-term exposure to dioxins can result in an increased risk for cancer, heart disease, diabetes, reproductive system disorders, and other disorders.40 Because dioxins easily accumulate in the fatty tissues of animals, most dioxin exposure in humans occurs through dietary intake of animal fats. To reduce your exposure, reduce your consumption of meat, especially fatty meat, and trim the fat from meats before cooking. Choose low-fat milk, yogurt, and cheese, and replace butter with plant oils.

**Poly- and Perfluoroalkyl Substances**

Concern has also been increasing about persistent residues from poly- and perfluoroalkyl substances (PFASs) that degrade very slowly and have been found all over the globe, including in the tissues of animals and humans. PFASs repel oil and water and are used in food packaging such as pizza boxes, fast food wrappers, and microwave popcorn bags. They also contaminate public tap water. They have been associated with organ damage, cancer, endocrine disorders, and other health problems.41

**Pesticides Protect Against Crop Losses--But at a Cost**

**Pesticides** are a family of chemicals used in both fields and farm storage areas to decrease the destruction and crop losses caused by weeds, animals, insects, and microorganisms. The three most common types of pesticides used in food production are:

*-* *Herbicides,* which are used to control weeds and other unwanted plant growth.

*-* *Insecticides,* which are used to control insects that can infest crops.

*-* *Fungicides,* which are used to control plant-destroying fungal growth.

Some pesticides used today have a low impact on the environment and are not considered harmful to human health. These include **biopesticides,** which are species-specific and work to suppress a pest's population, not eliminate it. For example, pheromones are a biopesticide that disrupts insect mating by attracting males into traps. Biopesticides do not leave residues on crops--most degrade rapidly and are easily washed away with water.

In contrast, pesticides made from petroleum-based products can persist in the environment, polluting soils, water, plants, and animals. They can also harm agricultural workers and consumers, acting as neurotoxins, carcinogens, and endocrine disruptors. In 2015, the World Health Organization's International Agency for Research on Cancer classified the herbicide glyphosate and the insecticides malathion and diazinon--all commonly used in the United States--as probable carcinogens.30

The EPA is responsible for regulating the use of all pesticides in the United States. Although the EPA certifies only pesticides with minimal environmental impact, the agency suggests taking the following steps to reduce your level of exposure to pesticides:42

- Wash and scrub all fresh fruits and vegetables thoroughly under running water.

- Peel fruits and vegetables whenever possible, and discard the outer leaves of leafy vegetables, such as cabbage and lettuce. Trim the excess fat from meat and remove the skin from poultry and fish because some pesticide residues collect in the fat.

- Eat a variety of foods from various sources, as this can reduce the risk of exposure to a single pesticide.

You can also reduce your exposure to pesticides by choosing organic foods, as discussed shortly.

[Image: Peeling a fruit reduces its level of pesticide residue; however, you should still scrub fruits before peeling.]

[Sidebar: **pesticides** Chemicals used either in the field or in storage to decrease destruction and crop losses by weeds, predators, or disease.]

[Sidebar: **biopesticides** Primarily insecticides, these chemicals use natural methods to reduce damage to crops.]

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**Growth Hormones and Antibiotics Are Used in Animals**

Introduced in the U.S. food supply in 1994, **recombinant bovine growth hormone**

**(rBGH)** is a genetically engineered growth hormone. It is used in beef herds to induce animals to grow more muscle tissue and less fat. It is also injected into some U.S. dairy cows to increase milk output.

Although the FDA has allowed the use of rBGH in the United States, both Canada and the European Union have banned its use for two reasons:43

- The available evidence shows an increased risk for mastitis (inflamed udders), in dairy cows injected with rBGH. Farmers treat mastitis with antibiotics, promoting the development of strains of pathogenic bacteria that are resistant to antibiotics.

- The milk of cows receiving rBGH has higher levels of a hormone called insulin-like growth factor (IGF-1). This hormone can pass into the bloodstream of humans who drink milk from cows that receive rBGH, and some studies have suggested that an elevated level of IGF-1 in humans may increase the risk for certain cancers. However, the evidence from these studies is inconclusive.

The American Cancer Society suggests that more research is needed to help better appraise these health risks. In the meantime, consumer concerns about rBGH have caused a decline in rBGH injection in cows to below 20%.43

Antibiotics are also routinely given to animals raised for food. They are added to the feed of swine, for example, to reduce the number of disease outbreaks in overcrowded pork-production facilities. Many researchers are concerned that animals treated with antibiotics have become significant reservoirs for the development of virulent antibiotic-resistant strains of bacteria--so-called superbugs. How does this occur? As conventional antibiotics are repeatedly administered within an animal population, they become less effective because atypical bacterial cells--such as those with advantageous DNA mutations--escape the drugs' effects. These atypical bacteria are enabled to survive and reproduce without competition from the bacterial cells vulnerable to the antibiotics. A particularly dangerous superbug, methicillin-resistant *Staphylococcus aureus* (MRSA), is commonly resident in swine, and about 2 % of the U.S. population has been infected.44 Infection with MRSA can cause symptoms ranging from a fever and skin rash to widespread invasion of tissues, including the bloodstream. MRSA blood infections are sometimes fatal.44

In 2013, concerns about the risk of antibiotic use in animals promoting the development of superbugs caused the FDA to restrict the use of antibiotics in food production. Farmers cannot use antibiotics to increase an animal's growth, but only for prevention and treatment of disease.

You can reduce your exposure to growth hormones and antibiotics by choosing organic eggs, milk, yogurt, and cheeses and by eating free-range meat from animals raised without the use of these chemicals. You can also reduce your risk by eating vegetarian and vegan meals more often.

**Organic Farming Promotes Ecological Balance**

Between 1990 and 2014, sales of organic products in the United States skyrocketed from $1 billion to over $39 billion.45 About 81 % of Americans make at least some organic purchases. But what, exactly, are they buying?

The USDA describes **organic agriculture** as "the application of a set of cultural, biological, and mechanical practices that support the cycling of on-farm resources, promote ecological balance, and conserve biodiversity."46 Specifically, organic producers cannot use irradiation, sewage sludge, synthetic fertilizers, prohibited pesticides, GMOs, growth hormones, or antibiotics. Animals must be fed certified organic feed and have access to the outdoors.

Any product labeled organic must comply with the following definitions:46

*-* *Organic:* products containing at least 95% organically produced ingredients by weight, excluding water and salt, with the remaining ingredients consisting of those products not commercially available in organic form.

*-* *Made with organic ingredients:* a product containing at least 70% organic ingredients.

[Image: The resistant strain of bacteria responsible for methicillin-resistant *Staphylococcus aureus* (MRSA).]

[Sidebar: **recombinant bovine growth hormone (rBGH)** A genetically engineered growth hormone used in beef herds and some dairy cows.]

[Sidebar: **organic agriculture** The application of practices that support the cycling of on-farm resources, ecological balance, and biodiversity.]

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In products containing less than 70 % organically produced ingredients, those ingredients that are organically produced can be specified on the label. Products that are organic may display the USDA organic seal **(FIGURE 12.14).**

Notice that, in contrast to these strict regulations governing the use of the term *organic,* there is no USDA or FDA standard governing use of the term *natural.* However, the FDA is currently investigating concerns raised by some consumer groups about the potentially misleading use of this unregulated term. Without such regulation, it's wise to assume that a product labeled "All natural" is simply a conventional food.

Farms certified as organic have passed an inspection verifying that they are following all USDA organic standards. Organic farming methods are strict and require farmers to find natural alternatives to many common problems, such as weeds and insects. Contrary to common belief, organic farmers can use pesticides as a "last resort" for pest control when all other methods have failed, but they are restricted to a limited number of approved bio- and synthetic pesticides.46

With these safeguards, many people assume that organic foods and beverages are superior to foods produced using conventional methods. Are they right? The Nutrition Debate tackles this question.

**[recap**

Foodborne persistent organic pollutants (POPs) of greatest concern include the heavy metals mercury and lead, plasticizers, dioxins, and PFASs. Pesticides are used to prevent or reduce food crop losses; however, they too can persist in the environment. POPs and some pesticides can act as neurotoxins, carcinogens, or endocrine disruptors. Research into the health effects of recombinant bovine growth hormone (rBGH) is currently inconclusive. The use of--and residues from--antibiotics in animals raised for food increases the U.S. population's risk for antibiotic-resistant infections. The USDA regulates organic farming standards and inspects and certifies farms that follow all USDA organic standards. Organic producers cannot use irradiation, sewage sludge, synthetic fertilizers, prohibited pesticides, GMOs, growth hormones, or antibiotics. Animals must be fed organic feed, and have access to the outdoors.]

**[FIGURE 12.14** The USDA organic seal identifies foods that are at least 95% organic.]

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## **nutrition debate Organic Foods: Are They Worth the Cost?**

[In a recent national survey, 51 % of families said that the higher cost of organic foods was a factor limiting their organic purchases. In fact, families who regularly purchase organic foods spend an average of $15 a week more on groceries than families who don't buy organic items.47 So it's reasonable to ask: Are organic foods worth the cost?

Over the past few decades, hundreds of studies have attempted to compare the nutrient levels of organic foods to those of foods conventionally grown. The results have been inconclusive. For example, two large review studies published in 2011 and 2012 reached opposite conclusions on this issue, one finding consistently higher levels of nutrients in organic produce, and the other finding no nutritional advantage.48,49 Then, in 2013 and 2015, studies found 62% more omega-3 fatty acids and antioxidants in organic milk as compared to conventional milk,50,51 and in 2014, a comprehensive review concluded that organically grown produce has a higher level of antioxidant nutrients and phytochemicals.52

The lack of conclusive evidence of a nutritional advantage of organic foods may not bother many consumers who choose organic foods to reduce their exposure to pesticide residues. How do organic foods compare on that measure? Two of the studies just mentioned found that organically produced foods were about 30 % less likely to be contaminated with detectable pesticide residues or antibiotic-resistant bacteria.49,52 Another study comparing organically grown soybeans with conventional and HT-GMO soybeans found that the organic beans not only had a much higher nutrient profile but also a much lower pesticide residue; in particular, the HT-GMO soybeans had a high level of glyphosate residue, whereas the organic beans had none.53 In addition, researchers for the American Academy of Pediatrics recently reviewed all available evidence on organic foods and concluded that "Organic diets have been convincingly demonstrated to expose consumers to fewer pesticides associated with human disease."54

Do you think organic foods are worth the extra cost? If you do but you're on a budget, a smart strategy is to spend more for organic when the conventionally grown version is likely to retain a high pesticide residue. **TABLE 12.4** identifies the foods that the Environmental Working Group advises should be your priority organic purchases. If your food budget is limited, spend your money on the organically grown versions of these foods. The table also identifies the 15 foods that tend to be lowest in pesticide residues.

You can feel confident purchasing conventional versions of these.

What else can you do? Grow some vegetables on your own, even if you have no plot of land, in raised beds in rooftop gardens, on a sunny balcony, or even in a sunny window. Learn more about container gardening at http://www.letsmove.gov/kitchen-garden-checklist.

Be sure to follow the EPA's guidelines for washing produce to reduce your ingestion of pesticide residues. Also try substituting foods on the "Dirty Dozen" list for similar foods among the "Clean Fifteen." For example, skip conventionally grown strawberries, and switch to kiwis. For potatoes, go with sweet potatoes.

**CRITICAL THINKING QUESTIONS**

1. Do you often purchase organic foods? Why or why not?

2. Given that organic foods are labeled for consumers, should GM foods also be labeled? Support your answer.

3. Search online for the USDA plant hardiness zone in which you live. Identify the length of your region's growing season, and two vegetables you could grow in your region during the summer.

**TABLE 12.4** The Environmental Working Group's 2016 Shopper's Guide to Pesticides in Produce

|  |  |
| --- | --- |
| **The Dirty Dozen Buy These Organic** | **The Clean Fifteen Lowest in Pesticides** |
| Strawberries | Avocados |
| Apples | Corn |
| Nectarines | Pineapples |
| Peaches | Cabbage |
| Celery | Sweet peas |
| Grapes | Onions |
| Cherries | Asparagus |
| Spinach | Mangoes |
| Tomatoes | Papayas |
| Bell peppers | Kiwi |
| Cherry Tomatoes | Eggplant |
| Cucumbers | Honeydew |
|  | Grapefruit |
|  | Cantaloupe |
|  | Cauliflower |

*Source:* Environmental Working Group. 2016. EWG's Shopper's Guide to Pesticides in Produce. http://www.ewg.org/foodnews/

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**[TEST YOURSELF** *ANSWERS*

**1** **F** Foodborne illness actually sickens about 48 million Americans each year, and about 3,000 die.

**2** **F** Freezing destroys some microorganisms but only inhibits the ability of other microorganisms to reproduce. When the food is thawed, these cold-tolerant microorganisms resume reproduction.

**3** **T** Although genetic modification can also improve a crop's nutritional profile or yield, the most common use is to increase a crop's ability to tolerate herbicides (weed killers).]

**review questions**

**LO 1 1.** A key reason that foodborne illness has become a serious public health concern in the United States is that

a. an estimated 4.8 million Americans experience foodborne illness each year, and about 300 die.

b. Americans are eating more and more processed foods containing potentially toxic levels of food additives.

c. federal oversight of food safety is fragmented among 15 different agencies.

d. Americans are eating out more frequently, and restaurants are responsible for nearly all cases of foodborne illness.

**LO 2** 2. Among the top microorganisms implicated in foodborne illness,

a. norovirus is responsible for the greatest number of illnesses.

b. *Listeria monocytogenes* is responsible for the greatest number of hospitalizations.

c. Shiga toxin-producing *E. coli* is responsible for the greatest number of deaths.

d. *Toxoplasma gondii* is the only species of helminth.

**LO 2 3.** The majority of foodborne microorganisms reproduce most successfully

a. between 40°F and 140°F.

b. in dry conditions.

c. in alkaline conditions.

d. in an anaerobic environment.

**LO 3 4.** During a 4th of July barbecue on a hot afternoon, a family enjoys grilled fish, potato salad, and coleslaw. Leftovers of these foods should be safe to eat later on as long as they are brought back indoors and refrigerated

a. immediately after serving.

b. within a maximum of 30 minutes after serving.

c. within a maximum of 1 hour after serving.

d. within a maximum of 2 hours after serving.

**LO 4 5.** A food preservation technique in which the oxygen in a food is replaced with an inert gas is

a. aseptic packaging.

b. modified atmosphere packaging.

c. high-pressure processing.

d. irradiation.

**LO 5 6.** Food additives that have raised health concerns include

a. sodium chloride and beta-carotene.

b. sulfites and nitrites.

c. alpha-tocopheral and ascorbic acid.

d. all of the above.

**LO 6 7.** The most common reason that crops in the United States are genetically modified is to

a. confer tolerance to herbicides.

b. protect them from disease.

c. enable them to grow in challenging environmental conditions.

d. boost their concentration of nutrients.

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**LO 7** 8. Residues from heavy metals, plasticizers, dioxins, PFASs, and certain pesticides pose a threat to public health mainly because

a. they promote the development of superbugs.

b. they cause allergies, asthma, and migraine headaches.

c. they can act as neurotoxins, carcinogens, or endocrine disruptors.

d. they can reduce biodiversity.

**LO 2 9.** **True or false?** A bacterium that commonly contaminates deli meats, smoked fish, and soft cheeses is *Listeria monocytogenes.*

**LO 7 10. True or false?** In the United States, farms certified as organic are allowed to use pesticides under certain conditions.

**math review**

**LO 3 11.** Below are the proper cooking temperatures for meat, poultry, and fish from the USDA. Use the following formula to convert each from Fahrenheit to Celsius. Round off.

Formula: (°Fahrenheit - 32) × 5/9 = (°Celsius)

Example: (90°F - 32) × 5/9 = (°Celsius)

90 - 32 = 58

58 × 5/9 = 32°C

a. Beef, pork, veal, lamb steaks, roasts, and chops 145° with a 3-minute rest time before serving; fish 145°

b. Ground beef and egg dishes 160°

c. Poultry, whole, pieces, and ground 165°

*Answers to Review Questions can be found online in the MasteringNutrition Study Area.*

**web links**

**www.foodsafety.gov**

Foodsafety.gov

*Use this website as a gateway to a range of government food-safety information from tips to outbreak reports.*

**www.cdc.gov/foodsafety/index.html**

CDC Food-Safety Homepage

*This section of the larger CDC website focuses on issues specifically related to food safety.*

**www.fsis.usda.gov/food\_safety\_education/index.asp**

USDA Food Safety and Inspection Service *Use the Food Safety and Inspection Service area of the larger USDA website to learn more about food safety through a variety of tools and resources.*

**www.epa.gov/pesticides**

U.S. Environmental Protection Agency: Pesticides

*This site provides information on agricultural and home-use pesticides, including effects of pesticides on health and the environment.*

**www.ams.usda.gov**

USDA National Organic Program

*Click on "National Organic Program" to get to the web page describing the NOP's standards, practices, and labeling.*

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# **in depth 12.5** **The Safety and Effectiveness of Dietary Supplements**

***After studying this In Depth, you should be able to:***

**1** Discuss the limitations in current regulation of dietary supplements sold in the United States, pp. 455-456.

**2** Explain what constitutes an herbal supplement and what special precautions are indicated for its use, pp. 456-457.

**3** Identify groups of people who might benefit from taking a dietary supplement as well as situations in which dietary supplements are not advised,

pp. 457-459.]

**In April of 2015, 14 U.S. Attorneys General signed a letter to the congressional subcommittee responsible for consumer product safety requesting that Congress launch an investigation into the dietary supplements industry.** The action came after DNA testing of several supplements found that they did not contain the ingredients listed on the labels; some were contaminated with high levels of heavy metals including lead and mercury; and some contained allergens such as wheat and grass not identified on the label. Some supplements were labeled as containing natural plant extracts when they actually contained synthetic stimulants. In November 2015, the U.S. Justice Department brought criminal and civil suits against 117 individuals and companies marketing these supplements, some of which had caused illnesses and even deaths.

The Office of Dietary Supplements (ODS) at the National Institutes of Health (NIH) reports that, in 2014, sales of dietary supplements reached nearly $37 billion.1 A recent survey of students at five U.S. universities found that 66% use a dietary supplement and 12% consume five or more.2 Is this smart? Dangerous? Who, if anyone, *should* be taking supplements?

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## **How are dietary supplements regulated?**

**LO 1** Discuss the limitations in current regulation of dietary supplements sold in the United States.

According to the U.S. Food and Drug Administration (FDA), a **dietary supplement** is a product containing ingredients such as vitamins, minerals, herbs, amino acids, or enzymes. They are intended to supplement the diet, not to treat, diagnose, prevent, or cure disease.3 Supplements come in many forms, including tablets, capsules, softgels, liquids, and powders.

**FIGURE 1** shows a label from a multivitamin and mineral (MVM) supplement. There are specific requirements for the information that must be included on the supplement label. Labels bearing a claim must also include the disclaimer "This statement has not been evaluated by the FDA. This product is not intended to diagnose, cure, or prevent any disease."

[Image: Dietary supplements can be pills, capsules, powders, or liquids and contain micronutrients, amino acids, herbs, or other substances.]

Any products not meeting these guidelines can be removed from the market.

The Dietary Supplement Health and Education Act (DSHEA) of 1994 classified dietary supplements within the general group of foods, not drugs.

**[1** Statement of identity

**2** Net quantity of contents

**3** Directions

**4** Supplement facts panel

**5** Other ingredients in descending order by weight and using common name

**6** Name and place of business, manufacturer, packer, or distributor; the address for more information]

[Sidebar: **dietary supplement** A product taken by mouth that contains a "dietary ingredient" intended to supplement the diet.]

**[FIGURE 1** A multivitamin and mineral supplement label highlighting the dietary supplement labeling guidelines.]

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This means that the regulation of supplements is much less rigorous than the regulation of drugs. Currently, the FDA is reconsidering how it regulates foods and supplements that are marketed with health claims, but no changes have been finalized at this time. As an informed consumer, you should know that:3

- The FDA does not have the authority to review the safety and effectiveness of dietary supplements before they are marketed.

- The company that manufactures a supplement is responsible for determining that the supplement is safe; the FDA does not test any supplement for safety prior to marketing.

- Supplement companies have to notify the FDA if their supplement contains a new dietary ingredient; however, the FDA only reviews such notifications--it does not approve them--and only for safety, not for effectiveness.

- The FDA requires supplements manufacturers to produce products of quality and free of contamination; however, it does not regulate practices to ensure the purity, quality, safety, and composition of dietary supplements.

- Once a supplement is marketed, the FDA can take steps to remove it from the market if it is found to be unsafe or if the claims on the label are false and misleading. Supplements advertisers must be able to substantiate all label claims.

Although many dietary supplements contain the ingredients listed and are safe, the recent investigations mentioned earlier show that many others are dangerous. Because the liver is responsible for clearing toxins from the blood, it is often the organ damaged by use of contaminated supplements. For example, a 2014 study found that, over a 10-year period, eight U.S. medical centers reported more than 100 cases of liver damage caused by dietary supplements. Many of these cases resulted in the need for a liver transplant, and 13% were fatal.4 How can you avoid purchasing such supplements? The FDA suggests that you keep in mind the nearby **Quick Tips** when evaluating dietary supplements.5

**[FIGURE 2** The USP Verified Mark indicates that the manufacturer has followed certain standards for features such as purity, strength, and quality. Registered Trademark of U.S. Pharmacopeial Convention (USP). Used with Permission.]

**Quick Tips**

**[Staying Safe with Supplements**

Check with your healthcare provider or an RDN about any nutrients you may need in addition to your regular diet.

Look for the Pharmacopeia (USP) Verified Mark on the label **(FIGURE 2).** Though it doesn't indicate that the supplement is effective in treating any condition, the mark does indicate that the manufacturer followed the standards that the USP has established for features such as purity, quality, and labeling.

Choose recognized brands of supplements. Although not guaranteed, products made by nationally recognized companies more likely have well-established manufacturing standards.

Do not assume that the word ***natural*** on the label means that the product is safe. Arsenic, lead, and many other natural substances can kill you if consumed in large enough quantities.

Be skeptical of anecdotal information or personal "testimonials."

Ask yourself if the claims for the supplement sound too good to be true; for example, promising that the supplement will enable you to lose a large amount of weight in a short amount of time, or that it is a "miracle cure," or can be used to treat a wide variety of diseases.

Do not hesitate to question a company about how it makes its products. Reputable companies have nothing to hide and are more than happy to inform their customers about the safety and quality of their products.

*Source:* U.S. Food and Drug Administration (FDA). Center for Food Safety and Applied Nutrition. 2015, September 4. Six tip-offs to rip-offs: Don't fall for health fraud scams. www.fda.gov/forconsumers/consumerupdates/ucm341344.htm

## **Are there special precautions for herbs?**

**LO 2** Explain what constitutes an herbal supplement and what special precautions are indicated for its use.

A common saying in India cautions that "A house without ginger is a sick house." Indeed, ginger, echinacea, lavender, and many other **herbs** (also called *botanicals)* have been used for centuries by different cultures throughout the world to promote health and treat discomfort and disease.

[Sidebar: **herb** A plant or plant part used for its scent, flavor, and/or therapeutic properties (also called a *botanical).*]

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[Image: Echinacea, commonly known as purple coneflower, has been used for centuries to prevent colds, flu, and other infections.]

Many prescription and over-the-counter drugs are based on botanicals.

The National Center for Complementary and Integrative Health (NCCIH) defines an herb as "a plant or plant part (such as leaves, flowers, or seeds) that is used for its flavor, scent, and/or potential health-related properties."6 As you would suspect, with a definition this broad there are hundreds of different herbs on the market. Which of these may be effective, and for what disorders, in what forms, and at what dosages? And are some ineffective or even dangerous? To help consumers answer these questions, NCCIH evaluates the most commonly used herbs in "Herbs at a Glance" fact sheets, available at its website (see the **Web Links** at the end of this chapter).

The use of herbal supplements requires special precautions. In addition to the **Quick Tips** for all types of dietary supplements, practice the following strategies offered by the NCCIH specifically for consumers considering the use of herbs:6

- Consult a healthcare provider before using any herbal supplement. Herbs can act the same way as drugs; therefore, they can cause medical problems if not prescribed.

- Never take herbal supplements if you have a serious illness, regularly take any prescription or over-the-counter medication, or are pregnant or breastfeeding, unless your physician has approved their use.

- Do not treat children with herbal supplements unless your physician has approved their use.

- Be aware that the active ingredients in many herbal supplements are not known. They may contain dozens, even hundreds, of unknown compounds. Analyses of herbal supplements, like those noted earlier, have routinely found differences between what is listed on the label and what is in the bottle. This means you may be taking less--or more--of the supplement than what the label indicates or ingesting potentially harmful substances such as grasses, metals, unlabeled prescription drugs, and microorganisms.

**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

- Be aware that the words *standardized, certified,* or *natural* on a label is no guarantee of product quality; in the United States, these terms have no legal definition for supplements.

- Finally, certain herbs are associated with severe--even life-threatening--adverse effects. These should be avoided entirely **(TABLE 1).**

## **Should you take a dietary supplement?**

**LO 3** Identify groups of people who might benefit from taking a dietary supplement as well as situations in which dietary supplements are not advised.

According to a recent survey, 67% of Americans use vitamin or mineral supplements, 35% use "specialty" supplements, 23% use botanicals, and 17% use sports supplements (some of which are ergogenic aids, discussed in more detail in Chapter 11).7 Many people take more than one. Among supplements users, MVM supplements are the most popular: 71 % take an MVM. But contrary to popular belief, a healthful diet can usually provide an adequate level of essential nutrients.

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Moreover, foods contain a diverse combination of compounds that interact to maintain our health, whereas vitamin and mineral supplements contain just the micronutrients identified on the label. Thus, they're not substitutes for a healthful diet.

However, nutritional needs do change throughout the life span, so you may benefit from taking a supplement at certain times for certain reasons. For instance, if you were to adopt a vegan diet, your healthcare provider might prescribe a supplement providing micronutrients absent or less available from plant foods, including riboflavin, vitamin B12, vitamin D, calcium, iron, and zinc. Or if you joined your college soccer team, your team's sport dietitian might review your diet and advise taking a supplement formulated to provide micronutrients that support intense physical activity.

Dietary supplements include hundreds of thousands of products sold for many purposes, so it's impossible to discuss here all of the situations in which their use might be advisable. To simplify this discussion, **TABLE 2** identifies groups of people who might benefit from micronutrient supplementation; however, not everyone in these groups needs the supplement indicated. If you fall within one of the groups listed, check with your healthcare provider or a registered dietitian nutritionist (RDN) to find out whether or not you should take the supplement.

The following are instances in which taking supplements is unnecessary or may be harmful:

- Providing fluoride supplements to children who already drink fluoridated water.

- Taking supplements in the belief that they will cure a disease, such as cancer, diabetes, arthritis, or heart disease.

- Taking nonprescribed supplements if you have a serious illness or are taking any prescription medications. For instance, physicians may prescribe micronutrient supplements for their patients with liver or kidney disease to replace nutrients lost during treatment for these diseases. However, these patients should not take any unprescribed supplements because their disease impairs their metabolism, putting them at high risk for toxicity. Similarly, people who take the blood-thinning drug Coumadin should not take any dietary supplements unless their physician has approved them.

**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 B6, 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 B12, 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 B12 |

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Vitamin E or K, licorice, St. John's wort, and willow bark are just a few of many supplements that can dangerously alter the effects of Coumadin. People who take aspirin daily should check with their physician before taking any supplements because aspirin also thins the blood.8

- Taking beta-carotene supplements if you are a smoker. There is evidence that beta-carotene supplementation increases the risk for lung and other cancers in smokers.

- Taking supplements to increase your energy level. Although many vitamins and minerals assist in energy metabolism, they do not provide energy because they do not contain fat, carbohydrate, or protein (sources of Calories). Moreover, many stimulant supplements that are taken to increase energy levels have been associated with altered heart rhythms, central nervous system disturbances, and even death.9

- Taking single-nutrient supplements, unless prescribed by your physician for a diagnosed medical condition (e.g., prescribing iron supplements for someone with anemia). These supplements contain high amounts of the given nutrient, and taking them can quickly lead to toxicity. Especially harmful in high doses are vitamin A, which can cause liver damage; vitamin B6, which can injure nerves; niacin, which can cause vomiting, diarrhea, and damage to muscles, liver, and heart; and the mineral selenium, which can cause tissue damage.

[Image: One of the best strategies for maintaining good health is to eat a diet that provides a variety of whole foods. If you do that, you probably won't need supplements.]

MVM supplements are unlikely to cause harm, so should you take one, just for "insurance"? A recent editorial in the *Annals of Internal Medicine* advised most Americans to stop wasting their money on MVM supplements.10 It cited other articles published in the same issue of the journal that illustrated no clear evidence of a beneficial effect of dietary supplementation on all-cause mortality, CVD, cancer,11 or cognitive decline.12,13 The U.S. Preventive Services Taskforce finds that current evidence is insufficient to support the use of MVMs or single- or paired-nutrient supplements.11 If you do decide to take an MVM, select one that contains no more than 100% of the recommended levels for the nutrients it contains, but be aware: you might be wasting your money.

## **nutri**-**case** **THEO**

"You know, I never thought I needed to take a multivitamin and mineral supplement because I'm healthy and I eat all different kinds of foods. But now I've learned in my nutrition course about what these vitamins and minerals do in the body, and I'm thinking, heck, maybe I should take one just for insurance. I mean, I use up a lot of fuel playing basketball and working out. Maybe if I popped a pill every day, I'd have an easier time keeping my weight up!" Do you think Theo should take a multivitamin and mineral supplement "just for insurance"? Why or why not? Would taking one be likely to have any effect on Theo's weight?

**web links**

**www.dietary-supplements.info.nih.gov**

Office of Dietary Supplements

*Search this website to find reports evaluating individual supplements you might be considering as well as general information about the health benefits, safety, and regulation of dietary supplements.*

**www.cfsan.fda.gov**

U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition

*This site provides information on how to make informed decisions and evaluate information related to dietary supplements.*

**https.nccih.nih.gov**

National Center for Complementary and Integrative Health

*From the menu on the left side of the home page, click on "Herbs at a Glance" to find information about an herb you might be considering using.*

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**[test yourself**

**1. T F** Because of insufficient money or other resources, people in more than 5% of U.S. households go without food.

**2. T F** In the United States, as compared to workers in other industries, a farm worker has nearly twice the risk of dying from an on-the-job injury.

**3. T F** Methane, a greenhouse gas emitted during livestock production, has almost double the atmospheric warming effect of carbon dioxide.

*Test Yourself answers are located in the Study Plan at the end of this chapter.*]

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# **CHAPTER 13**

**Food Equity, Sustainability, and Quality The challenge of "good food"**

**[learning outcomes**

***After studying this chapter, you should be able to: °***

**1** Compare and contrast levels of food insecurity globally and in the United States, pp. 462-463.

**2** Identify several ways in which human behavior contributes to food insecurity, pp. 463-467.

**3** Discuss inequities in agricultural and food retail and service labor, and their effects on workers and the consumers they serve, pp. 467-468.

**4** Discuss the effects of industrial agriculture on food security, food diversity, and the environment,

pp. 468-471.

**5** Discuss international, governmental, philanthropic, corporate, and local initiatives aimed at increasing the world's supply of and access to "good food," pp. 471-473.

6 Identify several steps you can take to promote production of and access to "good food," pp. 474-476.]

**In an affluent suburb in the United States, shoppers at a farmers market select organic meats, eggs, cheeses, produce, flour, and even freshly baked bread from nearby farms.** When asked why they shop there, they say that they want to provide their families "good food." Across the globe in a village in Kenya, a group of neighbors are members of a farming cooperative that grows corn and beans, raises chickens for eggs and cows and goats for milk. Members boast of their ability to feed their families "good food" for breakfast, lunch, and dinner every day.

What is "good food"? Although farmers, chefs, and public health experts would likely propose very different definitions, in this chapter, we define "good food" as nutrient-dense food that is equitably and sustainably produced, distributed, and sold. That might sound like a tall order, but such foods do exist. The challenge is to make them in large enough quantities to feed the world, and make sure that consumers have the ability and the desire to obtain them.1

*Equity* means fairness, and we begin this chapter by looking at inequities in the production, distribution, and sale of the world's food supply. We then discuss the effects of industrial agriculture on our environment and on the quality and diversity of our food. Finally, we identify some ways that nations and organizations are meeting the challenge of "good food," and how you can help.

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**LO 1** Compare and contrast levels of food insecurity globally and in the United States.

## **How** **prevalent is food insecurity?**

In Namibia, a nation in southern Africa, more than 42 % of the population is undernourished.2 Forty-six out of every 1,000 Namibian infants die before reaching their first birthday, and among those who survive to age 5, 13% are underweight. Average life expectancy is 52 years.3 In the United States, infant mortality is only 6 per 1,000, and instead of being underweight, over 8% of children age 2 to 5 are obese.3,4 Average life expectancy is now over 78 years; however, the average life expectancy of the poorest Americans is 10 years shorter (for women) and 15 years shorter (for men) than the average for the wealthiest Americans.5

Although a variety of factors contribute to disparities in infant mortality, body weight, and life expectancy, one of the most important is a population's level of **food insecurity**--unreliable access to a sufficient supply of nourishing food. Globally, the greatest health disparities are found between populations that are impoverished and those with a dependable supply of nourishing food. As the above comparisons illustrate, however, these disparities exist not only between poor and wealthy nations, but also between poor and wealthy people in developed countries like the United States. Are food distribution and access equitable? Let's have a look.

**About 795 Million People Worldwide Are Hungry**

The Food and Agricultural Organization of the United Nations (FAO) estimates that about 795 million people (one in nine people) worldwide are chronically undernourished, and 98% of these people live in developing nations.6 Although this is a disturbing statistic, it represents considerable progress: in 1990, over 1 billion people were undernourished. Then, in September of 2000, the United Nations (UN) and heads of state from around the world committed to a coordinated effort to reduce poverty. Using 1990 as a baseline, they set eight Millennium Development Goals, the first of which was to halve by the year 2015 the proportion of the world's people who suffer from hunger. Significant progress was made toward this goal: The share of undernourished people in the global population fell from 18.6% in 1990-92 to 10.9% in 2014-16, a reduction of nearly 45%.6

Still, hunger is endemic to many nations of the world **(FIGURE 13.1).** About 64% of the world's hungry people live in Asia, and sub-Saharan Africa--the region with the highest prevalence of hungry people--23%--accounts for almost 28%.6

[Image: Hunger and malnutrition are still experienced by many people around the world today.]

[Sidebar: **food insecurity** Unreliable access to a sufficient supply of nourishing food.]

**[FIGURE 13.1** Although people throughout the world--including in North America--are undernourished, parts of Asia and sub-Saharan Africa have the greatest prevalence of undernourishment overall.

*Source:* Food and Agricultural Organization of the United Nations (FAO) 2015. FAO Hunger Map 2015. http://www.fao.org/hunger/en/]

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Closer to home, at least 10% of people in some regions of Central and South America are undernourished, and in Haiti, the prevalence is greater than 50%. r The physical and societal consequences of malnutrition are explored In Depth following this chapter.

**Over 17 Million American Households Are Food Insecure**

Although the United States is one of the top 20 richest countries in the world,3 many of our poorest citizens go hungry. As shown in **FIGURE 13.2,** the Economic Research Service of the U.S. Department of Agriculture (USDA) estimates that 14% of U.S. households (17.4 million households) experienced food insecurity in 2014.7 This means that, at times during the year, members of these households were uncertain of having, or unable to acquire, enough food to meet their needs, because they had insufficient money or other resources for food.7

Of these 17.4 million households, 6.9 million had *very low food security;* that is, in 5.6% of U.S. households, one or more members had to reduce not only the quality, variety, or desirability of their food choices, but also the amount they were able to eat In other words, people in these homes, at times, were hungry. How do "households" translate into human beings? In 2014, 12.4 million adults and 914,000 children (1.2% of U.S. children), experienced very low food security.7

Those at higher risk for food insecurity are households with incomes below 185% of the official U.S. poverty threshold (which was $24,008 for a family of four in 2014), families consisting of single mothers or single fathers and their children, African American households, and Hispanic households. Rural areas have slightly higher prevalence of food insecurity than urban or suburban areas, and prevalence in the South is higher than elsewhere in the U.S.7

Sometimes physical, psychological, or social factors contribute to food insecurity among Americans. For instance, people with chronic diseases or disabilities may lose paid work hours due to illness, have to accept lower-wage jobs, or have medical expenses that limit money for food. Depression, addiction to alcohol or other substances, and other psychological disorders can similarly limit productivity and reduce income. Divorce frequently leads to financial stressors, especially for women, who may be unable to collect alimony or child support payments and may have jobs that do not provide an income sufficient to provide fully for the family's needs.

**[recap**

Health disparities exist between poor and wealthy nations, and between poor and wealthy regions within the same nation. Food insecurity, which is unreliable access to a sufficient supply of nourishing food, contributes to health disparities. Although significant progress has been made toward the millennium development goal to halve the 1990 prevalence of global hunger by the year 2015, about 795 million people worldwide are still chronically undernourished. In 2014, 14% of U.S. households experienced food insecurity, and over 13 million Americans, including 1.2% of all U.S. children, had very low food security. Low-income families and families headed by a single parent are among those with the highest rates of food insecurity.]

**LO 2** Identify several ways in which human behavior contributes to food insecurity.

## **Why** **don't all people have access to nourishing food?**

Weather events and human activity can result in a food supply that is inadequate to support the needs of all of the people in a particular place. Moreover, a recent and ongoing concern is the effect of climate change on the global food supply.

**[FIGURE 13.2** Prevalence of food insecurity in U.S. households in 2014.

*Source*: Coleman-Jensen, A., M. P Rabbitt, C. Gregory, and A. Singh. 2015, September. *Household Food Security in the United States in 2014.* Economic Research Service. United States Department of Agriculture. http://www.ers.usda.gov/]

[To read the FAO's 2015 report of The State of Food Insecurity in the World, visit

**www.fao.org/.]**

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## **nutri-case JUDY**

"I never seem to be able to make ends meet. I keep hoping next month will be different, but rent and utilities eat up most of my paycheck, so when something unexpected happens, I'm short. Last week, my car broke down and I'm way behind on my credit card payments. Today, a collections guy called and said that, if I didn't pay at least $100 right away, they'd take me to court. When I got off the phone, I started to cry, and Hannah asked me what was wrong. When I told her how bad the money situation is, she thought we might qualify for food stamps. I have a full-time job, so I don't think we'll qualify, but even if we do, I wonder if it'll help much."

In 2015, the federal minimum wage was $7.25 an hour. As a nurse's aide, Judy earns $9 an hour, or $1,560 a month. She is eligible for the Supplemental Nutrition Assistance Program (food stamps). Are you surprised that someone making almost 25% more than the minimum wage, and working full-time, qualifies for food assistance?

Before you're too certain that Judy's eligibility will solve her problems, consider that the average SNAP allotment in 2015 was $127.90 per person per month, or about $30 per week.\* If you had just $30 to keep yourself fed for a week, what would you buy?

Take this challenge one step further and follow the example of some U.S. college students to raise local awareness of food insecurity: For 1 week, restrict yourself to just $30 for all your food purchases. Let your campus newspaper and local media outlets know what you're doing, and ask readers to make donations to local food banks.

[Footnote: \*Congressional Budget Office. 2015, March. Supplemental Nutrition Assistance Program March 2015 Baseline. http://www.cbo.gov]

**Acute Food Shortages Are Often Caused by Weather Events and Wars**

A **famine** is a severe food shortage affecting a large percentage of the population in a limited geographic area at a particular time. Famines have occurred throughout human history and typically result from a combination of factors, including weather events and human miscalculations. For example, an estimated 20-43 million people died in the so-called great famine in China from 1958 to 1961 when disastrous government land-use policies, combined with both floods and droughts, dramatically limited crop yields. When a population is already living in extreme poverty, even a minor climate event such as high winds or a severe frost can have dire consequences. Other natural disasters that can quickly destroy crops are tsunamis, hurricanes, drought, pest infestations, and plant diseases.

Wars can induce acute food shortages when they interfere with planting or harvest times, when they destroy standing crops, or when populations are forced to flee. Since the civil war in Syria began in 2011, for example, there have been numerous reports of starvation, either because of insufficient funds for food relief to refugees or as a deliberate tactic of oppression.

**The Major Cause of Chronic Hunger Is Unequal Distribution of Food**

The world produces enough food to meet everyone's needs. Even developing nations currently produce about 2,600 kcal per person per day. Worldwide, the leading cause of longstanding hunger in a region is unequal distribution of this adequate food supply, largely because of poverty.8

[Image: An Indian farmer inspects what is left of his crop during a drought.]

[Sidebar: **famine** A severe food shortage affecting a large percentage of the population in a limited geographic area at a particular time.]

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The most at-risk populations are the rural poor. Lacking sufficient land to grow their own foods, the rural poor must work for others to earn money to buy food, but because they live in rural areas, employment opportunities are limited.

Unequal distribution also occurs because of cultural biases. In many countries, limited food is distributed first to men and boys and only secondarily to women and girls. In such situations, pregnant women and growing girls are the most vulnerable because of their increased needs. Food distribution to the elderly is sometimes also limited, particularly in countries where nutrition services are primarily directed toward pregnant and lactating women, infants, and young children. Access to food can also differ by ethnicity and religion. For example, officials in authority may order that food aid be distributed preferentially to areas where their own ethnic or religious group dominates.

**Overpopulation Contributes to Chronic Food Shortages**

Experts estimate that, in the year 1000 BCE, the world population was about 50 million people. Nearly 3,000 years would pass before, in the year 1804, world population reached 1 billion. Yet by the year 2011, world population had passed *7* billion; and by 2050, it is projected to reach 9.7 billion.9 Can the Earth sustain this many inhabitants?

An area is said to experience **overpopulation** when its resources are insufficient to support the number of people living there. In parts of the world with fertile land and adequate rainfall or irrigation systems to support abundant harvests, food shortages rarely happen. However, in more arid climates, especially in areas with high birthrates and low access to imported foods, seasonal and chronic food shortages are common. Of course, resources other than food may become depleted in overpopulated areas. Clean water, clean air, arable land (land suited to growing crops), safe housing, jobs, health care, quality education, and many other resources can be insufficient for the population's needs.

Is the world already overpopulated? Or will it soon become so? No one can answer these questions with absolute certainty, because we cannot predict how advances in technology will affect our depletion of the Earth's natural resources, our generation of pollution and wastes, or our ability to produce more food with fewer resources. However, reducing the demand for food within a region by slowing population growth is one way of improving an area's food supply, and one of the most effective methods of reducing birthrates is to improve education and career opportunities for girls and women.10 Their increased earning potential, access to contraception, and better health practices lead to smaller, healthier, more economically stable families. Other methods of improving an area's food supply are to increase food production and to import foods into the area.

**Local Conditions Can Contribute to Chronic Hunger**

Agricultural practices, lack of infrastructure, and the burden of disease can also contribute to hunger in regions around the world.

**Agricultural Practices**

Some traditional farming practices have the potential to destroy arable land. Deforestation by burning or any other means and overgrazing pastures and croplands destroy the trees and grass roots that preserve soils from wind and water erosion. Growing the same crop year after year on the same plot of ground can deplete the soil of nutrients and reduce crop yield. Use of arable land for **cash crops,** such as cotton, coffee, and tobacco, may replace land use for local food crops, or food crops such as corn and soybeans may be diverted to industrial uses. Also harmful is the practice of growing food for livestock, which compared to food crops feed far fewer people for the resources used. We compare the environmental costs of livestock versus food crops later in this chapter.

[Image: Cotton is a cash crop that farmers often grow instead of local food crops.]

[Sidebar: **overpopulation** Condition in which a region's available resources are insufficient to support the number of people living there.]

[Sidebar: **cash crops** Crops grown to be sold rather than eaten, such as cotton or tobacco.]

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**Lack of Infrastructure**

Exacerbating the scarcity of food production in some areas is a lack of infrastructure. For example, many developing countries lack roads and transportation into rural areas. This limits available food to whatever can be produced locally. In addition, lack of electricity and refrigeration can limit storage of perishable foods before they can be used.

Water management is another aspect of infrastructure that influences nutrition. In dry areas, irrigation can improve food production, but it must be managed carefully to avoid increasing the numbers of mosquitoes, intestinal parasites, and other pests, which can spread infectious diseases. The provision of safe drinking water and sewage systems is another aspect of water management that helps prevent disease.

**Impact of Disease**

Disease and lack of healthcare resources to fight disease reduce the work capacity of individuals, and this in turn reduces their ability to ward off poverty and malnutrition. This economic phenomenon is demonstrated by the AIDS epidemic. The World Health Organization (WHO) reports that there were nearly 37 million people living with HIV at the end of 2014. That year, about 1.2 million people died from AIDS.11 HIV is most likely to affect young, sexually active adults who are the primary wage earners in their families. Thus, their illness or death can orphan and impoverish their children, as well as create populations in which children and the elderly predominate.

**Climate Change Threatens Global Food Security**

**Global warming** is the general term used for the increase of about 1.5°F (0.85°C) in temperature that has occurred near the Earth's surface over the past century.12 The great majority of climate scientists agree that it has been caused by human activities that have released large amounts of carbon dioxide and other heat-trapping *greenhouse gases* into the atmosphere.12 Global warming is, in turn, the most significant factor contributing to **climate change,** which the U.S. Environmental Protection Agency (EPA) defines as any significant change in the measures of climate--such as temperature, precipitation, or wind patterns--that occurs over several decades or longer.13 A 2015 analysis, for example, attributed 75% of heat extremes and 18% of precipitation extremes to global warming.14

The United Nations' Intergovernmental Panel on Climate Change (IPCC) reports that global warming and climate change are affecting global food security in a number of ways:15

- Reduced crop yields. Higher average temperatures and elevations in greenhouse gases have reduced crop yields in many regions of the world.

- Crop destruction. Heat waves, droughts, tornados, hurricanes, and floods have all destroyed standing crops outright. During the last few decades, for example, California has experienced both its hottest and driest as well as its wettest years on record,16 causing billions of dollars of crop losses. Crops have also been destroyed by emerging varieties of pests such as fungal species that thrive in higher heat and humidity.

- Impacts on seafood availability. Climate change is reducing the abundance and distribution of seafood in tropical and temperate regions.

In contrast, very northern and southern latitudes of the globe have seen some minimal benefits from warmer temperatures. However, negative impacts of climate trends have been more common.15 Moreover, a 2015 report found that global food security is becoming increasingly susceptible to the effects of climate change and population growth.17

[Image: HIV/AIDS is most severe in under-nourished populations, especially in Africa.]

[To find out more about the World Food Programme's goal to eliminate hunger--and how students like you are contributing--go to www .wfp.org and click on the "students" tab.]

[Sidebar: **global warming** The increase of about 1.5°F (0.85°C) in temperature that has occurred near the Earth's surface over the past century.]

[Sidebar: **climate change** Any significant change in the measures of climate--such as temperature, precipitation, or wind patterns--that occurs over several decades or longer.]

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The world produces enough food to meet everyone's needs. Famines are widespread, severe food shortages that can result in starvation and death. They are most commonly caused by natural disasters or wars. Worldwide, the leading cause of longstanding hunger in a region is unequal distribution of an adequate food supply, largely because of poverty. Chronic food shortages can be influenced by regional overpopulation. Increasing educational and career opportunities for women and girls is an effective method of reducing birthrates. Poor agricultural practices, lack of infrastructure, and the burden of disease also contribute to chronic food shortages. Climate change reduces crop yields, destroys crops, and changes availability of seafood.]

**LO 3** Discuss inequities in agricultural and food retail and service labor, and their effects on workers and the consumers they serve.

## **Is our food equitably produced and sold?**

Most people consider the fresh fruits and vegetables, meats, and other nutritious foods available in U.S. supermarkets and restaurants "good food." But if we're defining "good" as equitably produced and sold, then much of the food we eat each day doesn't qualify. Why not? Let's take a look at the working conditions for those who labor in America's agricultural, food retail, and food service industries, which a recent report from the Rockefeller Foundation called "grossly inequitable."18

**Farm Labor Is Dangerous and Poorly Paid**

Throughout the U.S. labor market, in retail, industry, and even white-collar professions such as college teaching, more and more businesses are hiring "contingent workers." These positions typically offer little job security; no healthcare insurance, accrued sick- or vacation-leave, or retirement benefits; and low wages. This trend is nowhere more clearly seen than in agriculture, where about 20 % of the workforce is contingent, up from 14% in the early 1990s.19 Often referred to as "migrant workers" because they move from one region to another with changing harvest times, agricultural contingent workers also face hazardous conditions in the field. Consider these statistics:18-21

- The average annual income for a contingent U.S. farm worker is $10,000-$12,500. Large farms are required to pay minimum wage, but small farms are not, and a majority of contingent farm workers live below the poverty line.

- Under federal law, young people aged 16 years and older are allowed to work on farms during school hours, and children aged 12 years and older may work on farms after school and on weekends with parental permission.

- Farm workers are not entitled to breaks for rest or meals mandated for other U.S. workers by the Fair Labor Standards Act (FLSA).

- Only 17 % have any form of healthcare insurance and few have paid sick leave.

- Agriculture ranks as one of the most dangerous industries, with a fatality rate 7 times higher than the average for all workers in private industry. On average, more than 100 youths (under age 20) die each year from farm-labor injuries. Deaths are most commonly due to tractor overturns and other traumatic injuries, and heat stroke.

- Long-term exposure to pesticides, crop dusts, and excessive UV radiation causes lung disease and cancer, and constant bending and stooping causes musculoskeletal injuries.

- Contingent farm worker housing is often overcrowded and substandard, with some units lacking electricity, toilets, and running water.

**Food Retail and Service Work Maintains the "Working Poor"**

Conditions are only marginally better for the over 7 million cashiers and food and beverage service workers in the United States.22 The median hourly wage for retail cashiers is $9.14, an amount that puts even a single person with no dependents at increased risk for food insecurity.7,22

[Image: Contingent farm workers are inadequately compensated for their labor, receive few benefits, and have high rates of occupational injury and disease.]

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The median hourly wage for restaurant and other food service workers is even lower, just $8.96, and in many states, workers who earn more than $30 a month in tips may lawfully be paid just $2.13 an hour.22 Thus, it's not surprising that a majority of food retail and service workers live near or even below the poverty line, accounting for many of America's "working poor."

Low wages in the food retail and service industry affect everyone. Among the 52 million Americans who receive government assistance such as Medicaid and Supplemental Nutrition Assistance Program (SNAP) benefits, a majority are unemployed or not in the labor market; however, 6.7% of full-time workers in the U.S. (about 1 out of every 15 full-time workers) receive government assistance.23 In essence, this means that the average American taxpayer is subsidizing grocery stores, fast-food chains, and other food-service corporations, "making up the difference" in the inadequate wages they pay their employees. This situation has recently led cities and states across the United States to reexamine their minimum wage laws. Although the federal minimum wage has been stuck at $7.25 an hour since 2009, in 2015, Seattle, Washington, increased its minimum wage to $15 an hour, and in 2016, both California and Massachusetts raised the state minimum wage to $10 an hour.24

Many workers in food retail and service also have no paid sick leave. These workers are likely to show up for work even when ill with an infectious disease. You've learned (in Chapter 12) that the leading culprit in foodborne illness is norovirus, and the primary way that norovirus spreads is through infected food service workers. Foodborne illness is also a risk when farm workers don't receive paid sick leave. Farm workers infected with norovirus, hepatitis A virus, *Salmonella enteriditis,* and other foodborne microbes can contaminate produce during harvesting, and meat during processing.

Inequities in food security and labor can be discouraging and even distressing. Later in this chapter (pages 474-476) we'll explore some ways you can help promote the equitable production, distribution, and sale of food.

**[recap**

Working conditions in America's agricultural and food retail and service industries are inequitable. Contingent farm workers are inadequately paid, receive few benefits considered standard in other industries, and face much greater risks for occupational injury, chronic disease, and workplace fatality. Because farm and food retail and service workers are not paid a living wage, many receive Medicaid, SNAP benefits, and other government assistance funded by all Americans. The majority of these workers also lack paid time off for illness, and therefore are likely to work even when they risk contaminating foods during harvesting, production, preparation, and service.]

**LO 4** Discuss the effects of industrial agriculture on food security, food diversity, and the environment.

**How** **does industrial agriculture affect the security, sustainability, and diversity of our food supply?**

**Sustainability** is the ability to satisfy humanity's basic needs now and in the future without undermining the natural resource base and environmental quality on which life depends. Whereas some people view sustainability as a lofty but impractical ideal, others point out that it's a necessary condition of human survival. That's because sustainable practices can reduce pollution of our air, soil, and water and preserve resources for future generations. Is our current system of food production sustainable? Let's begin with some history.

**Industrial Agriculture Has Increased Food Security but Threatens Our Environment**

Like other modern wars, World War II led to innovations in industrial technology, engineering, and chemistry.

[Sidebar: **sustainability** The ability to meet or satisfy basic economic, social, and security needs now and in the future without undermining the natural resource base and environmental quality on which life depends.]

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After the war ended, these innovations were directed toward agriculture, specifically toward increasing worldwide food production to meet the food needs of a dramatically increasing postwar population. Together, the new technologies and practices became known as the **Green Revolution,** a massive program that has led to improved seed quality, fertilizers, pesticides, and farming techniques, which have boosted crop yields throughout the world. As part of the Green Revolution, for example, new **high-yield varieties (HYVs)** of grain were produced by cross-breeding plants and selecting for the most desirable traits. The first HYVs were rice and wheat, but now corn, beans, and many other crops are HYVs.

Industrial techniques were also applied to livestock production. As the total number of livestock and poultry farms with small numbers of animals declined, fewer but much larger operations increased. Between 1964 and 2012, for example, the number of farms raising cattle declined from over 2 million to just 26,500.25,26 Cattle, pigs, and chickens are now increasingly raised in huge and crowded *confined animal feeding operations* (CAFOs) where their movement is restricted and they are fattened with high-energy feed often containing growth hormones and--until recently banned in the United States by the Food and Drug Administration--growth-promoting antibiotics.

These increases in food crop and animal production have vastly increased the global food supply and improved nutrition for millions of formerly undernourished people. This improvement in global nutrition--and the millions of lives it has saved-- is important to bear in mind as we consider the environmental costs it has incurred. These include the following:27,28

- Depletion of topsoil due to erosion from heavy tilling leading to desertification of once-arable land

- Pollution of soils and water from salt build-up due to excessive irrigation, pesticide and fertilizer residues, animal waste, and other run-off, leading to loss of clean water and abandonment of once-arable land

- Depletion of ground water supplies from irrigation techniques requiring heavy water consumption

- Development of insecticide-resistant species of insects and herbicide-resistant varieties of weeds resulting from intensified use of agrochemical products

- Increased release of greenhouse gases from increasingly mechanized production and from methane released from animals in CAFOs

Beef production is a particular concern. Research data point to the inefficiency of eating meat from grain-fed cattle instead of eating the grains themselves, including in terms of the resources required and the level of greenhouse gas emissions generated. For corn-fed animals, for example, the efficiency of converting grain Calories to meat and dairy Calories ranges from roughly 3% to 40%, meaning that, on average, a crop capable of sustaining four to five people per acre will sustain only one person.29 Livestock production also leads to deforestation, as forests are cut down to clear land for grazing or for production of animal feed. The contribution of meat consumption to global warming and resource depletion is discussed further in the **Nutrition Debate** on page 477.

**Monopolization of Agriculture Reduces Food Diversity**

Industrial agriculture has also reduced **food diversity--**that is, the variety of different species of food crops available. Beginning in the 1960s, revisions of the federal Agricultural Adjustment Act, commonly called the "farm bill," provided financial incentives for America's farmers to grow **monocultures,** single crops cultivated on a massive scale. The number of small farms dwindled, and the remaining industrial operations focused on increasing their production of the few subsidized crops, especially corn, soybeans, wheat, and rice. These few crops then began to monopolize the food supply. Because no subsidies were paid for production of fresh fruits and vegetables, their availability and variety plummeted, and they became more expensive.

As a result of this monopolization, the average American diet lost its variety. As you know, variety is a key component of a healthful diet: different species of fruits, vegetables, and whole grains provide different combinations of nutrients, fiber, and phytochemicals that support our health.

[To learn more about the true costs of livestock production, go to **www.sustainabletableorg.** In the search bar, type "industrial livestock production" to get started.]

[Sidebar: **Green Revolution** The tremendous increase in global productivity between 1944 and 2000 due to selective cross-breeding or hybridization to produce high-yield grains and industrial farming techniques.]

[Sidebar: **high-yield varieties (HYVs)** Semi-dwarf varieties of plants that are unlikely to fall over in wind and heavy rains and thus can carry larger amounts of seeds, greatly increasing the yield per acre.]

[Sidebar: **food diversity** The variety of different species of food crops available.]

[Sidebar: **monoculture** A single crop species cultivated over a large area.]

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Moreover, variety reduces the vulnerability of crops to pests; in contrast, monoculture farming requires heavier application of stronger pesticides. Similarly, because growing the same crop year after year depletes the soil of natural plant nutrients, monocultures require the application of heavy doses of synthetic fertilizers. Finally, different plants respond differently to variations in temperature, rainfall, and other climate conditions. Thus, agricultural variety decreases a region's vulnerability to dramatic food shortages during heat waves, droughts, or other climate events.

The loss of food diversity is not limited to the United States. A 2014 study found that, worldwide, over the past 50 years, national food supplies have become increasingly similar, based on a dwindling number of crop plants, and as a result, global food security is threatened.30

**The Food Industry Influences America's Diet**

When the preliminary report on the *2015-2020 Dietary Guidelines for Americans* was released early in 2015, it proposed to include in the final Guidelines a recommendation that Americans consume less red meat and processed meat. In response, meat industry lobbyists sprang into action, meeting with officials at the USDA and the Department of Health and Human Services (HHS) to request that the Guidelines recommend that Americans eat lean meats. The final Guidelines include seemingly conflicting messages about red and processed meats: one passage assures Americans unambiguously that they are part of a healthful eating pattern, whereas a different passage states that "lower intakes of meats as well as processed meats" are healthful.31

This influence of food industry lobbyists on the American diet is not an isolated incident. The Center for Responsive Politics reports the following spending on lobbying efforts by segments of the food industry in 2015:32

- Livestock: $2.9 million

- Dairy: $7 million

- Sugar: $10.3 million

- Food manufacturers: $18.3 million

- Beer, wine, and liquor: nearly $25 million

Large corporations, from McDonald's to Nestle, may spend $1 million or more annually. Similarly, individuals and political action committees associated with the food and beverage industries contributed almost $16.9 million to the 2014 campaign cycle.32

The food and beverage industries also spend considerable sums to influence voters directly. The soft drink industry, for example, has spent millions of dollars to try to block proposed taxes on sugary drinks in Philadelphia, San Francisco, Berkeley, and New York State. In all but Berkeley, the industry efforts succeeded.

In addition to lobbying, the food and beverage industries influence the American diet through advertising. For example, the Yale Rudd Center for Food Policy and Obesity reports that, in 2012, the fast-food industry spent over $4.6 billion to advertise their products, a figure which is more than 12 times higher than the costs for advertising spent on fruits, vegetables, milk, and bottled water combined.33

Marion Nestle, PhD, MPH, and professor of nutrition at New York University, points out that the bottom line is simple: The U.S. food industry produces about twice as many Calories per capita per year than Americans require; thus, to continue to make a profit, the industry must encourage consumers to overeat.34

**[recap**

Sustainability is the ability to satisfy humanity's basic needs now and in the future without undermining the natural resource base and environmental quality on which life depends. The Green Revolution, a set of innovations in agricultural technologies and practices, has vastly increased the global food supply.]

[Image: Com in the American diet doesn't always look like corn. The French fries are deep-fried in corn oil, the cola and bun are sweetened with high-fructose corn syrup, and corn is commonly used to feed beef cattle..]

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[Its environmental costs include depletion and pollution of soils and water, the evolution of pesticide-resistant insects and weeds, and increased emissions of greenhouse gases. Industrial agriculture has also reduced food diversity and increased the vulnerability of our food supply to pests and climate events. The food industry spends billions of dollars annually on lobbying efforts, campaign contributions, advertising, and other efforts to influence America's diet.]

**LO 5** Discuss international, governmental, philanthropic, corporate, and local initiatives aimed at increasing the world's supply of and access to "good" food.

## **What initiatives are addressing the challenges of "good" food?**

By now it should be clear that everyone, from world leaders to food-industry executives to farmers to consumers, plays a role in addressing the complex and interconnected challenges of ensuring everyone's access to "good" food. The UN acknowledges the efforts of "the international community, national governments, civil society, and the private sector" to eradicate global poverty and ensure universal access to ample, nourishing food.35 Here, we address large-scale efforts to promote food security and sustain-ability. We'll discuss what you can do as an individual in the section that follows.

**Many International Initiatives Increase Access to Nourishing Food**

One of the most effective ways to improve the health and nutrition of children worldwide is to encourage breastfeeding. Breast milk not only provides optimal nutrition for healthy growth of the newborn but also contains antibodies that protect against infections. Moreover, infants who are breastfed exclusively are not exposed to the contaminants that may be present in local water and foods. In 1991, WHO and UNICEF initiated the Baby Friendly Hospital Initiative to increase breastfeeding rates worldwide. Under this initiative, new mothers are educated about the benefits of breast milk, and are encouraged to breastfeed exclusively for the first 6 months of the child's life and as part of the child's daily diet until the child is at least 2 years old.

Breastfeeding is one step among many that can significantly reduce a child's risk for infectious disease. Another important step is supplementation with key micronutrients such as vitamin A, iron, zinc, iodine, and folic acid, all of which are important to the immune system. As part of an international Micronutrient Initiative (MI), the WHO and several other national and international organizations collaborate to provide such supplements to children in developing countries. In addition, programs for deworming and mosquito control combat helminth and malarial infections along with their accompanying iron deficiency.

During famines or other acute food shortages, for example as a result of natural disasters and wars, the United Nations World Food Programme delivers food and other emergency aid. It also helps communities develop new technologies and practices to reduce chronic food shortages and increase resilience in the face of challenging climate conditions. The United States and other nations also donate food and other emergency aid independently.

In addition, many international organizations help improve food security by assisting communities and families to produce their own foods. For example, both USAID and the Peace Corps have agricultural education programs, the World Bank provides loans to fund small business ventures, and many nonprofit and nongovernmental organizations (NGOs) support community and family farms and gardens.

**National and Local Programs Help Nourish Americans**

In the United States, several USDA programs help low-income citizens acquire food over extended periods of time.

[Image: Breastfeeding is highly recommended worldwide.]

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Among these are the SNAP benefits mentioned earlier, which provides an allotment to low-income individuals of all ages to purchase food. In addition, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) helps pregnant women and children to age 5; the National School Lunch and National School Breakfast Programs provide low-income schoolchildren with free or low-cost meals; and the Summer Food Service Program provides meals to low-income children during the summer months.

The USDA's Commodity Supplemental Food Program distributes surplus foods to charitable agencies for distribution to low-income adults at least 60 years of age. The available items are typically limited to shelf-stable foods: canned fruits, vegetables, meats, and fish; dry beans, pasta, and rice and other grains; ready-to-eat cereals; peanut butter; and instant dry milk. Thus, the program is meant to supplement the fresh foods purchased by the individual.

Both federal health agencies and local governments can provide financial incentives to encourage markets selling fresh produce and other healthful foods to move into low-income areas, or to encourage stores already serving the area to offer more healthful foods. The CDC's Healthful Corner Stores initiative, for example, is helping communities from Philadelphia to Sacramento to invest in corner stores to increase city residents' access to healthy foods such as fresh produce. In addition, a new "urban agriculture" movement is helping to decrease the number of food deserts. Across the United States, city governments are changing zoning codes to encourage the cultivation of vegetable gardens on rooftops, in abandoned parking lots, and even as part of the landscaping on municipal properties.

The United States also has a broad network of local soup kitchens and food pantries that provide meals and food items to needy families. They are supported by volunteers, individual donations, and food contributions from local grocery stores and restaurants.

**Sustainable Agriculture Reduces Environmental Impact and Increases Food Diversity**

In response to the environmental problems and loss of food diversity associated with industrial agriculture, a new global movement toward **sustainable agriculture** has evolved. The goal of sustainable agriculture is to develop local, site-specific farming methods that improve soil conservation, crop yields, food security, and food diversity in a sustainable manner. For example, soil erosion can be controlled by **crop rotation,** by terracing sloped land for the cultivation of crops, and by tillage that minimizes disturbance to the topsoil. Organic farming is one method of sustainable agriculture, because to be certified organic, farms must commit to sustainable agricultural practices, including avoiding the use of synthetic fertilizers and toxic and persistent pesticides. Organic meats are produced without the use of antibiotics and hormones for animal growth. Sustainable agriculture also promotes the use of otherwise unusable plants for high-quality animal feed, recycles animal wastes for fertilizers and fuel, and practices humane treatment of animals.

The sustainable agriculture movement has led to an increase in family farms and a variety of farming programs, some of which you probably recognize:

*-* *Family farms.* For three decades, the number of farms in the United States has been decreasing, from 2.48 million in 1982 to 2.11 million in 2012.26 However, since 2007, the number of small farms (1 to 9 acres) has not declined, and in some states, mainly in New England and the Southwest, they have increased. Some small farmers are taking advantage of programs offering land at reduced prices, community support, and mentoring. Many of these small farms are dedicated to organic farming, crop diversity, and other practices of sustainable agriculture.

*-* *Community supported agriculture (CSA).* In CSA programs, a farmer sells a certain number of "shares" to the public. Shares typically consist of a box of produce from the farm on a regular basis, such as once weekly throughout the growing season. Farmers get cash early on, as well as guaranteed buyers. Consumers get fresh, locally grown food. Together, farmers and consumers develop ongoing relationships as they share the bounty in a good year, and the losses when weather extremes or blight reduces yield.

[Image: Eagle Street Rooftop Farm is a 6,000-square foot organic vegetable garden located on top of a warehouse in Brooklyn, New York.]

[Image: Terracing sloped land to avoid soil erosion is one practice of sustainable agriculture.]

[Sidebar: **sustainable agriculture** Term referring to techniques of food production that preserve the environment indefinitely.]

[Sidebar: **crop rotation** The practice of alternating crops in a particular field to prevent nutrient depletion and erosion of the soil and to help with control of crop-specific pests.]

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Although there is no national database on CSA programs, the organization LocalHarvest lists over 4,000.36

*-* *Farmers markets.* There are now more than 8,400 farmers markets in the United States, more than four times the number when the USDA began compiling these data in 1994.37 With the help of the USDA, many farmers markets are now able to accept SNAP benefits for payment. Thus, farmers markets are helping to increase everyone's access to nourishing food.

*-* *School gardens.* The School Garden Association of America was founded in 1910, and during World Wars 1 and II, school gardening became part of the war effort; however, in the postwar decades, school gardens dwindled. Recently, school garden programs have been increasing across the United States. In addition to introducing students to a variety of fruits and vegetables and promoting their acceptance, school garden programs teach valuable lessons in nutrition, agriculture, and even cooking. In many schools, cafeterias incorporate the foods into the school lunch menu.

*-* *Slow food.* Experts in sustainable agriculture and public health are increasingly challenging our loss of food quality and diversity by advocating "slow food"; that is, nutritious, fresh food produced in ways that preserve biodiversity, sustain the environment, ensure animal welfare, and are affordable by all while respecting the dignity of labor from field to fork.38 Slow food, to the extent possible, is locally grown, a term that typically refers to food grown within a few hundred miles of the consumer. Although growing a healthful variety of local food from fall through spring is not possible in cold climates, consuming local food when available limits energy use and greenhouse gas emissions from transportation (so-called "food miles"). Also, because these foods move much more quickly from farm to table, they tend to be fresher, retaining more of their micronutrients.

**Corporate and Philanthropic Initiatives Are Promoting "Good" Food**

Many individuals and venture capital firms are now investing in food technologies dedicated to increasing food security and preserving human health and the environment. Howard Buffett, son of investor Warren Buffett, is supporting no-till farming, crop rotation, and other techniques of sustainable agriculture to help relieve food insecurity in Africa, whereas philanthropist Bill Gates is supporting companies producing vegan versions of chicken, eggs, and other high-protein foods. Other investors are funding indoor agricultural growing systems that do not require soil, food-waste recycling programs, crop monitoring systems that identify specific pests and reduce the random use of pesticides, and services that bring fresh produce from local farms directly to consumers' doors.

Whereas many smaller natural-food companies have long made "good" food part of their company identity, only recently has this goal moved into corporate America. In the past few years, Walmart, Kellogg's, McDonald's, and several other corporations have begun to partner with local growers to promote sustainable agriculture, and in 2016, Walmart modestly increased their workers' minimum wage to $10 per hour.

**[recap**

Programs encouraging breastfeeding and providing micronutrient supplementation can significantly improve children's nutrition and reduce their risk for infectious disease. The World Food Programme and other efforts provide emergency food aid and support for investments in long-term food security. In the United States, SNAP, the Commodity Supplemental Food Program, the Healthy Corner Stores initiative, and many other national and local programs help increase access for low-income Americans to nourishing food. The goal of sustainable agriculture is to develop local, site-specific farming methods that improve soil conservation, crop yields, food security, and food diversity in a sustainable manner. Some of its more familiar efforts are organic farming, farmers markets, school gardens, and slow food. Individual investors and corporations are beginning to support or implement initiatives aimed at increasing the equity, sustainability, and quality of America's food.]

[Find a farmers market near you! Go to the USDA's Agricultural Marketing Service home page at **http://www.ams.usda.gov.** Type "National Farmers Market Directory" in the search bar to get started.]

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**LO 6** Identify several steps you can take to promote production of and access to "good" food.

## **How** **can you promote "good" food?**

This chapter has reviewed only a handful of the thousands of local to global initiatives comprising the so-called "food movement," in which millions of ordinary consumers are involved. Here, we review some simple steps you can take to join them.

**Support Food Security**

Have you ever wondered whether efforts you make locally can help feed people thousands of miles away? Let's take a look.

Eating just the Calories you need to maintain a healthful weight leaves more of the global harvest for others and will also likely reduce your use of medical resources. So to raise your consciousness about the physical experience of hunger, try turning off your cell phone and other devices and keeping silent during each meal for a day, so that you can more fully appreciate the food you're eating and reflect on those who are hungry. Also check in with your body before and as you eat: are you really hungry, and if so, how much and what type of food does your body really need right now?

Try to stay aware of how much food you throw away, and ask yourself why. Do you put more food on your plate than you can eat? Do you purchase more food than you can eat and as a result, allow foods stored in your refrigerator to spoil?

Join a community garden or shared farming program, with the goal of donating a portion of your produce each week to a local food pantry. While you're there, consider volunteering to help!

Donate to or raise money for one of the international agencies that work to relieve global hunger. Or join other students fighting food insecurity in the United States by becoming a member of the National Student Campaign Against Hunger and Homelessness. Visit www.studentsagainsthunger.org to learn more. The hungry people you work to help might be closer than you think. A recent study of over 4,000 community college students found that, in the previous 30 days, 22% had gone hungry because of lack of money.39 One way to help such students is to advocate for an on-campus food bank. Contact the College and University Food Bank Alliance for more information, at www.cufba.org.

Whatever you do, get the word out! If you find an organization whose goals you share, recommend them on your social networking page. Or send a short article about the organization's work to your campus news site, with suggestions about how other students can support their work.

**Purchase Fair Trade Goods**

The **fair trade** movement was born in response to the exploitation of farm laborers around the world. It began decades ago in North America and Europe, and has become a global effort that depends on support from consumers worldwide to purchase fruits, vegetables, coffee, tea, cocoa, wine, and many other products that display the Fair Trade Certified logo40 **(FIGURE 13.3).** Fair trade empowers farm laborers to demand living wages and humane treatment. It also reduces child labor and increases children's access to education, because parents earning higher wages are able to allow their children to leave the fields and attend school. Profits from fair trade purchases also support the building of schools and health clinics, provide funds to help farmers adopt sustainable agricultural practices, and provide financial assistance to women so they can set up small businesses.40

The choices you make when you shop can contribute to food equity, because your purchases influence local and global markets. To support equitable production worldwide, purchase Fair Trade goods whenever possible, whether at your grocery store or shopping online. The Fair Trade USA website has a handy shopping guide where you can check out what's available, from hundreds of brands of coffee to chocolate, produce, and even fair trade clothing!

**[FIGURE 13.3** The Fair Trade Certified logo guarantees that the product has been produced equitably without exploitation of workers or the environment.]

[Sidebar: **fair trade** A trading partnership promoting equity in international trading relationships and contributing to sustainable development by securing the rights of marginalized producers and workers.]

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**Choose Foods That Are Healthful for You and the Environment**

Any grocery store manager will tell you that your purchases influence the types of foods that are manufactured and sold. In our global economy, your food choices can even influence the types of foods that are imported. So to the extent that you can:

- Buy organic foods to reduce the use of synthetic pesticides and fertilizers.

- Buy produce from a local farmers market to encourage greater local availability of fresh foods. This reduces the costs and resources devoted to distribution, transportation, and storage of foods.

- Choose whole or less processed versions of packaged foods. This encourages their increased production and saves energy.

- Look to see if your grocery store displays candy and other junk foods at children's eye level--for example, beside the check-out line. If it does, complain to the store manager.

- Avoid empty-Calorie foods and beverages when you're shopping and eating out to discourage their profitability.

- When you eat at a fast-food restaurant, ask for information about the nutritional value of their menu items. Analyze the information. If you see aspects that concern you, take a few minutes to send the company an email sharing your concerns and asking for improved recipes.

In a recent national survey, 33% of college students said that their finances were "traumatic or difficult to handle."41 If you're one of them, you might be concerned that purchasing organic, local, and whole foods is beyond your budget. If so, you should know that healthful eating doesn't always have to be expensive. Some of the lowest-cost foods currently available in stores are also some of the most nutritious. To find them, check out the **Quick Tips** on this page.

**Quick Tips**

**[Spending Less to Eat Right**

Buy whole grains, such as cereals, brown rice, and pastas in bulk-- they store well for longer periods and provide a good base for meals and snacks.

Buy fresh fruits and vegetables in season; otherwise, buy them frozen. They're just as healthful as fresh vegetables, require less preparation, and are typically cheaper.

If lower-sodium options of canned beans and other vegetables are more expensive, buy the less expensive regular option and drain the juice from the vegetables before cooking.

Consume leaner meats in smaller amounts--by eating less, you'll not only save money but reduce the environmental costs of your meal while still obtaining the nutrients that support good health.

Choose frozen fish or canned salmon or tuna packed in water as an alternative to fresh fish.

Avoid frozen or dehydrated prepared meals. They are usually expensive; high in sodium, saturated fats, and energy; and low in fiber and important nutrients.

Buy generic or store brands of foods--be careful to check the labels to ensure that the foods are similar in nutrient value to the higher-priced options.

Cut coupons from local newspapers and magazines, and watch the sale circulars, so that you can stock up on healthful foods you can store.

Consider cooking more meals at home; you'll have more control over what goes into your meals and you'll be able to cook larger amounts and freeze leftovers for future meals.

Some specialty foods (such as organic or imported products) can be expensive, but lower-cost alternatives can be just as nutritious.]

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The amount of meat you eat also affects the environment and the global food supply, because the production of plant-based foods uses fewer natural resources and releases fewer greenhouse gases than the production of animal-based foods. To promote reduced meat consumption on campus, talk with your food services manager about sponsoring "Meatless Mondays." See the **Web Links** for a link to the Meatless Monday website, where you can download a *Meatless Monday Goes to College* toolkit. For more information on the link between meat production and climate change, see the **Nutrition Debate** on the following page.

Pay attention to packaging. As we discussed in Chapter 7, plastics often end up in landfills or as ocean debris. Moreover, their manufacture uses energy and releases greenhouse gases. So resist the urge to purchase a six-pack of bottled water, and purchase a reusable stainless steel or other BPA-free water bottle instead. If you don't like the taste of tap water, install an inexpensive carbon filter on your faucet to improve the taste. In general, purchase foods with the least packaging possible. For instance, skip the bakery products in plastic trays, purchase milk in cartons instead of plastic, and get your take-out from restaurants that use paper containers instead of polystyrene (Styrofoam) or other types of plastic. You won't be able to entirely avoid purchasing foods in plastic packaging, of course, so make it a habit to recycle those you do buy. Finally, carry your food purchases home in your own washable canvas bags.

You know that physical activity is important in maintaining health, but walking, biking, and taking public transportation also limit your consumption of nonrenewable fossil fuels and the emission of greenhouse gases. When it's time to purchase a car, research your options and choose the one with the best fuel economy. With the recent fall in gas prices, the price of many electric vehicles has been falling, too. But electric vehicles aren't your only option, as fuel economy has been improving on traditional vehicles for years. To research the average miles-per-gallon on a new or used car you're considering, visit the U.S. Department of Energy's www.fueleconomy.gov.

As Francis Moore Lappe, author of the groundbreaking *Diet for a Small Planet,* explains, the food movement encourages us to think with an "eco-mind," refusing to accept scarcity, oppression, pollution, and depletion of natural resources in the name of production and profit. By promoting the values of equity, sustainability, and quality, the food movement encourages us to make choices in ways that can positively change our world.42

**[recap**

Increasing your awareness of your own food cues and food waste can help motivate you to make choices that reduce your use of resources. Consider donating to or volunteering for a food relief organization, or advocating for a food bank on campus. Make fair trade purchases whenever possible, and when you're shopping for food, eating at your campus dining hall, or eating out, choose and request healthful foods. Consider eating vegetarian meals at least one day a week, reduce your purchases of foods in plastic packaging, and walk, bike, or take public transportation as often as possible.]

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**nutrition debate** **Meat Consumption and Climate Change: Tofu to the Rescue?**

[The surge in the world's population has been accompanied by increased meat consumption, particularly in nations transitioning out of poverty. In the United States, we consumed 24.1 billion pounds of beef in 2014.43 Why is this a concern?

According to the Food and Agricultural Organization of the United Nations, globally, livestock production generates 18% of the greenhouse gases (GHGs) responsible for global warming.44 These GHGs include not only carbon dioxide (CO2), but methane (CH4), which livestock release through belching, flatulence, and their manure. The global-warming potential of CH4 is 23 times greater than that of CO2 over a 100-year period.44

Other emissions of concern in livestock production are reactive nitrogen compounds (Nr), which have nearly 300 times the global warming potential of CO244 and contribute to smog and acid rain, damaging crops and decreasing biodiversity.

So precisely how different are emissions from beef versus plant foods? One of the most recent studies to tackle this question found that beef production releases 5 to 6 times more GHGs than the average of four other animal-based foods (pork, poultry, eggs, and dairy).45 However, as compared to the average of three plant-based foods (wheat, potatoes, and rice), the emissions from beef production are far greater **(FIGURE 13.4).**

The Cattlemen's Beef Board and National Cattlemen's Beef Association website offers a different perspective.46 They state that GHGs released by U.S. beef production represent 3% of all U.S. GHG emissions, versus 26% for transportation. Still, comparing cows to cars may be more distracting than helpful.

**[FIGURE 13.4** Comparison of resource use and emissions for beef versus plant foods.

*Source:* Data from Eshel, G., A. Shepon, T. Makov, and R. Milo. 2014. Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *PNAS* 111 (33); 11996-12001. doi: 10.1073/pnas. 1402183111]

We choose what to eat several times a day, and each of these choices can either contribute to or help mitigate climate change.

In addition to being a major source of GHG emissions, livestock production contributes to land degradation, using 30% of the earth's land surface for pasture or feed production.47 The analysis mentioned earlier found that beef production uses 28 times more land than non-meat animal foods and 160 times more land than plant foods.45 This loss has global effects, as it reduces the capture of CO2 performed by plants during photosynthesis. Livestock's presence in vast tracts of land and its demand for feed crops also have contributed significantly to a reduction in biodiversity and a decline in ecosystems.

Another environmental concern is the effect of livestock production on the global water supply. Beef production uses 11 times more water than non-meat animal foods and 8 times more water than plant foods.45 Moreover, animal waste can run off into neighboring waterways and onto irrigation fields used to produce crops for human consumption.

Although some individuals choose vegetarianism to protect the environment, it is not practical or realistic to expect every human around the world to adopt this lifestyle. Animal products provide important nutrients: the beef industry website points out that a 3-ounce serving of beef supplies 51 % of the Daily Value (DV) for protein, 38% of the DV for zinc, and 14% of the DV for iron.46

Still, if most Americans were to reduce their consumption of meat even modestly, the change would have a powerful collective impact. A 2014 study of the contribution of a variety of 2,000 kcal diets to climate change concluded that reducing meat consumption could "make a valuable contribution to climate change mitigation."48 Moreover, as we noted earlier in this chapter, replacing meat with plant proteins would improve food security because, Calorie for Calorie, growing crops for human consumption rather than conversion to meat is much more efficient.

As researchers debate the precise extent of environmental harm attributable to meat consumption, one thing is clear: You can help reduce the damage, starting with your next meal.

**CRITICAL THINKING QUESTIONS**

1. Given the accelerated pace of climate change, as well as land and water degradation, do we have an ethical responsibility to others with whom we share the planet, especially children, to reduce our consumption of meat?

2. What adverse impact might reducing meat consumption have on farmers and ranchers? Would this be greater or worse than the impact of climate change?

3. Would eating less meat be practical for you? Why or why not?]

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**[TEST YOURSELF** *ANSWERS*

**1** **T** In 2014, the most recent year for which data is available, 5.6% of U.S. households experienced very low food security, meaning that at least some members of those households reduced food intake because of insufficient money or other resources.

**2 F** The occupational fatality rate for U.S. farm workers is seven times higher than the average for workers in other industries.

**3** **F** Methane emissions are 23 times more potent greenhouse gases than carbon dioxide. In the United States, beef production alone is responsible for 18% of all methane emissions.]

**review questions**

**LO 1 1.** Which of the following statements about food insecurity is true?

a. Between 1990-92 and 2014-16, the share of undernourished people worldwide fell by nearly 45%.

b. About 64% of the world's hungry people live in Africa.

c. About 14% of U.S. children experience hunger.

d. The greatest prevalence of very low food security in the U.S. is in inner cities in the Northeast.

**2.** The leading cause of longstanding hunger in a region is

a. famine.

b. war.

c. unequal distribution of food, largely because of poverty.

d. overpopulation.

**LO 3** 3. Which of the following statements about food system labor is true?

a. In many states in the United States, grocery store cashiers may lawfully be paid just $2.13 an hour.

b. A majority of contingent farm workers in the United States live below the poverty line.

c. On average, nearly 100 workers die each year from farm-labor injuries in the United States.

d. About 1 out of every 50 full-time workers in the United States receives government assistance.

**LO 4** 4. Which of the following statements about the Green Revolution is true?

a. It has increased global production of organic foods.

b. It has dramatically increased food security throughout South America, Asia, and Africa.

c. It has ended the loss of topsoil that had been common with traditional farming methods.

d. It has reduced the depletion and pollution of ground water.

**LO 4 5.** Which of the following statements about the food industry is true?

a. The only crop that U.S. farmers receive subsidies to grow is corn.

b. The food industry spends about $4.6 billion a year on advertising.

c. The U.S. food industry produces about twice as many Calories per capita per year than Americans require.

d. All of the above are true.

**LO 5 6.** Of the following federal programs, which provides food assistance to low-income individuals of all ages?

a. the National School Lunch Program

b. the Special Supplemental Nutrition Program for Women, Infants, and Children

c. the Commodity Supplemental Food Program

d. the Supplemental Nutrition Assistance Program (SNAP)

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**LO 6 7.** Which of the following purchases would optimally support food equity, sustainability, and quality?

a. a fair trade certified t-shirt

b. a bottle of cherry soda you buy at a farmers market

c. a certified organic beef burger on a whole-grain bun from an organic foods restaurant

d. a pint of strawberries you pick yourself at an organic farm

**LO 1 8.** **True or false?** Adults over age 65 years are at greatest risk for food insecurity in the United States.

**LO 3** **9. True or false?** The blackberries on your morning cereal could have been harvested by a 12-year-old.

**LO 5 10.** **True or false?** Crop rotation and terracing are farming methods used in sustainable agriculture.

**math review**

**LO 3 11.** In the Rodgers family, Steve works 40 hours a week, all year, at a fast-food restaurant. He earns the federal minimum wage of $7.25. He has one week of paid vacation a year. Steve and his wife, Diane, have struggled to make ends meet since the birth of their son, now 5 months old, so Diane has decided to return to work at the same fast-food restaurant where her husband works. They have decided to stagger their schedules in order to avoid the cost of daycare for their son. The federal poverty threshold in 2016 was $20,160 for a family of three. Answer these questions: Are Steve, Diane, and their son currently living above, at, or below the federal poverty line? If Diane were to return to work 40 hours a week, would the family be characterized as at increased risk for food insecurity? Why or why not?

*Answers to Review Questions can be found online in the MasteringNutrition Study Area.*

**web links**

**www2.epa.gov/learn-issues/green-living**

Environmental Protection Agency's Sustainability Tips

*This site offers a wide variety of tips and tools to help you reduce your environmental footprint.*

**www.freefromhunger.org**

Freedom from Hunger

*Visit this site to learn about an established international development organization, founded in 1946, that works toward sustainable self-help against chronic hunger and poverty.*

**www.fooddemocracynow.org**

Food Democracy Now

*Visit this grassroots community dedicated to building a sustainable, equitable food system.*

**www.slowfoodusa.org/**

Slow Food USA

*Slow Food links the pleasure of growing, preparing, and consuming food with commitment to our communities and environment. Visit this site to learn more about the slow food movement and get involved.*

**www.fairtradeusa.org**

Fair Trade USA

*Visit this website to find out why "Every Purchase Matters!"*

**www.meatlessmonday.com/**

Meatless Monday

*This website offers information on the environmental and health benefits of going meatless one day a week, as well as recipes for vegetarian meals and a toolkit to promote Meatless Mondays on your campus.*

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# **in** **depth 13.5** **Malnutrition**

***After studying this In Depth, you should be able to:***

**1** Describe the health and societal problems associated with undernourishment, pp. 481-483.

**2** Explain how obesity can result from limited access to nourishing food, pp. 483-485.]

**Hailey knows she should eat more fresh fruits and vegetables, but she doesn't have a car, and the nearest grocery store is several miles away, over busy roads without sidewalks.** Besides, she tells herself, even if she took the bus there, she wouldn't be able to afford fresh produce. The few dollars in her purse have to last until the end of the month. And she's running out of her blood pressure medication, and owes her landlord last month's rent. Still, she's hungry. So she walks two blocks to a corner store where she purchases a steamed hot dog and a large bag of corn chips.

Why would someone with very little money purchase foods that are not nutritious? Why are so many of the world's poor--whether they live in developing nations or the United States--obese?

We begin this **In Depth** essay by discussing the broad range of health and societal problems linked to undernourishment, the most dramatic form of malnutrition. We then explore a variety of theories attempting to explain the troubling link between obesity and limited access to nourishing food.

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## **What problems are linked to undernourishment?**

**LO 1** Describe the health and societal problems associated with undernourishment.

Undernourishment may mean that an individual is unable to consume adequate energy to maintain weight and physiologic functioning; or the individual may consume enough energy, but experience deficiencies of one or more nutrients. In some cases, especially in wealthier nations, limited access to nourishing foods can actually promote simultaneous obesity and deficiency--in an individual who has an excessive intake of high-energy, nutrient-poor foods.

**Low Energy Intake Promotes Wasting, Stunting, and Mortality**

About 51 million children worldwide don't weigh enough for their height.1 This is because they suffer from **severe acute malnutrition (SAM),** a condition in which energy intake is so inadequate that the child experiences **wasting,** a lower than expected body weight. Approximately 161 million of the world's children also experience **stunted growth;** they are shorter than expected for their age.1 Stunting occurs when energy intake or specific nutrients are inadequate to sustain normal linear growth. In some impoverished communities, the great majority of residents are very short and small; thus, community members may not perceive their stunted growth as unusual or recognize it as a sign of chronic undernourishment.

[Image: Wasting (extreme thinness) and stunting (short stature for age) are commonly seen in undernourished children.]

SAM also dramatically increases a population's rate of **maternal mortality** (deaths of a woman during pregnancy, childbirth, or in the immediate postpartal period) and **infant mortality** (the death of infants between birth and 1 year). For example, the infant mortality rate in industrialized countries of Western Europe ranges from about 2 to 5 per 1,000, whereas in Afghanistan and Mali, two of the world's poorest countries, the infant mortality rate is more than 100 per 1,000.2

Worldwide, 43 of every 1,000 children die before reaching age 5. About 45% of these deaths of young children are due to malnutrition.3 Decreased resistance to infection as a result of undernourishment is a leading factor in these deaths.3 Protein and many micronutrients are essential to an effective immune response; therefore, in undernourished children, infections occur more frequently and take longer to resolve. These prolonged infections exacerbate malnutrition by decreasing appetite, causing vomiting and diarrhea, producing weight loss, and further weakening the immune system. A vicious cycle of malnutrition, infection, worsening malnutrition, and increased vulnerability to infection develops. **FIGURE 1** (page 482) summarizes the effects of SAM throughout the life cycle.

**Micronutrient Deficiencies Lead to Preventable Diseases**

In impoverished countries, micronutrient deficiencies are major public health concerns. These are some of the most severe:

- Iron deficiency is the most common micronutrient deficiency in the world.4 Although it occurs in both males and females of all ages, it is more prevalent in pregnant women and young children because of the demands of fetal and childhood growth. Iron-deficiency anemia contributes to 20% of maternal deaths.

- Prenatal iodine intake is particularly important for fetal brain development, and severe iodine deficiency is the single largest cause of preventable mental impairment worldwide.

[Sidebar: **severe acute malnutrition (SAM)** A state of severe energy deficit defined as a weight for height more than 3 standard deviations below the mean, or the presence of nutrition-related edema.]

[Sidebar: **wasting** A physical condition of very low body-weight-for-height or extreme thinness.]

[Sidebar: **stunted growth** A condition of shorter stature than expected for chronological age, often defined as 2 or more standard deviations below the mean reference value.]

[Sidebar: **maternal mortality** A population's rate of deaths of a woman during pregnancy, childbirth, or in the immediate postpartal period.]

[Sidebar: **infant mortality** A population's rate of death of infants between birth and 1 year of age.]

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[**FIGURE 1** Acute and long-term effects of chronic undernourishment throughout the life cycle.]

Nearly a third of the world's population is iodine deficient.5 Iodine-deficiency disorders have largely been eliminated in areas of the world with access to iodized salt or oil, and areas where iodine is added to irrigation water.

- Vitamin A deficiency is the leading cause of blindness in children.4 An estimated 250 million children worldwide are vitamin A deficient. In addition, because vitamin A supports immune function, these children are highly vulnerable to severe, often fatal infections. The WHO and other global health agencies provide vitamin A supplements, promote breastfeeding, and support family and community vegetable gardens. These efforts have reduced mortality by 23%.4

**Undernourishment Promotes Socioeconomic Problems**

Undernourishment has long been known to diminish work capacity. Iodine, vitamin B12, folate, certain essential fatty acids, and many other nutrients contribute to the development and maintenance of a healthy nervous system; thus, undernourishment--especially during fetal development, infancy, and early childhood--can permanently reduce cognitive functioning and an individual's ability to contribute to a community's economy.

[Image: In developing nations, providing vitamin A supplements twice a year to children under age 5 has significantly reduced mortality.]

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## **nutri-case LIZ**

"It was really hard spending last summer with my parents, because we kept arguing over food! Even though I'd told them that I'm a vegetarian, they kept serving meals with meat! Then they'd get mad when I'd fix myself a hummus sandwich! When it was my turn to cook, I made lentils with brown rice, whole-wheat pasta primavera, vegetarian curries, and lots of other yummy meals, but my dad kept insisting, 'You have to eat meat or you won't get enough iron!' I told him that plant foods have lots of iron, but he wouldn't listen. Was I ever glad to get back onto campus this fall!"

Recall that Liz is a ballet dancer who trains daily. If she eats a vegetarian diet including meals such as the ones she describes here, will she be at risk for iron deficiency? Why or why not? Are there any other micronutrients that might be low in Liz's diet because she avoids meat? If so, what are they? Overall, will Liz get enough energy to support her high level of physical activity on a vegetarian diet? How would she know if she were low energy?

Similarly, the vision loss caused by vitamin A deficiency can severely limit an individual's work capacity.

Inadequate energy intake and micronutrient deficiency can also prompt debilitating weakness, which is especially detrimental when manual labor is the main source of income. The reduced earning capacity of poor, undernourished adults often regenerates a cycle of poverty onto the next generation. Iron-deficiency anemia is particularly debilitating because of iron's role in oxygen transport. Because iron deficiency is a problem among women of childbearing age in both developed and developing countries, it is a global drain on work capacity and productivity.

## **How could limited access to good food promote obesity?**

**LO 2** Explain how obesity can result from limited access to nourishing food.

Throughout the world, the prevalence of obesity is increasing at an alarming rate and, along with it, obesity-related chronic diseases. The WHO estimates that the worldwide prevalence of obesity more than doubled between 1980 and 2014. Currently, 1.9 billion people worldwide are overweight, and 600 million of these are obese. Moreover, overweight and obesity are now linked to more deaths worldwide than underweight.6

Obesity used to be considered a disease of affluence, but in recent decades, public health researchers have observed an increasing prevalence of obesity in impoverished communities. If food is still scarce in many developing nations, how has the global rate of obesity more than doubled? And if an individual is poor and undernourished, how could he or she also be obese? Let's explore these two paradoxes.

**A Nutrition Paradox Is Evident in Transitioning Populations**

The **nutrition paradox** is characterized by the coexistence of stunting and overweight/obesity within the same region, the same household, and even the same person. People born in developing nations who were undernourished when young are likely to be short (due to growth stunting) but experience rapid weight gain when their country transitions out of poverty. The nutrition paradox is especially common in China, India, Mexico, and South America. In Colombia, for example, 5 % of households have both an overweight or obese mother and a stunted child, and in Ecuador, researchers found that 2.8% of children nationwide exhibited both stunting and overweight or obesity.7,8

The WHO identifies two key factors behind the nutrition paradox in transitioning nations:6

*A trend toward decreased physical activity* due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization.

*A global shift toward increased consumption of energy-dense foods* high in saturated fats and added sugars but low in micronutrients and fiber.

In effect, all nations have been exposed to a nutritional transition over the past 30 years, as international food companies have made processed, energy-dense foods available at lower cost to more people worldwide.

Another factor contributing to the nutrition paradox may be poor nutrition in previous generations in a population. Maternal undernourishment certainly affects the mother's offspring *in utero,* but researchers are increasingly convinced that the effect continues throughout childhood, into adulthood, and probably into succeeding generations.

[Sidebar: **nutrition paradox** The coexistence of aspects of both stunting and overweight/obesity within the same region, household, family, or person.]

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This "fetal origins of adult disease" theory proposes that biological adjustments to poor maternal nutrition made by a malnourished fetus as its organs are developing may be helpful to the child during times of food shortages, but make the child susceptible to obesity and chronic disease when food is plentiful. For example, when a mother is malnourished during the pregnancy, her baby will tend to have a low birth weight but be relatively fat. This occurs because the fetal body preserves fat tissue as a source of energy for growth of the brain; as a result, muscle tissue is reduced. The imbalance promotes abdominal adiposity and metabolic disease later in life; there is now significant evidence supporting this theory. (See the In Depth essay following Chapter 14, pages 524-527, for a detailed discussion of this theory.)

These effects can also be passed on to future generations when affected children of the current generation grow up and start their own families. For this reason, immigrants to richer nations and the poor in developing nations may need four or more generations of improved conditions to overcome all past risks for both short stature and overweight.

**Physical and Socioeconomic Factors May Promote Obesity Among the Poor**

Could poverty be an independent risk factor for obesity? Even among established (non-immigrant) populations in developed nations, some research has suggested a **poverty-obesity paradox** in which obesity is more prevalent in low-income populations. In the United States, for example, studies following children over time have found that a reduction in family income during early childhood increases the child's risk for becoming overweight or obese, whereas a shift to a higher family income increases the likelihood of weight loss.9,10 Some researchers have also observed a so-called *hunger-obesity paradox,* in which low-income people are obese while also deficient in one or more nutrients, and in some cases even hungry. For example, the studies in Columbia and Ecuador cited earlier found an increased prevalence of iron-deficiency anemia in impoverished households whose members were also overweight or obese.

What factors could explain these associations? Research is inconclusive, but several hypotheses are being studied. One of the most common hypotheses proposes that low-income people purchase energy-dense foods with longer shelf lives, such as vegetable oils, sugar, refined flour, snack foods, soft drinks, and canned goods, because they are less expensive than perishable foods such as meats, fish, milk, and fresh fruits and vegetables. Choosing such inexpensive, shelf-stable foods may be an important money-saving strategy especially for the rural poor.

A second hypothesis suggests that individuals with limited money to spend are more likely to purchase low-cost, high-volume, energy-dense foods high in carbohydrates and fats, and low in protein. An adequate level of protein intake triggers the body's satiety mechanisms. Thus, in order to reach satiety, individuals who choose cheap foods low in protein end up consuming more total Calories than they would if they were to consume foods higher in protein.11,12

Third, the link between obesity and poverty might be explained in part by stress. That is, the stress of having insufficient resources to meet day-to-day expenses results in chronic release of stress hormones--such as **Cortisol--**that slow metabolism and increase appetite, while simultaneously prompting short-sighted decision-making.13,14 Moreover, some research suggests that self-control itself is a limited resource. People who must continually make difficult economic decisions may "deplete" their ability to make thoughtful, healthful decisions around eating.15 Thus, the person may be more likely to overeat or eat empty-Calorie "comfort foods." A recent study also suggests that sugar may be particularly appealing to people experiencing chronic stress: Sugar consumption appears to trigger a negative feedback loop that "turns off" the stress response, prompting a measurable decrease in Cortisol levels. In other words, for people under stress, sugar may be calming.16

Fourth, low-income people's high rates of obesity may reflect their environment. Many obese people live in so-called **food deserts,** defined by the USDA as geographic areas where people lack access to fresh, healthful, and affordable food.17 Rural food deserts may have no access to any foods, whereas inner-city food deserts may be served only by fast food restaurants and convenience stores that offer few healthful options. A recent study of more than 18,000 U.S. households in 2,100 counties found a significant association between residence in a food desert and prevalence of obesity, even when controlling for other factors such as the food environment within the home.18 The USDA's Economic Research Service estimates that 23.5 million Americans live in food deserts.17

[Do you live in a food desert? Go to the USDA site, **http://ams.usda.gov/** and type in "food desert" in the search box to find out!]

[Sidebar: **poverty-obesity paradox** The high prevalence of obesity in low-income populations.]

[Sidebar: **food desert** A geographic area where people lack access to fresh, healthful, and affordable food.]

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[Image: "Food deserts" are geographic areas where people lack access to affordable, nutritious food, typically because of an absence of grocery stores.]

More than half of those people (13.5 million) are low-income. Living in a food desert might limit not only options for nourishing food but also options for physical activity; that is, a neighborhood that is separated from the nearest supermarket by freeways is also likely to have low walkability.15

In summary, then, although not all factors contributing to the coincidence of poverty and obesity are entirely clear, there is now substantial evidence of a global burden of overweight and obesity among the poor.

**web links**

**www.care.org**

Care

*Since 1945, this organization has been working to relieve hunger and improve economic conditions around the world.*

**www.feedingamerica.org**

Feeding America

Visit *this site to learn more about hunger and poverty in the United States, and click on Map the Meal Gap to find levels of food insecurity in your state and county.*

**www.unicef.org/nutrition**

United Nations Children's Fund

*Visit this site to learn about international concerns affecting the world's children, including nutrient deficiencies and hunger.*

**www.who.int/nutrition/en**

World Health Organization Nutrition

*Visit this site to learn about global malnutrition, micronutrient deficiencies, and the nutrition transition.*

**www.ers.usda.gov**

Economic Research Service

*The ERS plays a leading role in research into food insecurity in the United States. Visit their page entitled Food Security in the U.S. for annual updates and related reports.*

**endseniorhunger.aarp.org**

AARP Drive to End Hunger Campaign

*Visit this site and click on the Recent Research tab to access AARP's report on food insecurity among older Americans.*

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[**test yourself**

**1.** **T F** A pregnant woman needs to consume twice as many Calories as she did prior to the pregnancy.

**2. T F** Breast-fed infants tend to have fewer infections and allergies than formula-fed infants.

**3. T F** Most infants begin to require solid foods by about 3 months (12 weeks) of age.

*Test Yourself answers are located in the Study Plan at the end of this chapter.*]

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# **CHAPTER 14**

**Nutrition Through the Life Cycle Pregnancy and the first year of life**

**[learning outcomes**

***After studying this chapter you should be able to:***

**1** Explain how a healthful diet supports conception and normal embryonic and fetal development, pp. 488-494.

**2** Identify the nutrient recommendations that change during pregnancy, pp. 494-499.

**3** Discuss some common nutrition-related concerns of pregnancy as well as recommendations for engaging in exercise,

pp. 499-505.

**4** Describe the physiology of lactation and the nutrient recommendations for lactating women,

pp. 505-508.

**5** Identify the advantages and challenges of breastfeeding, pp. 509-513.

**6** Relate the growth and activity patterns of infants to their nutrient needs and the nutrient profile of infant formulas, pp. 513-518.

**7** Discuss some common nutrition-related concerns for infants, pp. 518-520.]

**The birth of baby Tomas brought joy to his parents and extended family.** However, little Tomas weighed just over 3 pounds, 5 ounces at birth--about half of what an average full-term newborn weighs. Fortunately, with early nutrition support in the neonatal intensive care unit, Tomas gained weight rapidly and within two weeks was discharged home.

Although the United States has an extensive and expensive healthcare system, the prevalence of low-, very-low-, and extremely low-birth-weight infants, such as Tomas, remains around 8%.1 In addition, the U.S. infant mortality rate is just over 6 infant deaths for every 1,000 live births,2 a number that is higher than that of many other developed nations, including most countries of Europe.

What contributes to these troubling statistics? More broadly, what role does prenatal diet play in determining the future health and well-being of the child? In this chapter, we'll discuss how adequate nutrition supports embryonic and fetal development, maintains a pregnant woman's health, and contributes to lactation. We'll then explore the nutrient needs of breastfeeding and formula-feeding infants.

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**LO 1** Explain how a healthful diet supports conception and normal embryonic and fetal development.

## **How** **does a healthful diet support conception and gestation?**

From conception through the end of the first year of life, adequate nutrition is essential for tissue formation, neurologic development, and bone growth, modeling, and remodeling. The ability to reach peak physical and intellectual potential in adult life is in part determined by the nutrition received during the earliest stages of development.

**A Healthful Diet Is Critical Before Conception**

Several factors make adequate nutrition important even before **conception,** the point at which a woman's ovum (egg) is fertilized with a man's sperm. First, some deficiency-related problems develop extremely early in the pregnancy, typically before the mother even realizes she is pregnant. An adequate and varied preconception diet reduces the risk for such early onset problems. For example, inadequate levels of folate during the first few weeks following conception can result in brain and spinal cord defects. This problem is discussed in more detail shortly. To reduce the incidence of such defects, federal guidelines advise all women capable of becoming pregnant to consume 400 µg of folic acid daily, whether or not they plan to become pregnant.

Second, adopting a healthful diet prior to conception includes the avoidance of alcohol, illegal drugs, and other known **teratogens** (substances that cause birth defects). Women should also consult their healthcare provider about their consumption of caffeine, medications, herbs, and supplements, and if they smoke they should attempt to quit.

Third, a healthful diet and an appropriate level of physical activity can help women achieve and maintain an optimal body weight prior to pregnancy. Women with a prepregnancy body mass index (BMI) between 19.8 and 26.0 kg/m2 have the best chance of a successful pregnancy. Women who are under- or overweight are at greater risk for infertility as well as complications when pregnancy does occur.3 For example, obesity is associated with a condition called polycystic ovary syndrome (PCOS), which is characterized by abnormal hormone levels, irregular or absent menstrual cycles, and/or impaired ovulation.4 Women diagnosed with this condition have lower fertility rates. Many, although not all, are overweight or obese and are insulin resistant. If successful in becoming pregnant, women with PCOS have three to four times the risk for pregnancy-related forms of hypertension and diabetes than healthy women, and twice the risk for preterm birth.5 In women with PCOS who are overweight or obese, weight loss is often the first step of a treatment plan. Achieving and maintaining a healthful weight prior to conception should be the goal of all women seeking a successful pregnancy.

Finally, maintaining a balanced and nourishing diet before conception reduces a woman's risk of experiencing any of several nutrition-related concerns during her pregnancy. These concerns, which are discussed later in the chapter, can affect the health of the pregnant woman as well as her newborn.

The man's nutrition and health prior to pregnancy is important as well. Paternal obesity contributes to abnormalities in sperm, impaired male fertility, alterations in gene expression, increased risk of pregnancy loss, and increased risk for chronic disease in offspring.6,7 Also, both sperm number and motility (ability to move) are reduced by alcohol consumption as well as by the use of certain prescription and illegal drugs. A man's reproductive health is supported by a diet rich in zinc, calcium, vitamin D, folic acid, and dietary antioxidants such as vitamin C.

**A Healthful Diet Supports Embryonic and Fetal Development**

A balanced, nourishing diet is important throughout **gestation**--the period from conception to birth--to provide the nutrients needed to support fetal development without depriving the mother of the nutrients she needs to maintain her own health. A healthful diet also minimizes the risk of excess energy intake.

[Image: During conception, a sperm fertilizes an egg, creating a zygote.]

[Sidebar: **conception** The uniting of an ovum (egg) and sperm to create a fertilized egg, or zygote. Also called *fertilization.*]

[Sidebar: **teratogen** Any substance that can cause a birth defect, gestation The period of intrauterine development from conception to birth; typically 38 to 42 weeks.]

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[**1** Ovulation: Ovum (egg) is released from ovary

**2** Fertilization: Ovum is fertilized by a single sperm cell in the uterine tube

**3** Zygote (fertilized ovum) undergoes rapid cell division as it travels toward uterus, developing into blastocyst

**4** Implantation: Blastocyst arrives at uterus and implants into the uterine lining]

**[FIGURE 14.1** Ovulation, conception, and implantation. The time between fertilization of the ovum and implantation of the blastocyst into the uterine lining is about 10 days.]

A full-term pregnancy lasts 38 to 42 weeks and is divided into three **trimesters,** with each trimester lasting about 13 to 14 weeks.

**The First Trimester**

About once each month, a nonpregnant woman of childbearing age experiences **ovulation,** the release of an ovum from an ovary. The ovum is then drawn into the uterine tube. The first trimester of pregnancy begins when the ovum and sperm unite to form a single, fertilized cell called a **zygote.** As the zygote travels through the uterine tube, it divides into a ball of 12 to 16 cells, which, at about day 4, arrives in the uterus **(FIGURE 14.1).** By day 10, the inner portion of the zygote, called the *blastocyst,* has implanted into the uterine lining. The outer portion becomes part of the placenta, which is discussed shortly.

Further cell growth, multiplication, and differentiation occur, resulting in the formation of an **embryo.** Over the next 6 weeks, embryonic tissues continue to differentiate and fold into a primitive, tubelike structure, which eventually develops limb buds, organs, and facial features **(FIGURE 14.2).** The embryo is most vulnerable to teratogens during this time.

[Sidebar: **trimester** Any one of three stages of pregnancy, each lasting 13 to 14 weeks.]

[Sidebar: **ovulation** The release of an ovum (egg) from a woman's ovary.]

[Sidebar: **zygote** A fertilized ovum (egg) consisting of a single cell.]

[Sidebar: **embryo** The human growth and developmental stage lasting from the third week to the end of the eighth week after fertilization.]

**[FIGURE 14.2** Human embryonic development during the first 10 weeks after conception. Organ systems are most vulnerable to teratogens during this time, when cells are dividing and differentiating.]

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[**FIGURE 14.3** Placental development. The placenta is formed from both embryonic and maternal tissues. When the placenta is fully functional, fetal blood vessels and maternal blood vessels are intimately intertwined, allowing the exchange of nutrients and wastes between the two. The mother transfers nutrients and oxygen to the fetus, and the fetus transfers wastes to the mother for disposal.]

Not only alcohol and illegal drugs, but also some prescription and over-the-counter medications, certain dietary supplements, some viruses and infections, cigarette smoking, and radiation can interfere with embryonic development and cause birth defects. A recent example is the increased risk of microcephaly (abnormally small brain) and other birth defects in the infants of pregnant women infected with the Zika virus. In some cases, the damage from teratogen exposure is so severe that the pregnancy ends in a **spontaneous abortion** *(miscarriage)*, most of which occur in the first trimester.

During the first weeks of pregnancy, the embryo obtains its nutrients from cells lining the uterus. But by the fourth week, a primitive **placenta** has formed in the uterus from both embryonic and maternal tissue. Within a few more weeks, the placenta will be a fully functioning organ through which the mother will provide nutrients and remove fetal wastes **(FIGURE 14.3).**

By the end of the embryonic stage, about 8 weeks postconception, the embryo's tissues and organs have differentiated dramatically. A primitive skeleton has formed and muscles have begun to develop, making movement possible. A primitive heart has begun to beat, and the digestive organs are becoming distinct. The brain has differentiated, and the head has a mouth, eyespots with eyelids, and primitive ears.

The third month of pregnancy marks the transition from embryo to **fetus.** To support its dramatic growth, the fetus requires abundant nutrients from the placenta. It is connected to the fetal circulatory system via the **umbilical cord,** an extension of fetal blood vessels emerging from the fetus's navel (called the *umbilicus).* Blood rich in oxygen and nutrients flows through the placenta and into the umbilical vein (see Figure 14.3). Wastes are excreted in blood returning from the fetus to the placenta via the umbilical arteries. Although many people think there is a mixing of blood from the fetus and the mother, the two blood supplies remain separate. Nutrients move from the maternal blood into the fetal blood and waste products are transferred out of the fetal blood into the maternal blood.

**The Second Trimester**

During the second trimester (weeks 14 to 27 of pregnancy), the fetus continues to grow and mature **(FIGURE 14.4).** It develops the ability to suck its thumb, hear, and open and close its eyes in response to light. At the beginning of the second trimester, the fetus is about 3 inches long and weighs about 1.5 pounds.

[Sidebar: **spontaneous abortion** The natural termination of a pregnancy and expulsion of pregnancy tissues because of a genetic, developmental, or physiologic abnormality that is so severe that the pregnancy cannot be maintained. Also called *miscarriage.*]

[Sidebar: **placenta** A pregnancy-specific organ formed from both maternal and embryonic tissues. It is responsible for oxygen, nutrient, and waste exchange between mother and fetus.]

[Sidebar: **fetus** The human growth and developmental stage lasting from the beginning of the ninth week after conception to birth.]

[Sidebar: **umbilical** cord The cord containing the arteries and veins that connect the baby (from the navel) to the mother via the placenta.]

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[**FIGURE 14.4** A timeline of embryonic and fetal development.]

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By the end of this trimester, it is generally over a foot long and weighs more than 2 pounds. Some babies born prematurely in the last weeks of the second trimester survive with intensive care.

**The Third Trimester**

During the third trimester (weeks 28 to birth), the fetus gains nearly half its body length and three-quarters of its body weight! Average birth length is approximately 18 to 22 inches and average birth weight about 7.5 pounds (see Figure 14.4). Brain growth (which continues to be rapid for the first 2 years of life) is also quite remarkable and the lungs become fully mature. The fetus acquires eyebrows, eyelashes, and hair on the head.

**Appropriate Maternal Weight Gain Supports a Healthy Birth Weight**

An adequate, nourishing diet is one of the most important variables under a woman's control for increasing the chances for birth of a mature newborn (38 to 42 weeks' gestation). Proper nutrition also increases the likelihood that the newborn's weight will be appropriate for his or her gestational age. Generally, a birth weight of at least 5.5 pounds is considered a marker of a successful pregnancy.

An undernourished mother who gains too little weight during her pregnancy is more likely to give birth to a **low-birth-weight** baby than a woman with appropriate nutritional intake. An infant weighing less than 2,500 g (about 5.5 pounds) at birth is considered to be of low birth weight and an infant weighing less than 1,500 g (about 3.3 pounds) is termed very low birth weight. Both groups are at increased risk for infection, learning disabilities, impaired physical development, and death in the first year of life **(FIGURE 14.5).** Many low- and very-low-birth-weight babies are born **preterm**--that is, before 38 weeks' gestation. Others are born at term but are small for gestational age; in other words, they weigh less than would be expected. Although nutrition is not the only factor contributing to maturity and birth weight, its role cannot be overstated.

Recommendations for weight gain vary according to a woman's weight *before* she became pregnant and whether she is expecting a single or multiple birth **(TABLE 14.1).** The average recommended weight gain for women of normal prepregnancy weight is 25 to 35 pounds; underweight women should gain a little more than this amount, and overweight and obese women should gain less. Adolescents should follow the same recommendations as those for adult women.8 Women of normal prepregnancy weight who are pregnant with twins are advised to gain 37 to 54 pounds.8

[Sidebar: **low birth weight** Having a weight of less than 5.5 pounds at birth.]

[Sidebar: **preterm** The birth of a baby prior to 38 weeks' gestation.]

**[FIGURE 14.5** A healthy 2-day-old infant (right) compared to two low-birth-weight infants.]

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**TABLE 14.1 Recommended Weight Gain for Women During Pregnancy**

|  |  |  |
| --- | --- | --- |
| **Prepregnancy Weight Status** | **Body Mass Index (kg/m**2) | **Recommended Weight Gain (lb)** |
| Normal | 18.5-24.9 | 25-35 |
| Underweight | <18.5 | 28-40 |
| Overweight | 25.0-29.9 | 15-25 |

*Source:* Data adapted from Rasmussen, K. M., and A. L. Yaktine, eds. 2009. *Weight Gain During Pregnancy: Reexamining the Guidelines.* Institute of Medicine; National Research Council. Washington, DC: National Academies Press.

Women who have a low prepregnancy BMI (< 18.5 kg/m2) or gain too little weight during pregnancy increase their risk of having a preterm or low-birth-weight baby; the pregnancy may also dangerously deplete their own nutrient reserves.

Gaining *too* much weight or being overweight (BMI ≥25 kg/m2) or obese (BMI ≥30 kg/m2) prior to conception is also risky and much more common. Excessive prepregnancy weight or prenatal weight gain increases the risk that the fetus will be large for gestational age, increasing the likelihood of trauma during vaginal delivery and of cesarean birth. Also, children born to overweight or obese mothers have higher rates of childhood obesity and metabolic abnormalities.9 In addition, the more weight a woman gains during pregnancy, the more difficult it will be for her to return to prepregnancy weight and the more likely it is that her weight gain will be permanent.

In addition to amount of weight, the *pattern* of weight gain is important. During the first trimester, a woman of normal weight should gain no more than 3 to 5 pounds. During the second and third trimesters, about 1 pound a week is considered healthful. Overweight women should gain only 0.6 pound per week and, for obese women, a gain of 0.5 pound per week is appropriate.8 If weight gain is excessive in a single week, month, or trimester, the woman should not attempt to lose weight. Instead, the woman should merely attempt to slow the rate of weight gain. In short, weight gain throughout pregnancy should be slow and steady.

In a society obsessed with thinness, it is easy for pregnant women to worry about weight gain. Focusing on the quality of food consumed, rather than the quantity, can help women feel more in control. In addition, following a physician-approved exercise program helps women maintain a positive body image and prevent excessive weight gain. The *2015-2020 Dietary Guidelines for Americans* offers the following guidance: "Before becoming pregnant, women are encouraged to achieve and maintain a healthy weight, and women who are pregnant are encouraged to gain weight within gestational weight gain guidelines" as defined by the Health and Medicine Division of the National Academies of Science (see Table 14.1).10

A pregnant woman may also feel less anxious about her weight gain if she understands how that weight is distributed. Of the total weight gained in pregnancy, 10 to 12 pounds are accounted for by the fetus itself, the amniotic fluid, and the placenta **(FIGURE 14.6)** (page 494). In addition, the woman's blood volume increases 40% to 50%, accounting for another 3 to 4 pounds. A woman can expect to be about 10 to 12 pounds lighter immediately after the birth and, within about 2 weeks, another 5 to 8 pounds lighter because of fluid loss. After that, losing the remainder of pregnancy weight depends on more energy being expended than is taken in. Although the production of breast milk requires significant energy, the effect of breastfeeding on postpartum weight loss varies. Moderate weight loss while breastfeeding is safe and will not interfere with the weight gain of the nursing infant.

**[recap**

Conception is the point at which a woman's ovum is fertilized with a man's sperm. A healthful diet prior to conception is important to reduce the risk for infertility, to prevent nutrient-deficiency disorders that can arise very early in the pregnancy, and to minimize the risk for nutrition-related concerns during pregnancy. A healthful body weight and a nourishing diet is also important for male fertility.]

[For an individualized pregnancy weight gain calculator, go to **www.choosemyplate.gov.** From the home page, search the list under "Online Tools." Click on "Pregnancy Weight Gain Calculator."]

[Image: Following a physician-approved exercise program helps pregnant women maintain a positive body image and prevent excess weight gain.]

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[**FIGURE 14.6** The weight gained during pregnancy is distributed between the mother's own tissues and the pregnancy-specific tissues.]

A full-term pregnancy lasts from 38 to 42 weeks and is traditionally divided into trimesters lasting 13 to 14 weeks. During the first trimester, cells differentiate and divide rapidly to form the various tissues of the human body. Vulnerability to nutrient deficiencies, toxicities, and teratogens is highest during this trimester. The second and third trimesters are characterized by continued growth and maturation of organ systems. Nutrition is important before and throughout pregnancy to maintain the mother's health, support fetal development, and increase the likelihood that the baby will be born after 37 weeks and will weigh at least 5.5 pounds.

**LO 2** Identify the nutrient recommendations that change during pregnancy.

## **What** **are a pregnant woman's nutrient needs?**

The requirement for nearly all nutrients increases during pregnancy to accommodate the growth and development of the fetus without depriving the mother of the nutrients she needs to maintain her own health. With the exception of iron, most of these increased needs can be met by carefully selecting foods high in nutrient density. The ChooseMyPlate.gov website provides useful information that emphasizes the need for dietary adequacy, balance, and variety in food choices; it also suggests food patterns for pregnant women (see the **Web Links** at the end of this chapter).

**Macronutrients Provide Energy and Build Tissues**

During pregnancy, macronutrients provide necessary energy and building blocks for developing embryonic and fetal tissues as well as other pregnancy-associated tissues.

**Recommendations for Energy Intake**

Energy requirements increase only modestly during pregnancy.11 In fact, during the first trimester, a woman should consume approximately the same number of Calories daily as during her nonpregnant days. Instead of eating more, she should attempt to maximize the nutrient density of what she eats.

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For example, drinking low-fat milk is preferable to drinking soft drinks. Low-fat milk provides valuable protein, vitamins, and minerals to feed the fetus's rapidly dividing cells, whereas soft drinks provide nutritionally empty Calories.

During the last two trimesters of pregnancy, caloric needs increase by about 350 to 450 kcal per day. For a woman consuming 2,000 kcal per day, an extra 400 kcal represents only a 20% increase in Calorie intake. For example, 1 cup of low-fat yogurt and a graham cracker with jam is about 400 kcal. At the same time, some vitamin and mineral needs increase by as much as 50%, so again, the key for getting adequate micronutrients while not consuming too many extra Calories is choosing nutrient-dense foods.

**Recommendations for Protein and Carbohydrate Intake**

During pregnancy, protein needs increase to 1.1 g per day per kg body weight (an additional 25 g or so of protein per day).11 Many women already eat this much protein each day. Dairy products, meats, eggs, and soy products are all rich sources of protein, as are legumes, nuts, and seeds.

Carbohydrate intake should be at least 175 g per day.11 The majority of carbohydrate intake should come from whole grains, fruits, and legumes and other vegetables. These foods are good sources of the B-vitamins and other micronutrients, phytochemicals, and fiber. Fiber-rich foods are satiating, thereby helping to prevent excessive weight gain, and may lower the risk of constipation.

**Recommendations for Fat Intake**

The guideline for the percentage of daily Calories that comes from fat does not change during pregnancy.11 Consumption of the right kinds of fats is important. Like anyone else, pregnant women should limit their intakes of saturated and *trans* fats because of their negative impact on cardiovascular health (see Chapter 5). The omega-3 polyunsaturated fatty acid *docosahexaenoic acid [DHA)* and the omega-6 arachidonic acid (ARA) have been linked in some, but not all, studies to both enhanced brain growth and eye development. Because the fetal brain grows dramatically during the third trimester, DHA is especially important in the maternal diet. Good sources of DHA are oily fish, such as salmon, sardines, anchovies, and mackerel. It is also found in smaller amounts in tuna, chicken, and eggs enhanced by feeding hens a DHA-rich diet. ARA is found in most types of meat, fish, and poultry.

Pregnant women who eat fish should be aware of the potential for mercury contamination because even a limited intake of mercury during pregnancy can impair a fetus's developing nervous system. Although pregnant women should avoid large fish, such as swordfish, shark, tile fish, and king mackerel, they can safely consume up to 12 ounces of most other types of fish per week, as long as it is properly cooked. Alba-core tuna, however, should be limited to 6 ounces per week because it is higher in mercury than other types of tuna.12

**Micronutrients Support Increased Energy Needs and Tissue Growth**

During pregnancy, expansion of the mother's blood supply and growth of the uterus, placenta, breasts, body fat stores, and the fetus itself all contribute to an increased need for micronutrients. In addition, the increased need for energy during pregnancy correlates with an increased need for the micronutrients involved in energy metabolism. Discussions of the micronutrients that are most critical during pregnancy follow. See **TABLE 14.2** for an overview of the changes in micronutrient needs with pregnancy

**Recommended Folate Intake**

Because folate is necessary for cell division, it follows that, during a time when both maternal and fetal cells are dividing rapidly, the requirement for this vitamin increases.

[Watch a video on the history of folic acid fortification of foods at **http://www.cdc.gov.** From the home page, type "folic acid fortification video" into the search bar, then click on the link.]

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**TABLE 14.2** **Changes in Nutrient Recommendations with Pregnancy for Adult Women**

|  |  |  |  |
| --- | --- | --- | --- |
| **Micronutrient** | **Prepregnancy** | **Pregnancy** | **% Increase** |
| Folate | 400 µg/day | 600 µg/day | 50 |
| Vitamin B12 | 2.4 µg/day | 2.6 µg/day | 8 |
| Vitamin C | 75 mg/day | 85 mg/day | 13 |
| Vitamin A | 700 µg/day | 770 µg/day | 10 |
| Vitamin D | 600 IU/day | 600 IU/day | 0 |
| Calcium | 1,000 mg/day | 1,000 mg/day | 0 |
| Iron | 18 mg/day | 27 mg/day | 50 |
| Zinc | 8 mg/day | 11 mg/day | 38 |
| Sodium | 1,500 mg/day | 1,500 mg/day | 0 |
| Iodine | 150 µg/day | 220 µg/day | 47 |

Adequate folate is especially critical during the first 28 days after conception, when it is required for the formation and closure of the **neural tube,** an embryonic structure that eventually becomes the brain and spinal cord. Folate deficiency is associated with neural tube defects, such as **anencephaly,** a fatal defect in which brain tissue is partially or fully absent, and **spina bifida,** in which a portion of the spinal cord protrudes through the spinal vertebrae, causing varying degrees of paralysis **(FIGURE 14.7).** Adequate folate intake does not guarantee normal neural tube development because the precise cause of neural tube defects is unknown, and there is a genetic component in some cases. Still, it is estimated that 70% of all neural tube defects could be prevented if all women of childbearing age consumed enough folate or folic acid.13

To reduce the risk for a neural tube defect, all women capable of becoming pregnant are encouraged to consume 400 µg of folic acid per day. Of course, folate remains very important even after the neural tube has closed. The RDA for folate for pregnant women is therefore 600 µg per day, a full 50 % increase over the RDA for a nonpregnant female.14 A deficiency of folate during pregnancy can result in macrocytic anemia (see Chapter 9) and has been associated with low birth weight, preterm delivery, and failure of the fetus to grow properly. Sources of folate include fortified cereals and grains, spinach, and lentils.

**[FIGURE 14.7** Spina bifida, a common neural tube defect. **(a)** An external view of an infant with spina bifida. **(b)** An internal view of the protruding spinal membrane and fluid-filled sac.]

[Sidebar: **neural tube** Embryonic tissue that forms a tube, which eventually becomes the brain and spinal cord.]

[Sidebar: **anencephaly** A fatal neural tube defect in which there is partial absence of brain tissue, most likely caused by failure of the neural tube to close.]

[Sidebar: **spina bifida** The embryotic neural tube defect that occurs when the spinal vertebrae fail to completely enclose the spinal cord, allowing it to protrude.]

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**Recommended Vitamin B**12 Intake

Vitamin B12 (cobalamin) is vital during pregnancy because it regenerates the active form of folate. Not surprisingly, deficiencies of vitamin B12 can also result in macrocytic anemia. Yet the RDA for vitamin B12 for pregnant women is only 2.6 µg per day, a mere 8% increase over the RDA of 2.4 µg per day for nonpregnant women.14 How can this be? One reason is that, during pregnancy, absorption of vitamin B12 is more efficient. The required amount of vitamin B12 can easily be obtainec from animal food sources. However, deficiencies have been observed in women who follow a vegan diet. Fortified foods or supplements provide these women with the needed B12.

**Recommended Vitamin C Intake**

Vitamin C is necessary for the synthesis of collagen, a component of connective tissue (including skin, blood vessels, and tendons) and part of the organic matrix of bones. The RDA for vitamin C during pregnancy is increased by a little more than 10% over the RDA for nonpregnant women (from 75 to 85 mg/day).15 A deficiency of vitamin C during pregnancy increases the risk for preterm birth and other complications. Abundant amounts of vitamin C are found in many food sources, such as citrus fruits and juices and numerous other fruits and vegetables.

**Recommended Vitamin A Intake**

Vitamin A needs increase during pregnancy by about 10%, to 770 µg per day.16 However, excess preformed vitamin A can cause fetal abnormalities, particularly heart defects and facial malformations. A well-balanced diet supplies sufficient vitamin A, so supplementation during pregnancy is not recommended. Beta-carotene (which is converted to vitamin A in the body) has not been associated with birth defects.

**Recommended Vitamin D Intake**

Despite the role of vitamin D in calcium absorption, the RDA for this nutrient does not increase during pregnancy.17 Pregnant women who receive adequate exposure to sunlight do not need vitamin D supplements. However, pregnant women with darkly pigmented skin and/or limited sun exposure who do not regularly drink vitamin D-fortified milk will benefit from vitamin D supplementation. Most prenatal vitamin supplements contain 10 µg per day of vitamin D, which is considered safe and acceptable. Pregnant women should avoid consuming excessive vitamin D because toxicity can cause developmental disability in the newborn.

**Recommended Calcium Intake**

Growth of the fetal skeleton requires a significant amount of calcium. However, the RDA for adult pregnant women is the same as that for nonpregnant women, 1,000 mg per day, for two reasons.17 First, pregnant women absorb calcium from the diet more efficiently than do nonpregnant women. Second, the extra demand for calcium has not been found to cause demineralization of the mother's bones or to increase fracture risk; thus, there is no justification for higher intakes. Sources of calcium include milk, yogurt, and cheese; nondairy foods, such as kale, collard greens, and broccoli; and calcium-fortified soy milk, juices, and cereals.

**Recommended Iron Intake**

Recall (from Chapter 9) the importance of iron in the formation of red blood cells, which transport oxygen throughout the body. During pregnancy, the demand for red blood cells increases to accommodate the needs of the mother's expanded blood volume, the growing uterus, the placenta, and the fetus itself. Thus, more iron is needed. Fetal demand for iron increases even further during the last trimester, when the fetus stores iron for use during the first few months of life.

Severely inadequate iron intake has the potential to harm the fetus, resulting in an increased risk for low birth weight, preterm birth, and death of the newborn. However, in most cases, the fetus builds adequate stores by "robbing" maternal iron, prompting iron-deficiency anemia in the mother.

[Image: Meats provide protein, vitamin B12, heme iron, and zinc.]

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During pregnancy, maternal iron deficiency causes paleness and exhaustion, but at birth it endangers her life: anemic women are more likely to die during or shortly following childbirth because they are less able to tolerate blood loss and fight infection.

The RDA for iron for pregnant women is 27 mg per day, compared to 18 mg per day for nonpregnant women and 15 mg per day for nonpregnant adolescents.16 This represents a 50% to 80% increase, despite the fact that iron loss is minimized during pregnancy because menstruation ceases. Typically, women of childbearing age have poor iron stores, and the demands of pregnancy are likely to produce a deficiency. To ensure adequate iron stores during pregnancy, an iron supplement (as part of, or distinct from, a total prenatal supplement) is routinely prescribed during the last two trimesters. Vitamin C enhances iron absorption, as do dietary sources of heme iron; however, substances in coffee, tea, milk, bran, and oxalate-rich foods decrease iron absorption. Therefore, many healthcare providers recommend taking iron supplements with foods high in vitamin C and/or heme iron. Sources of iron include meats, seafood, poultry, fortified cereals, legumes, spinach and other dark green leafy vegetables, and dried fruits.

**Recommended Zinc Intake**

The RDA for zinc for adult pregnant women increases by about 38% over the RDA for nonpregnant women, from 8 mg per day to 11 mg per day.16 Zinc is critical in DNA, RNA, and protein synthesis, and inadequate intake can lead to malformations in the fetus, premature labor, and extended labor. The absorption of zinc from supplements may be inhibited by high intakes of non-heme iron, such as high-potency iron supplements, when these two minerals are taken together.18 However, when food sources of iron and zinc are consumed together in a meal, absorption of zinc is not affected. In addition, the heme form of iron does not appear to inhibit zinc absorption.

**Recommended Sodium and Iodine Intake**

During pregnancy, the AI for sodium is the same as for a nonpregnant adult woman, or 1,500 mg (1.5 g) per day.19 Although too much sodium is associated with fluid retention, bloating, and high blood pressure, an increase in body fluids is a normal and necessary part of pregnancy, and as during any life stage, some sodium is necessary to maintain fluid and electrolyte balance.

Iodine needs increase significantly during pregnancy, but the RDA of 220 µg per day is easy to achieve by using a modest amount of iodized salt (sodium chloride) during cooking.

**Do Pregnant Women Need Supplements?**

Prenatal multivitamin and mineral supplements are not strictly necessary during pregnancy, but most healthcare providers recommend them. Meeting all the nutrient needs would otherwise take careful and somewhat complex dietary planning. Prenatal supplements are especially good insurance for specific populations, such as vegans, adolescents, and others whose diet might normally be low in one or more micronutrients. It is important that pregnant women understand, however, that supplements are to be taken *in addition to,* not as a substitute for, a nutrient-rich diet.

**Fluid Needs of Pregnant Women Increase**

Increased fluid allows for the necessary increase in the mother's blood volume, aids in regulating body temperature, and helps maintain the **amniotic fluid** that surrounds, cushions, and protects the fetus in the uterus. The AI for total fluid intake, which includes drinking water, beverages, and food, is 3 liters per day (or about 12.7 cups). This recommendation includes approximately 2.3 liters (10 cups) of fluid as total beverages, including drinking water.19

Drinking adequate fluid also helps combat two common discomforts of pregnancy: fluid retention and, possibly, constipation. Drinking lots of fluids may also lower the risk for **urinary tract infections,** which are common in pregnancy.

It's important for pregnant women to drink about 10 cups of fluid a day.

[Sidebar: **amniotic fluid** The watery fluid contained within the innermost membrane of the sac containing the fetus. It cushions and protects the growing fetus.]

[Sidebar: **urinary tract infection** A bacterial infection of the urethra, the tube leading from the bladder to the body exterior.]

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Fluids also combat dehydration, which can develop if a woman has frequent bouts of vomiting. For these women, fluids such as soups, juices, and sports beverages are usually well tolerated.

**[recap**

During the last two trimesters of pregnancy, caloric needs increase by about 350 to 450 kcal per day. The Calories consumed during pregnancy should be nutrient dense. Protein needs increase by about 25 grams a day. Protein, carbohydrates, and healthful unsaturated fats--especially the essential fatty acids DHA and ARA--provide the energy and building blocks for fetal growth. Folate deficiency has been associated with neural tube defects: The RDA increases to 600 µg per day during pregnancy, a full 50% increase over the RDA for nonpregnant women. The requirements for vitamins A, B12, and C increase modestly during pregnancy. Calcium and vitamin D are micronutrients that support bone growth, but intake recommendations do not increase during pregnancy. The requirements for iodine, iron, and zinc all increase to support fetal growth and development while maintaining the mother's health. Most healthcare providers recommend prenatal supplements for pregnant women. Fluid provides for increased maternal blood volume and amniotic fluid.]

**LO 3** Discuss some common nutrition-related concerns of pregnancy as well as recommendations for engaging in exercise.

## **What** **are some common nutrition-related concerns of pregnancy?**

Pregnancy-related conditions involving a particular nutrient, such as iron-deficiency anemia, have already been discussed. The following sections describe some of the most common discomforts and disorders of pregnant women that are related to their general nutrition.

**Morning Sickness, Cravings, and GI Discomfort Are Common**

Although many women look forward to becoming a mother, pregnancy is commonly accompanied by a variety of conditions that, while rarely life-threatening, may be very uncomfortable.

**Morning Sickness**

**Morning sickness,** or *nausea and vomiting of pregnancy (NVP),* is a condition characterized by varying degrees of nausea, from occasional mild queasiness to constant nausea with bouts of vomiting. In truth, "morning sickness" is not an appropriate term because the nausea and vomiting can begin at any time of the day and may last all day. NVP usually peaks between weeks 8 and 12, then resolves by weeks 12 to 16, but some women experience it throughout the pregnancy. Usually, the mother and fetus do not suffer lasting harm. However, NVP can become threatening in women who experience such frequent vomiting that they are unable to nourish or hydrate themselves or their fetus adequately.20 These women may require hospitalization or in-home intravenous (IV) therapy.

There is no cure for morning sickness. However, some women find the following strategies helpful for reducing its severity:

- Eating small, frequent meals and snacks throughout the day. An empty stomach can trigger nausea.

- Consuming the majority of fluids between meals. Frozen ice pops, watermelon, gelatin desserts, and mild broths are some well-tolerated sources of fluid.

- Keeping snacks such as dry cereal or crackers at the bedside to ease nighttime queasiness or nausea before rising.

- Taking prenatal supplements at a time of day when vomiting is least likely.

- Avoiding sights, sounds, smells, and tastes that bring on or worsen queasiness. Cold or room-temperature foods are often easier to tolerate than hot foods.

[Image: Deep-fried foods are often unappealing to pregnant women.]

[Sidebar: **morning sickness** Varying degrees of nausea and vomiting associated with pregnancy, most commonly in the first trimester.]

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For some women, alternative therapies, such as acupuncture, acupressure wrist bands, biofeedback, meditation, and hypnosis, help. Women should always verify with their healthcare provider that the therapy they are using is safe and does not interact with other treatments, medications, or supplements.

**Cravings**

It seems like nothing is more stereotypical about pregnancy than the image of a frazzled husband getting up in the middle of the night to run to the convenience store to get his pregnant wife some pickles and ice cream. This image, although humorous, is far from reality for most women. Although some women have specific cravings, most crave a general type of food ("something sweet" or "something salty") rather than a particular food.

Why do pregnant women crave certain tastes? Does a desire for salty foods mean that the woman is experiencing a sodium deficit? Although some people believe that we crave what we need, scientific evidence is lacking. It is more likely that cravings during pregnancy are due to hormonal fluctuations or physiologic changes or have familial or cultural roots. Most cravings are, of course, for edible substances. But a surprising number of pregnant women crave nonfoods, such as laundry starch and clay. This craving, called **pica,** can result in nutritional or health problems for the mother and fetus.21

**Gastroesophageal Reflux**

Gastroesophageal reflux (GER) is common during pregnancy because pregnancy-related hormones relax the smooth muscle of the lower esophagus.22 During the last two trimesters, the enlarging uterus pushes up on the stomach, worsening the problem. Practical tips for minimizing GER are discussed in detail in Chapter 3. In addition, the woman's healthcare provider may be able to suggest an antacid that is safe for use during pregnancy.

**Constipation**

Hormone production during pregnancy causes the smooth muscles to relax, including the muscles of the large intestine, slowing colonic movement of food residue.22 In addition, pressure exerted by the growing uterus on the colon can slow movement even further, making elimination difficult. Practical hints that may help a pregnant woman avoid constipation include consuming 25 to 35 g of fiber each day, concentrating on fresh fruits, legumes and other vegetables, and whole grains. The woman should also make sure to drink the recommended 10 cups of water and other beverages a day, and eat water-rich fruits and vegetables, such as melons, citrus, and lettuce. Regular exercise can also help, as it increases motility of the large intestine. Pregnant women should not use laxatives without the approval of their healthcare provider.

**Serious Disorders Include Diabetes, Hypertension, and Foodborne Illness**

Although most pregnancies are uncomplicated, serious disorders can develop, especially in women who have health challenges before becoming pregnant.

**Gestational Diabetes**

**Gestational diabetes** is increasingly common in the United States,23 diagnosed in as many as 10% of U.S. pregnancies. It is generally a temporary condition in which a pregnant woman is unable to produce sufficient insulin or becomes insulin resistant, resulting in elevated levels of blood glucose. Screening for gestational diabetes is a routine aspect of prenatal care because the symptoms, which include frequent urination, fatigue, and an increase in thirst and appetite, appear to be the same as normal pregnancy symptoms.

Fortunately, gestational diabetes has no ill effects on either the mother or the fetus if blood glucose levels are strictly controlled through diet, exercise, and/or medication.23 If not controlled, gestational diabetes can result in a baby who is too large as a result of receiving too much glucose across the placenta during fetal life.

[Image: Foods high in fiber, such as dried fruits, reduce the chances of constipation.]

[Sidebar: **pica** An abnormal craving to eat nonfood substances such as clay, paint, or chalk.]

[Sidebar: **gestational diabetes** A condition of insufficient insulin production or insulin resistance that results in consistently high blood glucose levels, specifically during pregnancy; the condition typically resolves after birth occurs.]

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## **nutri-case JUDY**

"Back when I was pregnant with Hannah, the doctor told me I had gestational diabetes but said I shouldn't worry about it. He said I didn't need any medication, and I don't remember changing my diet. In fact, I just kept eating whatever I wanted, and by the time Hannah was born, I had gained almost 60 pounds! I never did lose all that extra weight."

Review what you learned about diabetes in the In **Depth** essay following Chapter 4 (pages 130-137). What information would have been important for Judy to learn while she was pregnant? Is it common for women with gestational diabetes to develop type 2 diabetes later? What are some things Judy could have done to lower her risk for type 2 diabetes?

Inappropriately large infants are at risk for early delivery and trauma during vaginal birth, and they may need to be born by cesarean section. There is also evidence that exposing a fetus to maternal diabetes significantly increases the risk for overweight, obesity, and metabolic disorders such as type 2 diabetes later in life.23

Women who are obese, women who are age 35 years or older, and women of Native American, African American, or Hispanic origin have a greater risk of developing gestational diabetes as compared to Caucasian women. Any woman who develops gestational diabetes has a 40% to 60% risk of developing type 2 diabetes within the next 5 to 10 years--particularly if she is obese or overweight. As with any form of diabetes, a healthful diet and regular physical activity reduce the risk for gestational diabetes.

**Hypertensive Disorders of Pregnancy**

Up to 10% of U.S. pregnancies are complicated by some form of hypertension, yet it accounts for almost 16% of pregnancy-related deaths in developed nations such as the United States.24 The term *hypertensive disorders of pregnancy* encompasses several different conditions. A woman who develops high blood pressure, with no other symptoms, during her pregnancy is said to have *gestational hypertension.* **Preeclampsia** is characterized by a sudden increase in maternal blood pressure, edema, which leads to excessive and rapid weight gain unrelated to food intake, and protein in the urine. If left untreated, it can progress to *eclampsia,* a very serious condition characterized by seizures, kidney failure, and, potentially, fetal and/or maternal death.

No one knows exactly what causes the various hypertensive disorders of pregnancy, but deficiencies in dietary protein, vitamin C, vitamin E, calcium, and magnesium seem to increase the risk. Other risk factors include first pregnancy, age over 40, African American race, obesity, diabetes, multifetal pregnancy, and a family history of preeclampsia.24 Management focuses mainly on blood pressure control. Typical treatments include medication and close monitoring, with hospitalization if necessary. Ultimately, only childbirth will cure the condition. Today, with good prenatal care, gestational hypertension is nearly always detected early and can be appropriately managed, and outcomes for both mother and fetus are usually very good. In nearly all women without prior chronic high blood pressure, maternal blood pressure returns to normal within about a day after the birth.

**Foodborne Illness**

Pregnancy alters a woman's immune system in a way that leaves her more vulnerable to infectious diseases, including foodborne illness. A developing fetus is also at high risk. The bacterium *Listeria monocytogenes,* which causes **listeriosis,** is of particular concern to a pregnant woman and her fetus. Listeriosis is the third leading cause of death from foodborne illness, and 90% of people who contract the disease are in highly vulnerable groups, including pregnant women. In the fetus, listeriosis can result in severe infection that triggers miscarriage or premature birth.

[Image: Pregnant women should have their blood pressure measured regularly to test for gestational hypertension.]

[Sidebar: **preeclampsia** High blood pressure that is pregnancy specific and accompanied by protein in the urine, edema, and unexpected weight gain.]

[Sidebar: **listeriosis** Serious and sometimes fatal illness caused by infection with the bacterium *Listeria monocytogenes,* typically from consumption of contaminated food.]

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[**FIGURE 14.8** Certain foods are more likely to be contaminated with *Listeria monocytogenes,* a bacterium that causes listeriosis, a serious illness in pregnant women.]

The Centers for Disease Control and Prevention recommends that pregnant women avoid foods that are more likely to be contaminated with the bacterium **(FIGURE 14.8).**

As discussed earlier, pregnant women are also advised to avoid eating large fish and to limit their intake of canned albacore tuna because of their high mercury content. Pregnant women should consult their state or county health department for information on the safety of locally caught fish.

Safe food-handling practices, discussed in Chapter 12, should be carefully followed by pregnant women and their families.

**Maternal Age Can Affect Pregnancy**

The adolescent birth rate in the United States has declined by nearly one-third since 1991 and is currently 24 births for every 1,000 adolescents.25 Although this is the lowest rate in the past 60 years, it is still one of the highest among all industrialized nations.

Throughout the adolescent years, a woman's body continues to change and grow. Peak bone mass has not yet been reached. Full physical stature may not have been attained, and teens are more likely to be underweight than are young adult women. Thus, pregnant adolescents have higher needs for Calories and bone-related nutrients, such as calcium. Teens also commonly begin pregnancy in an iron-deficient state and so have an increased iron need. In addition, many adolescents have not established healthful nutritional patterns. At the same time, higher rates of alcohol use, smoking, and drug use contribute to a greater frequency of nutritional deficiencies.

With regular prenatal care and close attention to proper nutrition and other healthful behaviors, the likelihood of a positive outcome for both the adolescent mother and the infant is similar to that for other mothers and their infants.

Although there is no strict definition of an "older" pregnant woman, many healthcare workers use age 35 as a cut-off point. Older women typically have reduced fertility and an increased risk for miscarriage, stillbirth, gestational diabetes, and hypertension. The risk for chromosomal and other birth defects is also increased. However, on average, older women have higher incomes and more education than younger women, and these can support a healthy pregnancy. Overall, the majority of pregnancies in women over age 35 have the best possible outcome: a healthy baby!

**A Careful Vegetarian Diet and Regular Exercise Are Safe During Pregnancy**

Pregnant women who are vegetarians often worry about the quality of their diet, and many pregnant women--and their family members--wonder about the safety of vigorous physical activity. These concerns are discussed here.

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**Vegetarianism**

A recent review of maternal and birth outcomes among pregnant vegetarians and vegans reported no increased risk for complications of pregnancy or birth defects among women following a vegetarian or vegan diet.26 With the possible exception of iron, zinc, and the fatty acids EPA and DHA, vegetarian women who consume dairy products and/or eggs (lacto-ovo-vegetarians) have no nutritional concerns beyond those encountered by every pregnant woman. In contrast, vegan women need to be more vigilant than usual about their intake of nutrients that are derived primarily or wholly from animal products. These include vitamin D (unless fair skinned and regularly exposed to adequate sunlight throughout pregnancy), riboflavin, vitamin B6, vitamin B12, calcium, iron, and zinc as well as EPA and DHA. Supplements containing these nutrients are usually necessary. A regular prenatal supplement will fully meet the vitamin and iron needs of a vegan woman but does not fulfill calcium needs, so a separate calcium supplement or consumption of calcium-fortified milk alternatives or orange juice, is usually required. Non-animal-based EPA and DHA supplements are also available for vegans.

**Exercise**

Physical activity during pregnancy is recommended for all women experiencing normal pregnancies.27 Women who rarely, if ever, exercised before becoming pregnant, and overweight or obese women, can benefit greatly from increased activity but should begin slowly and progress gradually under the guidance of their healthcare provider.

Exercise during pregnancy benefits both mother and fetus in the following ways:

- Reduces risk of gestational diabetes and preeclampsia

- Helps prevent excessive prenatal weight and body fat gain

- Improves mood, energy level, sleep patterns

- Enhances posture and balance

- Improves muscle tone, strength, and endurance

- Reduces lower back pain and shortens the duration of active labor

- Reduces the risk of preterm birth and large-for-gestational age infants

Recent guidelines suggest exercises that engage large muscle groups in a continuous manner, including a combination of moderate- and vigorous-intensity aerobic activity, and muscle-strengthening activities.28,29 (See Chapter 11.) The more vigorous the activity, the less total time is needed to reap its benefits: 6.5 hours per week of brisk walking versus fewer than 3 hours per week of stationary cycling.

Recommendations for muscle-strengthening exercise during pregnancy are straightforward:

- Choose lighter weights and more repetitions.

- Opt for resistance bands over free weights, which might accidently hit or fall on the abdomen.

- Don't lift weights while lying on your back because this might compress a major blood vessel and restrict blood flow to the fetus.

- Avoid sudden movements that might place you off balance, such as lunges or twists.

- Pay attention to your body's signals!

What about yoga and pilates? Both offer classes tailored to pregnant women, adapting certain exercises to accommodate the body's changing center of gravity and increased joint flexibility. Activities that strengthen body core, abdominals, and pelvic floor or Kegel muscles make for an easier pregnancy and birth.

Pregnant women should avoid activities such as horseback riding, scuba diving, water or snow skiing, hockey, gymnastics, and soccer. They should also avoid exercising vigorously in hot and humid weather, dress comfortably, and stay hydrated. If symptoms of stress, such as dizziness, shortness of breath, chest pain, vaginal bleeding or leakage, or uterine contractions occur, all physical activity should stop and a healthcare provider contacted immediately.

[Image: During pregnancy, women should adjust their physical activity toward comfortable low-impact exercises such as swimming.]

[Want more details on maintaining fitness while pregnant? Watch this slideshow on exercise during and after pregnancy: **www.webmd.com.** Enter "slideshow pregnancy fitness" into the search bar, then click on the link.]

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**Many Substances Can Harm the Embryo or Fetus**

Anything a pregnant woman takes into her body has the potential to reach and affect her fetus; however, the following substances are of particular concern.

**Caffeine Consumption**

Caffeine, a stimulant found primarily in coffee, tea, soft drinks, and chocolate, crosses the placenta and thus reaches the fetus. Current thinking holds that women who consume less than about 200 to 300 mg per day (the equivalent of one to two cups of coffee) are very likely causing no harm to the fetus.30,31 However, some studies have linked maternal intakes as low as 100 mg per day to an increased risk for miscarriage, stillbirth, preterm birth, and decreased birth weight.31 In addition, sweetened coffees, teas, chocolate, and soft drinks provide considerable Calories. A low- or nonfat decaf latte, known to Latinas as *cafe con leche,* offers a more healthful nutrient profile than coffee alone.

**Alcohol Consumption**

Frequent drinking (more than seven drinks per week) or occasional binge drinking (more than four to five drinks on one occasion) during pregnancy increases the risk for miscarriage, complications during delivery, preterm birth, and sudden infant death syndrome. In addition, alcohol is a known teratogen, and its consumption during pregnancy increases the risk that the baby will be born with any of a variety of birth defects, including heart, skeletal, kidney, ear, and eye malformations as well as a range of lifelong developmental, behavioral, and mental problems (e.g., hyperactivity and attention deficit disorder). Heavy drinking (more than three to four drinks per day) throughout pregnancy can result in a condition called fetal alcohol syndrome. (See the **In Depth** essay on Alcohol following Chapter 7.) Despite these known dangers, 10% of pregnant women in the United States reported drinking alcohol at some point over the last 30 days while 3% admitted to binge drinking.32

Although some women do have the occasional alcoholic drink with no apparent ill effects, there is no amount of alcohol that is known to be safe. The best advice regarding alcohol during pregnancy is to abstain, if not from before conception, then as soon as pregnancy is suspected.

**Smoking**

Although the dangers of smoking are well known, about 10% of pregnant women smoke during pregnancy.33 Maternal smoking exposes the fetus to toxins such as lead, cadmium, cyanide, nicotine, and carbon monoxide. Fetal blood flow is reduced, which limits the delivery of oxygen and nutrients, resulting in impaired fetal growth and development. Maternal smoking greatly increases the risk for miscarriage, stillbirth, placental abnormalities, preterm delivery, and low birth weight. Rates of sudden infant death syndrome, respiratory illness, and allergies are higher in the infants and children of smokers compared to those of nonsmokers.

**Illegal Drug Use**

Despite the fact that the use of illegal drugs is unquestionably harmful to the fetus, nearly 5 % of pregnant women in the United States report having used illicit drugs and as many as 20% of pregnant women abuse prescription medications.34,35 Most drugs pass through the placenta into fetal blood, where they accumulate. Prenatal use of illegal drugs also impairs placental blood flow and increases the risk for low birth weight, premature delivery, miscarriage, and placental defects. Newborns suffer signs of withdrawal, including tremors, excessive crying, sleeplessness, and poor feeding. All women are strongly advised to stop taking drugs before becoming pregnant. There is no safe level of use for illegal drugs during pregnancy.

**[recap**

About half of all pregnant women experience morning sickness and many experience cravings, including pica. Gastroesophageal reflux and constipation in pregnancy are related to hormonal relaxation of smooth muscle.]

[Image: Maternal smoking is extremely harmful to the developing fetus.]

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Gestational diabetes and hypertensive disorders can seriously affect maternal and fetal well-being. Listeriosis is a foodborne illness that is particularly serious in pregnant women. The nutrient needs of pregnant adolescents are so high that adequate nourishment becomes difficult. A careful vegetarian diet can be healthful during pregnancy, but pregnant women who follow a vegan diet usually need to consume supplements. Exercise (provided the mother has no contraindications) can enhance the health of a pregnant woman. Caffeine intake should be limited and the use of alcohol, cigarettes, and illegal drugs should be completely avoided during pregnancy.

**LO 4** Describe the physiology of lactation and the nutrient recommendations for lactating women.

## **How** **does nutrition support lactation?**

Throughout most of human history, infants have thrived on only one food: breast milk. But during the first half of the 20th century, commercially prepared infant formulas slowly began to replace breast milk as the mother's preferred feeding method. Aggressive marketing campaigns promoted formula-feeding as a status symbol, proof of the family's wealth and modern thinking. In the 1970s, this trend began to reverse as several public health organizations, including the World Health Organization, the American Academy of Pediatrics, and La Leche League, began to promote the nutritional, immunologic, financial, and emotional advantages of breastfeeding and sponsored initiatives to support it.36 These efforts have paid off: In 2014, almost 80% of new mothers in the United States initiated breastfeeding; nearly 50% of mothers were still breastfeeding their babies at 6 months of age; and 19% of mothers were still exclusively breastfeeding at 6 months.37

**Lactation Is Maintained by Hormones and Infant Suckling**

**Lactation,** the production of breast milk, is a process that is set in motion during pregnancy in response to estrogen and progesterone, which are produced by the placenta. In addition to performing various functions to maintain the pregnancy, these hormones prepare the breasts physically for lactation. The breasts increase in size, and milk-producing glands (alveoli) and milk ducts are formed **(FIGURE 14.9).** Toward the end of pregnancy, the hormone *prolactin* increases. Prolactin is released by the anterior pituitary gland and is responsible for milk synthesis.

**Production of Colostrum**

By the time a pregnancy has come to full term, the level of prolactin is about 10 times higher than it was at the beginning of pregnancy. At birth, the suppressive effect of estrogen and progesterone ends, and prolactin is free to stimulate milk production. The first substance released is **colostrum,** sometimes called pre-milk or first milk. It is thick, yellowish in color, and rich in protein and micronutrients, and it includes antibodies that help protect the newborn from infection. Colostrum also contains a factor that fosters the growth of a particular species of "friendly" bacteria in the infant gastrointestinal tract. These bacteria in turn prevent the growth of other, potentially harmful bacteria. Finally, colostrum has a laxative effect in infants, helping the infant expel *meconium,* the sticky "first stool."

Within 4 to 6 days, colostrum is fully replaced by mature milk. Mature breast milk contains protein, fat, and carbohydrate (lactose) as well as all the essential vitamins and minerals. Much of the protein and fat is synthesized in the breast, while the rest enters the milk from the mother's bloodstream.

**[FIGURE 14.9** Anatomy of the breast. During pregnancy, estrogen and progesterone secreted by the placenta foster the preparation of breast tissue for lactation. This process includes breast enlargement and development of the milk-producing glands, or alveoli.]

[Sidebar: **lactation** The production of breast milk.]

[Sidebar: **colostrum** The first fluid made and secreted by the breasts from late in pregnancy to about a week after birth. It is rich in immune factors and protein.]

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**Production of Breast Milk**

Continued, sustained breast milk production depends entirely on infant suckling (or a similar stimulus, such as a mechanical breast pump). Infant suckling stimulates the continued production of prolactin, which in turn stimulates more milk production. The longer and more vigorous the feeding, the more milk will be produced. Thus, even multiples (twins, triplets) can be successfully breastfed.

Prolactin allows for milk to be produced, but that milk has to move through the milk ducts to the nipple in order to reach the baby's mouth. The hormone responsible for this "let down" of milk is *oxytocin.* Like prolactin, oxytocin is produced by the pituitary gland, and its production is dependent on the suckling stimulus at the beginning of a feeding **(FIGURE 14.10).** This response usually occurs within 10 to 30 seconds but can be significantly inhibited by stress. Finding a relaxed environment in which to breastfeed is therefore important.

**Breastfeeding Woman Have High Nutrient Needs**

Breastfeeding requires even more energy than pregnancy, as well as increased intakes of certain micronutrients.

**Energy and Macronutrient Recommendations**

Milk production requires an estimated 700 to 800 kcal per day. It is generally recommended that lactating women 19 and older consume 330 kcal per day above their prepregnancy energy needs during the first 6 months of lactation and 400 additional kcal per day during the second 6 months.11 This additional energy is sufficient to support adequate milk production. The remaining energy deficit will assist in the gradual loss of excess fat and body weight gained during pregnancy, approximately 1 to 4 pounds per month. It is critical that lactating women avoid severe energy restriction because it can result in decreased milk production. **MEAL FOCUS FIGURE 14.11** compares two sets of meals providing the additional 400 kcal per day required to support the second6 months of breastfeeding.

**[1** Suckling stimulates nerves in nipple.

**2** Nerves send message to hypothalamus.

**3** Hypothalamus sends message to pituitary gland.

**4** Pituitary gland releases prolactin, which stimulates milk production, and oxytocin, which stimulates milk release.]

**[FIGURE 14.10** Sustained milk production depends on the mother-child interaction during breastfeeding, specifically the suckling of the infant. Suckling stimulates the continued production of prolactin, which is responsible for milk production, and oxytocin, which is responsible for the let-down response.]

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**meal focus figure 14.11** **Meeting the Nutrient Needs of Breastfeeding**

**a day or meals**

**low** **NUTRIENT DENSITY**

**high NUTRIENT**

**BREAKFAST**

*1 cinnamon raisin bagel with*

*2 tbsp. cream cheese*

*8 fl. oz coffee with*

*2 tbsp. cream*

*1 cup Raisin Bran Cereal with*

*1/2 cup nonfat milk*

*2 slices of whole grain bread with peanut butter and jam Medium apple*

*1 cup orange juice*

*8 fl. oz decaf nonfat latte*

**LUNCH**

*1 beef hot dog*

*1 white bun*

*Medium french fries*

*2 tbsp. catsup*

*2 oz bag of pretzels*

*16 fl. oz orange soda*

*1 cup low-sodium lentil soup*

**Mixed salad with spinach:**

*1 hard-boiled egg 1/2 tomato*

*1/2 green pepper*

*2 oz cheddar cheese*

*1 cup raw baby carrots*

*2 tbsp. low-fat salad dressing*

**DINNER**

*2 beef tocos*

*2 oz tortilla chips with*

*1/2 cup guacamole*

*16 fl. oz unsweetened ice tea*

*One brownie*

*2 grilled salmon tacos (3 oz each)*

*1/2 cup black beans*

*1/2 cup brown rice*

*1 cup steamed broccoli*

*2 oz dark chocolate*

*1/2 cup fresh strawberries*

*8 fl. oz decaf nonfat latte*

**nutrient analysis**

**2,600** kcal

**60** grams of protein

**22** grams of dietary fiber

**468** micrograms of folate

**20** milligrams of vitamin C

**540** milligrams of calcium

**7** milligrams of zinc

**3,570** milligrams of sodium

**nutrient analysis**

**2,600** kcal

**80** grams of protein

**48** grams of dietary fiber

**983** micrograms of folate

**240** milligrams of vitamin C

**1,550** milligrams of calcium

**12** milligrams of zinc

**2,163** milligrams of sodium

[Provides the DRI for ALL nutrients even before snacks!]

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Notice that the meals on the right meet all of the lactating woman's DRIs even before snacks. One set of meals is low in nutrient density whereas the other meets the nutrient recommendations for breastfeeding mothers.

Of the macronutrients, protein and carbohydrate needs are different from pregnancy requirements. Increases of 15 to 20 g of protein per day and 80 g of carbohydrate per day above prepregnancy requirements are recommended during lactation.11 Women who breastfeed also need good dietary sources of the essential fatty acids.

**Micronutrient Recommendations**

The needs for several vitamins and minerals increase over the requirements of pregnancy. These include vitamins A, C, and E, riboflavin, vitamin B12, biotin, and choline, as well as the minerals copper, chromium, manganese, iodine, selenium, and zinc. The requirement for folate during lactation is 500 µg per day, which is decreased from the 600 µg per day required during pregnancy, but it is still higher than prepregnancy needs (400 µg/day).14

Requirements for iron decrease significantly during lactation to a mere 9 mg per day.16 This is because breast milk is relatively low in iron and breastfeeding usually suppresses menstruation for at least a few months, minimizing iron losses.

Calcium is a significant component of breast milk; however, as in pregnancy, calcium absorption is enhanced during lactation, and urinary loss of calcium is decreased. Thus, the recommended intake for calcium for a lactating woman is unchanged from pregnancy and nonpregnant guidelines; that is, 1,000 mg per day for mothers over age 18 and 1,300 mg per day for teen mothers.17 Typically, if calcium intake is adequate, a woman's bone density returns to normal shortly after lactation ends.

ChooseMyPlate.gov provides a Daily Food Plan for Moms with specific, individualized dietary advice for women who are pregnant, or who are exclusively or partially breastfeeding their infants (see **Web Links** at the end of this chapter).

## **Do Breastfeeding Women Need Supplements?**

If a breastfeeding woman appropriately increases her energy intake, and does so with nutrient-dense foods, her nutrient needs can usually be met without supplements. However, there is nothing wrong with taking a basic multivitamin for insurance, as long as it is not considered a substitute for proper nutrition. Lactating women should consume fish to increase the levels of DHA in their breast milk in order to support the infant's developing nervous system. Vegetarian and vegan women can boost their DHA intake with non-animal-based supplements. Women who don't consume dairy products should monitor their calcium intake carefully.

**Fluid Recommendations for Breastfeeding Women**

Because extra fluid is expended with every feeding, lactating women need to consume about an extra quart (about 1 liter) of fluid per day.19 This extra fluid facilitates milk production and reduces risk for dehydration. Breastfeeding women are encouraged to drink a nutritious beverage, such as water, juice, or milk, each time they nurse their baby. However, it is not good practice to drink hot beverages while nursing because accidental spills could burn the infant.

**[recap**

Lactation is the result of the coordinated effort of several hormones, including estrogen, progesterone, prolactin, and oxytocin. Breasts are prepared for lactation during pregnancy, and infant suckling provides the stimulus that sustains the production of the prolactin and oxytocin needed to maintain the milk supply. It is recommended that lactating women consume an extra 300 to 400 kcal per day above prepregnancy energy intake, including increased protein, DHA, and fluids. The intake recommendations for vitamins A, C, and E, riboflavin, vitamin B12, biotin, and choline, as well as the minerals copper, chromium, manganese, iodine, selenium, and zinc, increase over the requirements of pregnancy. The intake recommendations for folate and iron decrease from the requirements of pregnancy.]

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**LO 5** Identify the advantages and challenges of breastfeeding.

## **What** **are some advantages and challenges of breastfeeding?**

This section explains why breastfeeding is considered the perfect way to nourish a baby for the first 6 months of life. It also explores factors that may make breastfeeding a difficult choice.

**Breast Milk Is Nutritionally Superior to Infant Formula**

As adept as formula manufacturers have been at simulating the components of breast milk, an exact replica has never been produced. First, the amount and types of protein in breast milk are ideally suited to the human infant. The main protein in breast milk, lactalbumin, is easily digested in infants' immature gastrointestinal tracts, reducing the risk for gastric distress. Certain proteins in human milk improve the absorption of iron; this is important because breast milk is low in iron. Other proteins in breast milk bind iron and prevent the growth of harmful bacteria that require iron. Antibodies from the mother are proteins that help prevent infection while the infant's immune system is still immature.

The primary carbohydrate in milk is lactose. Lactose provides energy and prevents ketosis in the infant, promotes the growth of beneficial bacteria, and increases the absorption of calcium.

The amounts and types of fats in breast milk are ideally suited to the human infant. DHA and ARA have been shown in many studies to be essential for growth and development of the infant's nervous system and for development of the retina. The concentration of DHA in breast milk reflects the amount of DHA in the mother's diet, and is highest in women who regularly consume fish.

The fat content of breast milk changes according to the age of the infant and during the course of every feeding: The milk that is initially released *[foremilk)* is watery and low in fat, and is thought to satisfy the infant's initial thirst. As the feeding progresses, the milk increases in fat content. Finally, the very last 5% or so of the milk produced during a feeding (*hindmilk)* is very high in fat, similar to cream. This milk is thought to satiate the infant. It is important to let infants suckle for at least 20 minutes at each feeding, so that they get this hindmilk. Breast milk is also relatively high in cholesterol, which supports the rapid growth and development of the brain.

Another important aspect of any type of feeding is the fluid it provides the infant. Because of their small size, infants are at risk for dehydration, which is one reason feedings must be consistent and frequent. This topic is discussed at greater length in the section on infant nutrition.

Breast milk is a good source of readily absorbed calcium and magnesium. It is low in iron, but the iron it does contain is easily absorbed. Because healthy full-term infants store iron in preparation for the first few months of life, most experts agree that their iron needs can be met by breast milk alone for the first 6 months, after which iron-rich foods are needed. Although breast milk provides some vitamin D, the American Academy of Pediatrics and other professional groups recommend that all infants, including those who are breastfed, be provided a vitamin D supplement, particularly those infants with highly pigmented skin.36 Research suggests that providing a vitamin D supplement to breastfeeding women effectively maintains the vitamin D status of breastfed infants without the need to supplement the infant.38,39

Breast milk composition changes as the infant grows and develops. Because of this adaptation, breast milk alone is entirely sufficient to sustain infant growth for the first 6 months of life. In addition, exclusively breast-fed infants maintain total control over their food intake, allowing them to self-regulate energy intake during a critical period of growth and development. Some researchers believe this self-regulation accounts for the finding that breast-fed babies grow in length and weight at a slower rate than formula-fed infants while still maintaining excellent health; they also have a lower risk of obesity throughout their life.

Throughout the next 6 months of infancy, as solid foods are gradually introduced, breast milk remains the baby's primary source of superior-quality nutrition.

[Image: Breastfeeding has benefits for both the mother and her infant.]

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The American Academy of Pediatrics recommends exclusive breastfeeding for the first 6 months of life, continuing breastfeeding for at least the first year of life, and, if acceptable within the family, into the second year of life.36

**Breastfeeding Has Many Other Benefits for the Infant and Mother**

In addition to its nutritional advantages, breast milk provides a variety of other healthful compounds, and breastfeeding itself has benefits.

**Protection from Infections, Allergies, and Residues**

Immune factors from the mother are passed directly to the newborn through breast milk. These factors provide important disease protection for the infant while its immune system is immature. Breast-fed infants have lower rates of respiratory tract, gastrointestinal tract, and ear infections than formula-fed infants. Even a few weeks of breastfeeding is beneficial, but the longer a child is breastfed, the greater the level of passive immunity from the mother. In the United States, exclusive breastfeeding for 6 months has the potential to lower healthcare costs by as much as $13 billion per year, in large part due to a reduction in infant mortality rates related to **sudden infant death syndrome (SIDS)** and necrotizing enterocolitis (a disorder that causes tissue death in the intestine) in breast-fed infants.40

In addition, breast milk is nonallergenic, and breastfeeding is associated with a reduced risk for allergies during childhood and adulthood. Breast-fed babies also have a decreased risk of developing diabetes, overweight and obesity, and chronic digestive disorders.41

Breast-fed infants are known to have a different profile of gastrointestinal flora compared to formula-fed infants. They have greater numbers of health-promoting *Bifidobacteria* and lower counts of infection-producing bacteria. Moreover, it is thought that the microbiome of breast-fed infants reduces future risk of obesity42 as well as protecting against infections and diabetes.43

Exclusively breast-fed infants are also protected from exposure to known and unknown contaminants and residues that may be present in infant formulas or introduced by caregivers preparing them. For example, a bacterium called *Cronobacter* can contaminate powdered infant formulas. It causes several cases of sepsis (blood infection) and an often fatal meningitis in infants each year.44 Past concerns centered on bisphenol A (BPA), a toxic chemical that the U.S. Food and Drug Administration banned in 2012 from all baby bottles and toddler's cups. Baby bottles or cups manufactured before 2012 should be discarded unless they are BPA free.

**Physiologic Benefits for Mother**

Breastfeeding causes uterine contractions, which quicken the return of the uterus to prepregnancy size and reduces bleeding. Many women also find that breastfeeding helps them lose the weight they gained during pregnancy, particularly if it continues for more than 6 months. In addition, breastfeeding appears to be associated with a decreased risk for breast cancer and possibly type 2 diabetes and ovarian cancer.43

Breastfeeding also suppresses ovulation, lengthening the time between pregnancies and giving a mother's body the chance to recover before she conceives again.43 This benefit can be lifesaving for malnourished women living in countries that discourage or outlaw the use of contraceptives. Ovulation may not cease completely, however, so healthcare providers typically recommend the use of contraceptives while breastfeeding to avoid another conception occurring too soon to allow a mother's body to recover from the earlier pregnancy.

**Mother-Infant Bonding**

Breastfeeding is among the most intimate of human interactions. Ideally, it is a quiet time away from distractions when mother and baby begin to develop an enduring bond of affection known as *attachment.* Breastfeeding enhances attachment by providing the opportunity for frequent, direct skin-to-skin contact, which stimulates the baby's sense of touch and is a primary means of communication.

[Image: Breast-fed infants have a lower incidence of respiratory, gastrointestinal, and ear infections than formula-fed infants.]

[Sidebar: **sudden infant death syndrome (SIDS)** The sudden death of a previously healthy infant; the most common cause of death in infants over 1 month of age.]

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The cuddling and intense watching that occur during breastfeeding begin to teach the mother and baby about the other's behavioral cues. Breastfeeding also reassures the mother that she is providing the best possible nutrition for her baby. Most hospitals now encourage round-the-clock rooming-in of newborns in order to encourage breastfeeding. Attachment can also occur with bottle-feeding, of course, as long as the caregivers provide closeness, cuddling, and skin and eye contact.

**Convenience and Cost**

Breast milk is always ready, clean, at the right temperature, and available on demand, whenever and wherever it's needed. In the middle of the night, when the baby wakes up hungry, a breastfeeding mother can respond almost instantaneously, and both are soon back to sleep. In contrast, formula-feeding is a time-consuming process: parents have to continually wash and sterilize bottles, and each batch of formula must be mixed and heated to the proper temperature.

In addition, breastfeeding costs nothing other than the price of a modest amount of additional food for the mother. In contrast, formula can be relatively expensive, and there are the additional costs of bottles and other supplies as well as the cost of energy used for washing and sterilization. Finally, breastfeeding is environmentally responsible, using no external energy and producing no external wastes.

**Physical and Social Concerns Can Make Breastfeeding Challenging**

For some women and infants, breastfeeding is easy from the very first day. Others experience some initial difficulty, but with support from an experienced nurse, lactation consultant, or volunteer from La Leche League, the experience becomes successful and pleasurable. In contrast, some families encounter difficulties that make formula-feeding their best choice. This section discusses some challenges that may impede the success of breastfeeding.

**Effects of Drugs and Other Substances on Breast Milk**

Many substances, including illegal, prescription, and over-the-counter drugs, as well as herbal and other dietary supplements, pass into breast milk. Breastfeeding mothers should inform their physicians that they are breastfeeding. If a safe and effective form of a necessary medication cannot be found, the mother will have to avoid breastfeeding while she is taking the drug. During this time, she can pump and discard her breast milk, so that her milk supply will be adequate when she resumes breastfeeding.

Caffeine, alcohol, nicotine, and illegal drugs also enter breast milk. Caffeine, nicotine, and other stimulant drugs can make the baby fussy and disturb sleep. Breastfeeding women should reduce their caffeine intake to no more than two or three cups of coffee per day (or the equivalent of other caffeine containing beverages and foods) and avoid caffeine intake within 2 hours prior to nursing their infant. They should also quit smoking and avoid the use of illegal drugs. Alcohol can make the baby sleepy, depress the central nervous system, and slow motor development, in addition to inhibiting the mother's milk supply. Breastfeeding women should abstain from alcohol in the early stages of lactation because it easily passes into the breast milk and infants 0 to 3 months of age metabolize alcohol at a rate half that of adults. It takes about 2 to 3 hours for the alcohol from a single serving of beer or wine to be eliminated from the body, so it is possible but challenging for breastfeeding women to coordinate moderate alcohol intake with their breastfeeding schedule.

Environmental contaminants, including pesticides, industrial solvents, and heavy metals such as lead and mercury, can pass into breast milk when breastfeeding mothers are exposed to these chemicals. Mothers can limit their infants' exposure to these harmful substances by controlling their own environments. Fresh fruits and vegetables should be thoroughly washed and peeled to minimize exposure to pesticides and fertilizer residues. Exposure to paint fumes, gasoline, solvents, and similar products should be greatly limited.

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Even with some exposure to these environmental contaminants, U.S. and international health agencies agree that the benefits of breastfeeding almost always outweigh potential concerns.

Components that pass into the breast milk from certain foods, such as garlic, onions, peppers, broccoli, and cabbage, may be distasteful enough to the infant to prevent proper feeding. Some babies have allergic reactions to foods the mother has eaten, such as wheat, cow's milk, eggs, or citrus, and suffer gastrointestinal upset, diaper rash, or other reactions. The offending foods must then be identified and avoided.

**Maternal HIV Infection**

HIV, which causes AIDS, can be transmitted from mother to baby through breast milk. Thus, HIV-positive women in the United States and Canada are encouraged to feed their infants formula. This recommendation does not apply to all women worldwide, however, because the low cost and sanitary nature of breast milk, as compared to the potential for waterborne diseases with formula-feeding, often make breastfeeding the best choice for women in developing countries.

**Maternal Obesity**

There is strong evidence that maternal obesity significantly reduces the rate of successful breastfeeding.45 Fewer obese women plan to breastfeed and fewer actually initiate breastfeeding compared to normal weight women. Among those obese women who do breastfeed, they do so for shorter durations and produce a less adequate supply of milk. Obese women report more problems, such as cracked nipples and difficulty initiating breastfeeding, and are more likely to feel uncomfortable breastfeeding in front of others. These findings are particularly troubling because breastfeeding helps a woman lose some of her pregnancy weight, and has been shown to reduce the risk of overweight and obesity in the child, whereas children of obese mothers are, on average, at increased risk for overweight and obesity later in life.

**Employment Conflicts**

Breast milk is absorbed more readily than formula, making more frequent feedings necessary. Newborns commonly require breastfeedings every 1 to 3 hours versus every 2 to 4 hours for formula-feedings. Mothers who are exclusively breastfeeding and return to work within the first 6 months after the baby's birth must leave several bottles of pumped breast milk for others to feed the baby in their absence. They must then pump their breasts to express the breast milk during the workday and maintain their milk production. Federal legislation now requires "reasonable" break time (typically unpaid) and a private space other than a bathroom for breastfeeding mothers to express their milk.46

Work-related travel is also a concern: If the mother needs to be away from home for longer than 24 to 48 hours, she can typically pump and freeze enough breast milk for others to give the baby in her absence. When longer business trips are required, some mothers take the baby with them and arrange for childcare at their destination. Understandably, many women cite returning to work as the reason they switch to formula-feeding.

Some working women successfully combine breastfeeding with commercial formula-feeding. For example, a woman might breastfeed in the morning before she leaves for work, as soon as she returns home, and once again before going to bed. The remainder of the feedings is formula given by the infant's father or a childcare provider. Women who choose supplemental formula-feedings usually find that their body adapts quickly to the change and produces sample milk for the remaining breastfeedings.

**Social Concerns**

In North America, women have been conditioned to keep their breasts covered in public, even when feeding an infant. Over the past decade, however, both social customs and state laws have become more accommodating and supportive of nursing mothers. Some states have even passed legislation preserving a woman's right to breastfeed in public.

[Image: Working moms can be discouraged from--or supported in-- breastfeeding in a variety of ways.]

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With both legal and cultural support, as well as ongoing support from the health care team, women feel free to nurse their infants upon demand, whether they are at home or out in public.46,47

**What About Bonding for Fathers and Siblings?**

With all the attention given to attachment between a breastfeeding mother and her infant, it is easy for fathers and siblings to feel left out. One option that allows other family members to participate in infant feeding is to supplement breastfeedings with bottle-feedings of stored breast milk or formula. If a family decides to share infant feeding in this manner, bottle-feedings can begin as soon as breastfeeding has become well established. That way, the infant will not become confused by the artificial nipple. Fathers and other family members can also bond with the infant when bathing and/or dressing the infant as well as through everyday cuddling and play.

**[recap**

Breastfeeding provides many benefits to both mother and newborn, including superior nutrition, heightened immunity, mother-infant bonding, convenience, and cost. However, breastfeeding may not be the best option for every family. The mother may need to use a medication that enters the breast milk and makes it unsafe for consumption. HIV-positive women in the United States and Canada are encouraged to feed their infants formula. Obese women report more difficulties with breastfeeding and tend to breastfeed for shorter durations and produce a less adequate supply of milk. A mother's job may interfere with the baby's requirement for frequent feedings. The infant's father and siblings can participate in feedings using a bottle filled with either pumped breast milk or formula.]

**LO 6** Relate the growth and activity patterns of infants to their nutrient needs and the nutrient profile of infant formulas.

## **What** **are an infant's nutrient needs?**

Most first-time parents are amazed at how rapidly their infant grows. Optimal nutrition is extremely important during the first year, as the baby's organs and nervous system continue to develop and the baby grows physically. In fact, physicians use length and weight measurements as the main tools for assessing an infant's nutritional status. These measurements are plotted on growth charts for boys and girls, which track an infant's growth over time **(FIGURE 14.12)** (page 514). Although every infant is unique, in general, physicians look for a correlation between length and weight. In other words, an infant who is in the 60th percentile for length is usually in about the 50th to 70th percentile for weight. An infant who is in the 90th percentile for weight but is in the 20th percentile for length might be overfed. Consistency over time is also a consideration; for example, an infant who suddenly drops well below her established profile for weight might be underfed or ill.

**Nutrition Fuels Infant Growth and Activity**

Babies' basal metabolic rates are high, in part because their body surface area is large compared to their body size. Still, their limited physical activity keeps total energy expenditure relatively low. For the first few months of life, their activities consist mainly of eating and sleeping. As the first year progresses, they begin rolling over, sitting up, crawling, standing, and finally taking the first few wobbly steps. Nevertheless, relatively few Calories are expended in movement, and the primary use of energy is to support growth.

In the first year of life, an infant generally grows about 10 inches in length and triples in weight--a growth rate more rapid than will ever occur again. Not surprisingly, energy needs per unit body weight are also the highest in order to support this phenomenal growth and metabolism.

The infant's growth surge includes the brain. To accommodate such a large increase in brain size, the bones of the skull do not fuse until the second year of life. An infant's head is typically quite large in proportion to the rest of the body. Pediatricians use head circumference as an additional tool for the assessment of growth and nutritional status. After around 18 months of age, the rate of brain growth slows, and gradually the body "catches up" to head size.

[Image: Fathers and siblings can bond with infants through bottle-feeding and other forms of close contact.]

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[**FIGURE 14.12** This weight-for-age growth chart is a much smaller version of charts used by healthcare providers to monitor and assess the growth of an infant/toddler from birth to 36 months. This example shows the growth curves of girls over time, each at different percentiles.

*Source*: Data adapted from "Clinical Growth Charts: Infants, Birth to 36 Months." Centers for Disease Control and Prevention.]

**Infants Have Unique Nutrient Needs**

Three characteristics of infants combine to make their nutritional needs unique: (1) their high energy needs per unit body weight to support rapid growth, (2) their immature digestive tract and kidneys, and (3) their small size.

**Energy and Macronutrient Recommendations**

An infant needs to consume about 40 to 50 kcal per pound of body weight per day.11 This amounts to about 600 to 650 kcal per day at around 6 months of age. Given the immature digestive tract and kidneys of infants, as well as their high fluid needs, providing this much energy may seem difficult.

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Fortunately, breast milk and commercial formulas are energy dense, contributing about 650 kcal per liter of fluid. When complementary (solid) foods are introduced at 4 to 6 months of age, they provide additional energy.

Infants are not merely small versions of adults. The proportions of macronutrients they require differ from adult proportions, as do the types of food they can tolerate. About 40% to 50% of an infant's energy should come from fat during the first year of life; fat intake below this level can be harmful before the age of 2. Given the high energy needs of infants, it makes sense to take advantage of the energy density of fat (9 kcal/g) to help meet these requirements. Breast milk and commercial formulas are both high in fat (about 50 % of total energy). As noted earlier, breast milk is an excellent source of the fatty acids ARA and DHA, although DHA levels vary considerably with the mother's diet. Many formula manufacturers now add ARA and DHA to their products.

Infants 0 to 6 months of age need approximately 9 g of protein per day, whereas infants 7 to 12 months need almost 10 g per day to support their rapid growth.11 Infants' immature kidneys are not able to process and excrete the excess nitrogen groups from higher-protein diets; thus, no more than 20% of an infant's daily energy requirement should come from protein. Breast milk and commercial formulas both provide adequate total protein and appropriate essential amino acids to support growth and development.

The recommended intake for carbohydrate is set at 60 g per day for infants 0 to 6 months of age and 95 g per day for infants 7 to 12 months old.11 These levels reflect the lactose content of human milk, which is used as the reference point for most infant nutrient guidelines.

**Micronutrient Recommendations**

Infants need micronutrients to accommodate their rapid growth and development. The micronutrients of particular concern are iron, vitamin D, zinc, fluoride, and iodine. Fortunately, breast milk and commercial formulas provide most of the micronutrients needed for infant growth and development, with some special considerations, discussed shortly.

In addition, all infants are routinely given an injection of vitamin K shortly after birth. This provides vitamin K until the infant's intestine can develop its own healthful bacteria, which then contribute to the infant's supply of vitamin K.

**Do Infants Need Supplements?**

Breast milk and commercial formulas provide most of the vitamins and minerals infants need. However, several micronutrients may warrant supplementation.

For breast-fed infants, a supplement containing vitamin D is commonly prescribed from birth to around 6 months of age, even in sunny climates, because exposure of a young infant's skin to adequate direct sunlight for vitamin D synthesis is not advised. Vitamin D deficiency is actually quite common among breast-fed infants,48 especially those with dark skin and limited sunlight exposure. It has been estimated that exclusively breast-fed infants receive less than 20% of the recommended intake of vitamin D, reinforcing the importance of vitamin D supplementation for these infants or their breastfeeding mothers.48,49

Iron is extremely important for cognitive development and prevention of iron-deficiency anemia. Breast-fed infants require additional iron beginning no later than 6 months of age because the infant's iron stores become depleted and breast milk is a poor source of iron. At 4 to 6 months of age, breast-fed infants should be started on complementary (solid) foods that are high in iron, such as pureed meats or iron-fortified infant rice cereal.

If the mother is a vegan, her breast milk may be low in vitamin B12, and a supplement of this vitamin should be given to the baby. Fluoride is important for strong tooth development, but fluoride supplementation is not recommended during the first 6 months of life.

For formula-fed infants, supplementation depends on the formula composition and the water supply used to make the formula.

[Image: Infants 7 to 12 months old need almost 10 g of protein and 95 g of carbohydrate a day.]

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Many formulas are already fortified with iron, for example, and some municipal water supplies contain fluoride. If this is the case, and the baby is getting adequate vitamin D through the intake of at least 1 liter of formula per day, then an additional supplement may not be necessary.

Consultation with the infant's pediatrician is essential before giving a supplement. The supplement should be formulated specifically for infants, and the daily dose should not be exceeded. High doses of micronutrients can be dangerous. Too much iron can be fatal, too much fluoride can cause discoloration and pitting of the teeth, and too much vitamin D can lead to calcification of soft tissue, such as the kidneys.

**Fluid Recommendations for Infants**

Fluid is critical for everyone, but for infants the balance is more delicate for two reasons. First, because infants are so small, they proportionally lose more water through evaporation than adults. Second, their kidneys are immature and unable to concentrate urine. Thus, they are at even greater risk for dehydration. An infant needs about 2 ounces of fluid per pound of body weight, and either breast milk or formula is almost always enough to provide this amount. Experts recently confirmed that "infants exclusively fed human milk do not require supplemental water."19

Certain conditions, such as diarrhea, vomiting, fever, or hot weather, can greatly increase fluid loss. In these instances, supplemental fluid, ideally as water, may be necessary. Because too much fluid can be particularly dangerous for an infant, supplemental fluids (whether water or an infant electrolyte formula) should be given only under the advice of a physician. Generally, it is advised that supplemental fluids not exceed 4 ounces per day, and parents should avoid giving sugar water, fruit juices, or any sweetened beverage in a bottle. Parents can be sure that their infant's fluid intake is appropriate if the infant produces six to eight wet diapers per day.

**Infant Formula Is a Nutritious Alternative to Breast Milk**

If breastfeeding is not feasible, several types of commercial formulas provide nutritious alternatives. By law, U.S. formula manufacturers must meet standards for 29 different nutrients. Although formula companies try to mimic the nutritional value of breast milk, their formulas still cannot duplicate the immune factors, enzymes, and other unique components of human milk.

Most formulas are based on cow's milk that has been modified to make it more appropriate for human infants. The amount of protein is reduced and the balance of the proteins casein and whey are modified to improve digestibility. The sugars lactose (naturally occurring) and sucrose (added), alone or in combination, provide carbohydrates, and vegetable oils and/or synthetic fatty acids replace the naturally occurring butterfat. Recently, some manufacturers have added other nutrients, such as taurine, carnitine, and the fatty acids ARA and DHA, to more closely mimic the nutrient profile of human milk. This chapter's **Nutrition Label Activity** feature identifies some of these ingredients.

Soy-based formulas are a viable alternative for infants who are lactose intolerant (although this is rare in infants) or cannot tolerate the proteins in cow's milk-based formulas. Soy formulas may also satisfy the requirements of families who are strict vegans. However, soy contains isoflavones, phytochemicals that act as estrogens and may alter infant growth and development. Babies can also have allergic reactions to soy-based formulas.

There are also specialized formula preparations for infants with certain medical conditions. Some contain proteins that have been predigested, for example, or have been specially formulated for preterm infants, older infants, and toddlers. The final choice of formula should depend on infant tolerance, stage of infant development, and the advice of the infant's pediatrician.

It is important to note that the use of cow's milk (fresh, dried, evaporated, or condensed) is inappropriate for infants under the age of 1 year. Infants also should not be fed goat's milk, or any plant-based milk alternative such as soymilk, rice milk, or nut milks, as none of these will meet their nutrient needs and can lead to severe nutrient deficiencies.50

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## [**nutrition** **label activity Reading Infant Food Labels**

Imagine that you are a new parent shopping for infant formula. FIGURE 14.13 shows the label from a typical can of formula. As you can see, the ingredients list is long and has many technical terms. Even well-informed parents would probably be stumped by many of them. Fortunately, with the information you learned in previous chapters, you can probably answer the following questions.

- One of the ingredients listed is a modified form of *whey protein concentrate.* What common food is the source of *whey?*

- The second ingredient listed is *lactose.* Is lactose a form of protein, fat, or carbohydrate? Why is lactose important for infants?

- The front label states the formula has added DHA (docosahexaenoic acid). Is DHA a form of protein, fat, or carbohydrate? Why is this nutrient thought to be important for infants?

- The label also claims that this formula is "Our closest formula to mature breast milk." Can you think of some differences between breast milk and this formula that still exist?

Also, look at the list of nutrients on the label. You'll notice that there is no "% Daily Value" column, which you see on most food labels. Next time you are at the grocery store, look at other baby food items, such as baby cereal or pureed fruits. Do their labels simply list the nutrient content or is the "% Daily Value" column used? Why do you think infant formula has a different label format?

Let's say you are feeding a 6-month-old infant who needs about 500 kcal per day. Using the information from the nutrition section of the label, you can calculate the number of fluid ounces of formula the baby needs (this assumes that no cereal or other foods are eaten):

**[FIGURE 14.13** An infant formula label. Notice that there is a long list of ingredients and no % Daily Value.]

There are 100 kcal (Calories) per 5 fluid ounces.

100 kcal ÷ 5 fl. oz = 20 kcal/fl. oz

500 kcal ÷ 20 kcal/fl. oz = 25 fl. oz of formula per day to meet the baby's energy needs

A 6-month-old infant needs about 210 mg calcium per day. Based on an intake of 25 fluid ounces of formula per day, as just calculated, you can use the label nutrition information to calculate the amount of calcium that is provided:

There are 78 mg calcium per 5 fluid ounce serving of formula.

78 mg ÷ 5 fl. oz = 15.6 mg calcium per fl. oz 15.6 mg calcium per fl. oz x 25 fl. oz = 390 mg of calcium per day

You can see that the infant's need for calcium is easily met by the formula alone.]

**[recap** Infancy is characterized by the most rapid growth a human being will ever experience, and appropriate growth is the most reliable long-term indicator of adequate infant nutrition. Three characteristics of infants combine to make their nutritional needs unique: (1) their high energy needs--40 to 50 kcal per pound of body weight--to support rapid growth, (2) their immature digestive tract and kidneys, and (3) their small size. Breast milk is the ideal infant food for the first 6 months of life; infant formula is also a nutritious choice.]

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[About 40% to 50% of an infant's energy intake should come from fat, and no more than 20% from protein. Infants need about 2 ounces of fluid per pound of body weight. Breast milk and commercial formulas provide most of the vitamins and minerals infants need. However, vitamin D, iron, and for infants of vegan mothers, vitamin B12 may warrant supplementation.]

**LO 7** Discuss some common nutrition-related concerns for infants.

## **What** **are some common nutrition-related concerns of infancy?**

Nutrition is one of the primary concerns of new parents. Many are uncertain when to begin offering solid foods, and what to offer. Moreover, as infants begin to consume a variety of foods, they may begin to experience allergic reactions or other disorders or feeding challenges.

**Infants Begin to Need Solid Foods at About 6 Months of Age**

Infants begin to need solid, or complementary, foods at around 6 months of age. Before this age, several factors make most infants unable to consume solid food.

One factor is the *extrusion reflex.* In early infancy, the suckling response depends on a particular movement of the tongue that draws liquid out of the breast or bottle. But when solid foods are introduced with a spoon, the extrusion reflex causes the baby to push most of the food back out of the mouth. The extrusion reflex begins to lessen around 4 to 5 months of age.

Another factor is the development of appropriate muscle control and oral skills.51 To minimize the risk for choking, infants must have gained muscular control of the head and neck and be able to sit up (with or without support). In addition, they must be able to signal readiness to eat by opening their mouth, and to move the food from the front of the mouth to the back, where it can be safely swallowed.

Still another part of being ready for solid foods is sufficient maturity of the digestive and kidney systems. Although infants can digest and absorb lactose from birth, they do not develop the ability to digest starch until the age of 3 to 4 months. Feeding cereal, for example, before an infant can digest the starch may cause diarrhea and discomfort. Finally, the kidneys must have matured so that they are better able to process nitrogen wastes from proteins and concentrate urine.

The need for solid foods is also related to nutrient needs. At about 6 months of age, if not fed iron-fortified formula, infant iron stores become depleted; thus, iron-fortified infant cereals are often the first foods introduced. Iron-fortified rice cereal, a source of non-heme iron, rarely provokes an allergic response and is easy to digest. Once a child reaches 6 months of age, pureed meats and poultry can provide well-absorbed heme iron. At this point, overreliance on breast milk or formula can limit the infant's intake of iron-rich foods, resulting in a condition known as *milk anemia.*

Delaying the introduction of infant foods until at least 4 months of age reduces the risk of food allergies. Infant foods should be introduced one at a time, with no other new foods for about 1 week, so that parents can watch for signs of allergies, such as a rash, gastrointestinal problems, a runny nose, or wheezing. The appropriate delaying of solid foods is also associated with a reduced risk of child obesity.52

Between 6 months and the time of weaning (from breast or bottle), solid foods should gradually make up an increasing proportion of the infant's diet. A variety of single-grain cereals, strained vegetables, fruits, and protein sources should be introduced by the end of the first year. During this time, food textures can advance from purees to very soft foods and eventually harder or textured foods. Commercial baby foods are convenient, nutritious, typically made without added salt or sugar, and come in a range of age-appropriate textures. However, home-prepared baby foods are usually cheaper and reflect the cultural food patterns of the family. Even throughout the first year, however, solid foods should be a supplement to, not a substitute for, breast milk or iron-fortified formula.

[Image: The extrusion reflex will push solid food out of an infant's mouth.]

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**Some Foods and Beverages Are Not Safe for Infants**

The following foods should never be offered to an infant:

**-** **Foods that can cause choking.** Infants cannot adequately chew foods such as grapes, hot dogs, cheese sticks, nuts, popcorn, raw carrots, raisins, and hard candies. These can cause choking.

**-** **Corn syrup and honey.** These may contain spores of the bacterium *Clostridium botulinum.* These spores can germinate and grow into viable bacteria in the immature digestive tract of infants. The bacteria secrete the potent botulism toxin, which can be fatal. Children older than 1 year can safely consume corn syrup and honey because their digestive tract is mature enough to kill any C. *botulinum* bacteria.

**-** **Cow's milk, goat's milk, and plant-based milk alternatives.** As noted earlier, these milks do not have a nutrient profile that meets infants' needs. Infants can begin to consume them after the age of 1 year. Infants and toddlers should not be given reduced-fat milks before the age of 2 because they do not contain enough fat. Infants should not be given evaporated milk or sweetened condensed milk.

**-** **Too much salt and sugar.** Infant foods should not be seasoned with salt or spices. Naturally occurring sugars, such as those found in fruits, are acceptable, but cookies and other processed desserts high in added sugar should be avoided.

**Several Nutrition-Related Disorders Are Concerns for Infants**

Infants cannot speak, and their cries are sometimes indecipherable. Feeding time can therefore be very frustrating for parents if the child is not eating, is not growing appropriately, or has problems such as colic, diarrhea, vomiting, or persistent skin rashes. The following are some nutrition-related concerns for infants.

**Allergies**

Many foods have the potential to stimulate an allergic reaction. Breastfeeding helps reduce the risk of food allergies, as does delaying the introduction of solid foods until the age of 4 to 6 months. One of the most common allergies in infants is to the proteins in cow's milk-based formulas. Egg white, peanut, and wheat are other common triggers of food allergies. Symptoms vary but may include diarrhea, constipation, bloating, blood in the stool, and vomiting. As stated earlier, every new food should be introduced in isolation, so that any allergic reaction can be identified and the offending food avoided. New techniques to prevent food allergies in infants are the subject of some controversy, as discussed in the **Nutrition Debate** at the end of this chapter.

**Dehydration**

Whether the cause is diarrhea, vomiting, or inadequate fluid intake, dehydration is extremely dangerous to infants and, if left untreated, can quickly result in death. Treatment includes providing fluids, a task that is difficult if vomiting is occurring. In some cases, the physician may recommend that a pediatric electrolyte solution be administered on a temporary basis. In more severe cases, hospitalization may be necessary. If possible, breastfeeding should continue throughout an illness. A physician should be consulted concerning formula-feeding and solid foods.

**Colic**

Perhaps nothing is more frustrating to new parents than the relentless crying spells of some infants, typically referred to as **colic.** In this condition, newborns and young infants who appear happy, healthy, and well-nourished suddenly begin to cry or even shriek, continuing for several minutes to 3 hours or more, no matter what their caregiver does to console them. The spells tend to occur at the same time of day, typically late in the afternoon or early in the evening, and often occur daily for a period of several weeks. Overstimulation of the nervous system, feeding too rapidly, swallowing of air, and intestinal gas pain are considered possible culprits, but the precise cause is unknown.

[For a list of foods and objects associated with choking, visit the American Academy of Pediatrics' **www.healthychidlren.org.** Enter "choking prevention" into the search bar, then click on the link.]

[Image: Colicky babies will begin crying for no apparent reason, even if they otherwise appear well nourished and happy.]

[Sidebar: **colic** A condition of inconsolable infant crying that lasts for hours at a time.]

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As with allergies, if a colicky infant is breastfed, breastfeeding should be continued, but the mother should try to determine whether eating certain foods seems to prompt crying and, if so, eliminate the offending food(s) from her diet. Formula-fed infants may benefit from a change in type of formula. In the worst cases of colic, a physician may prescribe medication. Fortunately, most cases disappear spontaneously, possibly because of the maturity of the gastrointestinal tract, around 3 months of age.

**Anemia**

As stated earlier, full-term infants are born with sufficient iron stores to last for approximately the first 6 months of life. In older infants and toddlers, however, iron is the mineral most likely to be deficient. Iron-deficiency anemia causes pallor, lethargy, and impaired growth. Commercial formulas are fortified with iron. For breastfed infants, some pediatricians prescribe an iron supplement; however, iron for older infants is also supplied by iron-fortified rice cereal.

**Nursing Bottle Syndrome**

Infants should not be left alone with a bottle, whether lying down or sitting up. As infants manipulate the nipple of the bottle in their mouth, the high-carbohydrate fluid (whether breast milk, formula, or fruit juice) drips out, coming into prolonged contact with the developing teeth. This high-carbohydrate fluid provides an optimal food source for the bacteria that are the underlying cause of **dental caries** (cavities). Severe tooth decay can result **(FIGURE 14.14).** Encouraging the use of a cup around the age of 8 months helps prevent nursing bottle syndrome, along with weaning the baby from a bottle entirely by the age of 15 to 18 months.

**Lead Poisoning**

The heavy metal lead is a neurotoxin that is especially harmful to infants and children because their brains and central nervous systems are still developing. Lead poisoning can result in decreased mental capacity, behavioral problems, impaired growth, impaired hearing, and other problems. Unfortunately, leaded pipes and lead paint can still be found in older homes and buildings, and as occurred in the city of Flint, Michigan, in 2015, lead can even leach into the municipal water supply. The following measures can reduce lead exposure:

- Use only cold tap water for drinking, mixing with foods, or cooking. Hot tap water is more likely to leach lead. After a faucet has not been used for a few hours, or overnight, allow the water to run for a minute or so to clear the pipes of any lead-contaminated water before using the water for consumption or cooking. The water should be very cold.

- Replace old plumbing with lead-free fixtures.

- Have lead-based paint professionally removed, or paint over it with latex paint.

**[recap** Breast milk or iron-fortified formula provides all necessary nutrients for the first 6 months of life. After that, solid foods can gradually be introduced into an infant's diet. Iron-fortified cereal or strained meats are typical choices, and single-item vegetables and fruits are appropriate. Foods and beverages with added sugars should be avoided. Micronutrient supplements should be given only if prescribed. Parents must avoid giving their infants foods that could trigger choking, such as hot dogs, grapes, and other firm foods. New foods should be introduced slowly, and infants must be monitored for allergies. Colic typically resolves by 3 months of age. Dehydration is a significant risk in infants and must be treated at the earliest signs. To prevent dental caries, infants should not be left alone with a bottle, whether lying down or sitting up. Infants and children are highly vulnerable to lead in paints or contaminated water. Lead poisoning can result in neurological problems.]

**[FIGURE 14.14** Leaving a baby alone with a bottle can result in the tooth decay of nursing bottle syndrome.]

[Sidebar: **dental caries** Dental erosion and decay caused by acid-secreting bacteria in the mouth and on the teeth. The acid produced is a by-product of bacterial metabolism of carbohydrates deposited on the teeth.]

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[**nutrition debate Preventing Food Allergies in Infants: Allergen Avoidance or Introduction?**

Recently, the incidence of food allergies (see Chapter 3) among U.S. children has increased by 50 percent, with an annual cost of nearly $25 billion.53 An estimated 10 percent of infants and toddlers and 8 percent of children in the United States are affected by food allergies,54 and nearly 40 percent of these children experience a severe reaction.55 The three most common food triggers of pediatric allergies are peanut, cow's milk, and shellfish; soy, wheat, tree nuts, egg, and fin fish are other common allergens. Whereas many infants grow out of food allergies, children with peanut allergies often remain reactive for decades, if not their entire life.

Historically, the risk for food allergies in infants and toddlers has been linked to early exposure to the food(s). Therefore, national guidelines have recommended--and continue to recommend--delaying the introduction of solid foods until the infant is 4 to 6 months of age.56 Many concerned parents avoid giving foods with common allergens even to their older infants and toddlers. In one study, nearly half of mothers of 8- to 10-month-old infants withheld nuts, while a small percentage withheld eggs, dairy, and/or fish.57 Over the past decade, however, there has been growing evidence that this "avoidance" approach has failed to reduce the incidence of food allergies, and may have increased it.55

As a result, some allergy and immunology specialists have been encouraging parents to repeatedly feed very small amounts of potentially allergenic foods, such as peanut butter, to their infants.58 This practice has been shown to reduce the incidence of allergic reactions.58,59 In one study, parents in the experimental group gave their high-risk infants (4 to 11 months of age) about 1 teaspoon of peanut butter at least three times per week (equal to about 1 tablespoon of peanut butter per week). Parents in the control group completely withheld all peanut-containing foods until the children reached the age of 5. Those who were exposed to peanut early in life had an 80% lower rate of peanut allergy at age 5 years compared to those who had avoided peanuts. A follow-up study showed that the "early exposure" children remained at low risk for peanut allergy even after avoiding peanuts for 1 year.60 Another study began introducing very small amounts of potentially allergenic foods to breast-fed infants when they were only 3 months old. When reexamined between the ages of 1 and 3 years, the children exposed to the potential allergens were less likely to demonstrate food allergies compared to controls, but only if the parents carefully followed the feeding schedule.58 Otherwise, there was no protective effect compared to the infants who were exposed at 6 months of age or older. Unfortunately, less than half of the parents were able to adhere to the feeding schedule, so it is unlikely that this approach could be widely adopted.

Based on this evidence, a group of 10 national and international medical groups released new recommendations on how and when to introduce peanut to high-risk infants in order to prevent peanut allergies.61

Early introduction of foods containing common allergens--such as peanut butter, wheat biscuits, or plain yogurt--may help reduce the risk for food allergies in childhood.

While supportive of the "early introduction" approach, the recommendations included "evaluation by an allergist or physician trained in management of allergic diseases in this age group" in order to assess the safety of early introduction of potential allergens.

Thus, parents of infants at low risk (based on family history and other factors) should not withhold common allergens because, as we have seen, prolonged avoidance appears to increase the risk of subsequent food allergies. In contrast, infants considered "at risk" should be evaluated by a specialist who may consider the early introduction approach.

**CRITICAL THINKING QUESTIONS**

**1**. Imagine that one of your relatives known to have a peanut allergy recently gave birth to a baby and told you she would ***never*** feed her child peanuts until

6 years of age. Would you share with her this new research on pediatric allergies? Why or why not?

2. Why do you think it was so difficult for many parents in the pediatric allergy studies to follow for 1 year the schedule for introducing the potentially allergenic foods?

3. Other than a family history of food allergies, what are other factors that increase the risk of food allergies for children? For example, does income, race, geography, or health history of the child make a difference? Go online to review the research and help you identify risk factors.]

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**TEST YOURSELF** *ANSWERS*

**1** **F** Pregnant women need only 350 to 450 additional Calories per day, and only during the second and third trimesters of pregnancy. This is an increase of only 20% or less, not a doubling of Calories.

**2** **T** Breast milk contains various immune factors (antibodies and immune system cells) from the mother that protect the infant against infection. The nutrients in breast milk are structured to be easily digested by an infant, resulting in fewer symptoms of gastrointestinal distress and fewer allergies.

**3** **F** Most infants do not have a physiologic need for solid food until about 6 months of age.

**review questions**

**LO 1 1.** Folate deficiency in the first weeks after conception has been linked with which of the following problems in the newborn?

a. anemia

b. neural tube defects

c. low birth weight

d. preterm delivery

**2.** During the last two trimesters of pregnancy, about how many extra Calories per day does a woman need over her pre-pregnancy intake?

a. 350 to 450 kcal/day

b. 450 to 550 kcal/day

c. 550 to 650 kcal/day

d. 650 to 750 kcal/day

**LO 3 3**. Which of the following is a valid recommendation for reducing symptoms of morning sickness?

a. Eat as much as possible at each meal, as a full stomach can reduce nausea.

b. Consume fluids only at mealtimes because fluids on an empty stomach can increase nausea.

c. Keep dry cereal or crackers at the bedside to ease nighttime and morning nausea.

d. Drink colas and other caffeinated, carbonated beverages because these reduce nausea.

**LO 4 4.** Which of the following hormones is responsible for the letdown response?

a. progesterone

b. estrogen

c. oxytocin

d. prolactin

**LO 4 5.** Which of the following statements about maternal nutrition is true?

a. Lactating women need more Calories than pregnant women.

b. Lactating women need more iron than pregnant women.

c. Lactating women need more folate than pregnant women.

d. Lactating women must entirely avoid caffeine and alcohol.

**LO 5 6.** Which of the following statements about breast milk is true?

a. Most carbohydrate in breast milk is in the form of glucose.

b. The fat content of breast milk is lower than that of cow's milk.

c. Breast milk is cholesterol-free.

d. Certain proteins in breast milk help protect the newborn from infection.

**LO 6 7.** Which of the following micronutrients should be added to the diet of breast-fed infants when they are around 6 months of age?

a. vitamin K

b. calcium

c. iron

d. vitamin A

**LO 7** 8. After 6 months of age, it is safe and healthful to give infants

a. non-fat milk.

b. a cheese stick or chunks of cheese.

c. honey.

d. none of the above.

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**LO 1** **9. True or false?** Major developmental errors and birth defects are most likely to occur in the first trimester of pregnancy.

**LO 3 10. True or false?** If gestational diabetes is uncontrolled, the fetus may not receive enough glucose and may be born small for gestational age.

**LO 5** **11.** Mature breast milk averages about 700 kcal per liter, with 35 g of fat and 9 g of protein. Calculate the % of kcal from fat and protein. How do these values compare to those recommended for a healthy young adult? Why are the nutrient proportions of breast milk appropriate for infants?

*Answers to Review Questions and Math Review are located at the back of this text and in the MasteringNutrition Study Area.*

**web links**

**www.aap.org**

American Academy of Pediatrics

*Visit this website for information on infants' and children's health. Searches can be performed for topics such as "neural tube defects" and "infant formulas."*

**www.emedicine.com**

eMedicine: Pediatrics

*Enter "Pediatrics" into the search bar, then select "toxicology," and then "iron toxicity" to learn about accidental iron poisoning in children and infants.*

**www.marchofdimes.com**

**March of Dimes**

*Click on "During Your Pregnancy" to find links on nutrition during pregnancy, exercise, and things to avoid.*

**www.diabetes.org**

American Diabetes Association

*Search for "gestational diabetes" to find information about diabetes that develops during pregnancy.*

**www.choosemyplate.gov**

USDA ChooseMyPlate

*Search on the term "Daily Food Plan for Moms" and enter your information to get specific, individualized dietary advice for pregnant, or exclusively or partially breastfeeding, women via the Supertracker feature.*

**www.lalecheleague.org**

La Leche League

*Search this site to find multiple articles on the health effects of breastfeeding for mother and infant.*

**www.nofas.org**

National Organization on Fetal Alcohol Syndrome

*This site provides news and information relating to fetal alcohol syndrome.*

**www.helppregnantsmokersquit.org**

The National Partnership for Smoke-Free Families

*This site was created for healthcare providers and smokers with the purpose of educating about the dangers of smoking while pregnant and providing tools to help pregnant smokers quit.*

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# **in** depth **14.5** **The Fetal Environment**

***After studying this In Depth, you should be able to:***

**1** Identify three health problems seen in adults whose mothers were exposed to famine during their first trimester of pregnancy, pp. 525-526.

**2** Describe the effects seen later in life among children born to mothers with specific nutrient deficiencies, obesity, or gestational diabetes, pp. 526-527.]

**Would you be surprised to learn that your risk of developing obesity, metabolic syndrome, and certain chronic diseases as an adult might have been influenced by what happened before your birth?** Over the last several decades, a growing body of evidence has revealed that the fetal environment, including the mother's nutritional status, influences the health of her offspring not only during the first few weeks of life, but also as the infant grows into a child and adult.

In this **In Depth** essay, we explore this relationship, often referred to as the "fetal origins of adult disease" theory. Although it's based on studies of populations that have endured famine, it has broad-ranging implications, including for immigrants from developing nations who move to the United States. We also describe the enduring effects of a variety of other nutritional imbalances in the fetal environment, including specific micronutrient deficiencies and maternal obesity.

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## **How** **does fetal adaptation to famine affect adult health?**

**LO 1** Identify three health problems seen in adults whose mothers were exposed to famine during their first trimester of pregnancy.

Some of the earliest research into the fetal origins theory investigated the health of adults born during or shortly after a famine in the Netherlands from 1944 to 1945. During World War II, the Dutch population had been relatively well nourished until October 1944, when the Germans placed an embargo on all food transport into the western Netherlands. At the same time, an unusually early and harsh winter set in. As a result, a severe famine hit the western Netherlands. For the next several months, energy intakes were as low as 500 kcal/day. In May 1945, with the liberation of the country, food supplies were once again plentiful and dietary intake rapidly normalized. Luckily for scientists, the Dutch maintained excellent healthcare records, providing important information not only about pregnancy outcomes but also the health of the offspring over the next 60 years. Not surprisingly, maternal weight gain and infant birth weight were much lower than normal. What was unexpected, however, was the long-term impact of the famine as these "embargo babies" progressed through adulthood.1,2

Exposure to famine during the first trimester of pregnancy resulted in a much higher risk among the offspring for obesity, abdominal obesity, hypertension, coronary heart disease, abnormal blood lipids, and metabolic syndrome during adulthood. Exposure during mid-gestation increased the risk of kidney disorders. There is also evidence that prenatal exposure to famine affected the health not only of the individuals deprived *in litem,* but also of their children.1,2

Why, you might wonder, would low pregnancy weight gain and low birth weight lead to an increased risk of obesity and other diseases some 50 years later? Most of the proposed mechanisms relate to a process known as **fetal adaptation.** A fetus exposed to a stressful environment, such as maternal starvation or malnutrition, goes into survival mode. Fetal production of hormones shifts in favor of those that promote energy storage, the activity of certain enzymes may change, and the size and functioning of body organs such as the liver, kidney, and pancreas are affected. There may even be changes in the expression of certain genes. Although these adaptations enable the fetus to survive the harmful prenatal environment, these same hormonal, enzymatic, organ, and genetic changes may contribute to the development of chronic diseases over the life span.

The results of other "natural experiments" suggest that the effects of the prenatal environment on adult health depend quite heavily on the precise

circumstances in each situation. For example, Leningrad (now St. Petersburg) was under siege by the Germans during World War II for over 2 1/2 years, and as a result the population experienced starvation--over a million people died. And yet, adults who were born during this period did not have the same increased disease risks as found in those exposed, in utero, to the Dutch famine.3 How could this be, since the Leningrad babies were exposed to conditions far worse than those experienced by the Dutch babies?

Researchers theorize that the impact of fetal exposure to malnutrition is actually worsened if followed by high nutrient intakes shortly after birth.3 This was a key difference between the Netherlands and Leningrad famines: once the Dutch embargo was lifted, the population returned to a nourishing, adequate diet. This allowed the underweight infants to experience rapid weight gain and catch-up growth during their first year of life **(FIGURE 1).** In contrast, the Leningrad infants who survived into adulthood may have continued to suffer from malnutrition throughout infancy and even into toddlerhood, remaining underfed and underweight until they were in their childhood years.

**How** **do other nutritional imbalances in utero affect adult health?**

**LO 2** Describe the effects seen later in life among children born to mothers with specific nutrient deficiencies, obesity, or gestational diabetes.

By definition, a famine is a widespread lack or severe reduction in all food. Thus, research on the long-term health effects of famines cannot identify or describe the impact of in utero deficiencies of specific nutrients. Other studies, however, have been able to look at the impact of specific food patterns or nutrient deficiencies.4 For example:

- Evidence suggests that poor maternal intake of calcium increases risk of hypertension in adult offspring.

- Poor maternal folate status has been linked not only to neural tube defects in the newborn but also to increased risk of insulin resistance in the child. This, in turn, increases the child's risk for developing diabetes and other metabolic abnormalities.5

[Sidebar: **fetal adaptation** The process by which fetal metabolism, hormone production, and other physiologic processes shift in response to factors, such as inadequate energy intake, in the maternal environment.]

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[**FIGURE 1** Fetal adaptation to undernutrition can lead to a variety of diseases in childhood and throughout adulthood.]

- Given the role of vitamin D in calcium regulation, it may not be surprising that low vitamin D status of pregnant women is associated with reduced bone density in their children.6

Research with rats has revealed other links between micronutrient deficiencies and adult health.6 Thus, fetal stressors that influence adult health include not only starvation and inadequate energy but also specific micronutrient deficiencies.

Strong evidence also links maternal dietary excesses to health problems in adult offspring. Maternal obesity has been linked not only to an increased risk of childhood and adult obesity,7,8 but also to changes in the "programming" of the fetal brain, resulting in altered feeding behaviors. Maternal obesity is also linked to a higher risk of birth defects, including neural tube defects, many of which have lifelong implications for health.9 Population studies have also reported an association between high birth weight, common in infants born to obese women, and an increased risk of breast cancer in adulthood.

Maternal diabetes, with its high-glucose environment, has been shown to greatly increase the risk of type 2 diabetes, overweight, abdominal adiposity, high blood triglycerides, hypertension, and metabolic syndrome in adult offspring.1,10-12 The children of diabetic women are up to eight times more likely to develop type 2 diabetes or prediabetes as adults compared to the general population.

Prenatal exposure to excessive levels of individual nutrients also has lifelong implications. A high maternal intake of *trans* and/or saturated fatty acids is associated with increases for heart disease, hypertension, and type 2 diabetes in offspring.13 Scientists continue to investigate the possible lifelong effects of other nutrient excesses, including the impact of high maternal intake of sodium on risk of hypertension and the effect of high maternal saturated fat intake on risk for congenital heart defects.

## **nutri-case HANNAH**

"In my nutrition class, I learned that having a mother with diabetes increases the risk that you'll develop diabetes in childhood or adulthood. That helps me understand why my blood sugar test showed I have pre-diabetes, but it doesn't help me understand what to do about it."

Is Hannah destined to develop type 2 diabetes? Why or why not? Identify the factors that increase her risk, as well as the steps she can take to reduce her blood glucose levels and avoid the disease. (Review the **In Depth** on diabetes on pages 130-137.)

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In short, research suggests that there are lifelong consequences to any type of nutrient imbalance during pregnancy, whether the imbalance is a total energy deficit, a single nutrient deficiency, or an energy or nutrient excess.

If your mother experienced some type of nutritional imbalance during pregnancy, you certainly are not doomed to suffer from one or more of the health problems mentioned here. That's because most research reports on large groups of people, not individuals. It calculates increases in risk of--or susceptibility to--certain conditions, but it does not and cannot predict health outcomes for individuals. Moreover, fetal adaptation is just one factor in your personal wellness. Much more significant are your lifestyle choices, especially your eating pattern, activity level, alcohol intake, and whether or not you smoke. In short, you have the power to influence your genetics and biology every day.

[Image: Regular physical activity is one of the most significant factors in maintaining wellness.]

**web links**

**www.marchofdimes.com**

March of Dimes

*This website provides information on the potential risks of maternal dietary imbalances.*

**www.acog.org/Patients/FAQs/Nutrition-During-Pregnancy**

American College of Obstetrics and Gynecology

*Visit this web page to find comprehensive information on nutrition during pregnancy, as well as links to related pages.*

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[**test yourself**

**1.** **T F** A toddler who does not readily accept a new food after being given it for a second time will probably never like it.

**2. T F** Adolescents experience an average 10% to 15% increase in height during the years of puberty.

**3. T F** Participating in regular physical activity can delay or reduce some of the loss of muscle mass that occurs with aging.

*Test Yourself answers are located in the Study Plan at the end of this chapter.*]

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# **CHAPTER 15** **Nutrition Through Childhood to late adulthood**

***After studying this chapter, you should be able to:***

**1** Describe nutrient recommendations, appropriate food choices, and the risks of a vegan diet for toddlers, pp. 530-535.

**2** Discuss the nutrient needs of children, the role of school attendance, and nutrition-related concerns of childhood, pp. 535-540.

**3** Explain how puberty influences the nutrient needs and health concerns of adolescents, pp. 541-546.

**4** Discuss the problem of pediatric obesity, including medical issues and preventive measures, pp. 546-549.

**5** Describe the growth of the older adult population in the United States and the physiologic changes that accompany normal aging, pp. 549-551.

**6** Explain how aging influences the nutrient needs and health concerns of older adults, pp. 551-558.]

**On Sunday afternoons, the Hsiao family gathers for dinner at the Long Beach apartment of their 88-year-old matriarch, Leng.** Leng is petite and slender, as are her 70-year-old daughter and 67-year-old son. But when her granddaughters, who are cooking the family meal, send everyone to the table, a change becomes evident. Many of Leng's grandchildren and their spouses are obese, as are some of her greatgrandchildren. Leng worries about everyone's weight. One of her grandsons has had a heart attack, and some in her family have been diagnosed with type 2 diabetes. Leng's family isn't alone in their weight problems: in the United States, although the prevalence of obesity has recently stabilized and has actually decreased in preschool children, rates remain unacceptably high.1 Currently, about 17% of U.S. children and adolescents age 2 to 19 years are classified as obese, leading to both short-and long-term health problems.1

Why are the rates of obesity and its associated chronic diseases so high, and what can be done to promote weight management across the life span? How do our nutrient needs change as we grow and age, and what other nutrition-related concerns develop in each life stage? This chapter will help you answer these questions.

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**LO 1** Describe nutrient recommendations, appropriate food choices, and the risks of a vegan diet for toddlers.

## **What** **are the nutritional needs and concerns of toddlerhood?**

As babies begin to walk and explore, they transition out of infancy and into the active world of toddlers. From their first to their third birthday, a toddler will grow a total of about 5.5 to 7.5 inches and gain an average of 9 to 11 pounds. Like people of all ages, toddlers need to consume a nutrient-dense diet. But feeding a toddler raises new challenges for parents and caregivers.

**Body Size and Activity Increase Toddlers' Nutrient Needs**

Nutrient needs increase as a child progresses from infancy to toddlerhood. Although toddlers' rates of growth have slowed, their increased nutrient needs reflect their larger body size and increased activity. Refer to **TABLE 15.1** for a review of specific nutrient recommendations.

**Energy and Macronutrient Recommendations for Toddlers**

Although the energy requirement per kilogram of body weight for toddlers is slightly less than for infants, *total* energy requirements are higher because toddlers are larger and much more active than infants. The estimated energy requirements (EERs) vary according to the toddler's age, body weight, and level of activity.2 In general, toddlers should consume a diet that provides enough energy to sustain a healthy and appropriate rate of growth.

Healthy toddlers of appropriate body weight need to consume 30% to 40% of their total daily energy intake as fat.2 We know that fat provides a concentrated source of energy in a relatively small amount of food, and this is important for toddlers, especially those who are fussy eaters or have little appetite. Moreover, fats, especially the unsaturated fatty acids AA and DHA, support the toddler's still developing nervous system.

Toddlers' protein needs increase modestly because they weigh more than infants and are still growing rapidly. The RDA for protein for toddlers is 1.10 g/kg body weight per day, or approximately 13 g of protein daily.2 Remember that 2 cups of milk alone provide 16 g of protein; thus, most toddlers have little trouble meeting their protein needs.

**TABLE 15.1 Nutrient Recommendations for Children and Adolescents**

|  |  |  |  |
| --- | --- | --- | --- |
| **Nutrient** | **Toddlers (1-3 Years)** | **Children Children (4-8 Years) (9-13 Years)** | **Adolescents (14-18 Years)** |
| Fat | No RDA | No RDA | No RDA | No RDA |
| Protein | 1.10 g/kg body weight per day | 0.95 g/kg body weight per day | 0.95 g/kg body weight per day | 0.85 g/kg body weight per day |
| Carbohydrate | 130 g/day | 130 g/day | 130 g/day | 130 g/day |
| Vitamin A | 300 µg/day | 400 µg/day | 600 µg/day | Boys: 900 µg/day Girls: 700 µg/day |
| Vitamin C | 15 mg/day | 25 mg/day | 45 mg/day | Boys: 75 mg/day Girls: 65 mg/day |
| Vitamin E | 6 mg/day | 7 mg/day | 11 mg/day | 15 mg/day |
| Calcium | 700 mg/day | 1,000 mg/day | 1,300 mg/day | 1,300 mg/day |
| Iron | 7 mg/day | 10 mg/day | 8 mg/day | Boys: 11 mg/day Girls: 15 mg/day |
| Zinc | 3 mg/day | 5 mg/day | 8 mg/day | Boys: 11 mg/day Girls: 9 mg/day |
| Fluid | 1.3 liters/day | 1.7 liters/day | Boys: 2.4 liters/day Girls: 2.1 liters/day | Boys: 3.3 liters/day Girls: 2.3 liters/day |

[Image: Toddlers expend significant amounts of energy exploring their world.]

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The RDA for carbohydrate for toddlers is 130 g/day, and carbohydrate intake should be about 45 % to 65 % of total energy intake.2 As with older children and adults, most of the carbohydrates eaten should be complex, and refined carbohydrates from high-fat/high-sugar items, such as desserts and snack foods, should be kept to a minimum. Fruits and 100% fruit juices are nutritious sources of simple carbohydrates; however, too much fruit juice can displace other foods, including milk and whole fruits, and can cause diarrhea. The American Academy of Pediatrics recommends that the intake of fruit juice be limited to 4 to 6 fl. oz/day for children 1 to 6 years of age.3

Adequate fiber is important for toddlers to maintain bowel regularity. The adequate intake (AI) is 14 g of fiber per 1,000 kcal of energy, or, on average, 19 g/day.2 Whole-grain breads and cereals and fresh fruits and vegetables are healthful choices for toddlers. Too much fiber, however, can inhibit the absorption of iron, zinc, and other essential nutrients; can harm the toddler's small digestive tract; and can cause toddlers to feel full before they have consumed adequate nutrients.

Determining the macronutrient requirements of toddlers can be challenging. See the **You Do the Math** box on page 532 for an analysis of the macronutrient levels in one toddler's daily diet.

**Micronutrient Recommendations for Toddlers**

As toddlers grow, their micronutrient needs increase (see Table 15.1). Of particular concern with toddlers are adequate intakes of the nutrients associated with fruits and vegetables. In addition, vitamin D, calcium, and iron have been identified as "priority nutrients" for children aged 2 to 4 years. Vitamin D intake, which often decreases in toddlers, is closely linked to milk consumption. The American Academy of Pediatrics recommends vitamin D supplements for all children who consume less than 1 liter of vitamin D-fortified dairy products each day--a group that includes the majority of U.S. children.3 Vitamin D-fortified soymilk and other milk alternatives, in adequate amounts, are also acceptable.

Adequate calcium is necessary for children to build optimal bone mass, which continues to accumulate until early adulthood. For toddlers, the RDA for calcium is 700 mg/day.4 Dairy products are excellent sources of calcium. When a child reaches the age of 1 year, whole cow's milk can be given; however, reduced-fat milk (2% or less) should *not* be given until age 2 due to the relatively high need for total energy in young children. If consumption of dairy products is not feasible, calcium-fortified orange juice or soymilk can supply calcium, or children's calcium supplements can be given. Toddlers generally cannot consume enough dark-green vegetables and similar plant foods to depend on them for adequate calcium.

Iron-deficiency anemia is the most common nutrient deficiency in young children in the United States and around the world. Iron-deficiency anemia can affect a child's energy level, attention span, and mood. The RDA for iron for toddlers is 7 mg/day.5 Good sources of well-absorbed heme iron include lean meats, fish, and poultry; non-heme iron is provided by eggs, legumes, greens, and fortified foods, such as breakfast cereals. When toddlers consume non-heme sources of iron, eating vitamin C at the same meal will enhance the absorption of iron from these sources.

Given toddlers' typically erratic eating habits, pediatricians often recommend an age-appropriate multivitamin and mineral supplement, providing no more than 100% of the Daily Value per dose for any nutrient, as a precaution against deficiencies. Toddlers who are fed a vegan diet, live in a household that cannot afford adequate amounts of nourishing food, or have certain medical issues often benefit from supplements. The toddler's physician or dentist may also prescribe a fluoride supplement if the community water supply is not fluoridated. Toddlers are at particularly high risk of overdosing on iron supplements, so parents must be careful to keep such products out of reach of their children.

**Fluid Recommendations for Toddlers**

Toddlers lose less fluid from evaporation than infants, and their more mature kidneys are able to concentrate urine, conserving the body's fluid when intake is low. However, as toddlers become active, they start to lose significant fluid through sweat, especially in hot weather. Parents need to make sure an active toddler is drinking adequately.

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## [**you do the math Is This Menu Good for a Toddler?**

A dedicated mother and father want to provide the best nutrition for their son, Ethan, who is now 1 1/2 years old and has just been completely weaned from breast milk. Ethan weighs about 26 pounds (11.8 kg). In the accompanying table is a typical day's menu for Ethan. Grams of protein, fat, and carbohydrate are given for each food. The day's total energy intake is 1,168 kcal.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Meal** | **Foods** | **Protein (g)** | **Fat (g)** | **Carbohydrate (g)** |
| Breakfast | Oatmeal (1/2 cup, cooked) | 2.5 | 1.5 | 13.5 |
| Brown sugar (1 tsp.) | 0 | 0 | 4 |
| Milk (1%, 4 fl. oz) | 4 | 1.25 | 5.5 |
| Grape juice (4 fl. oz) | 0 | 0 | 20 |
| Mid-morningsnack | Banana slices (1 small banana) | 0 | 0 | 16 |
| Yogurt (nonfat, fruit-flavored 1.3 fl. oz) | 5.5 | 0 | 15.5 |
| Orange juice (4 fl. oz) | 1 | 0 | 13 |
| Lunch | Whole-wheat bread (1 slice) | 1.5 | 0.5 | 10 |
| Peanut butter (1 tbsp.) | 4 | 8 | 3.5 |
| Strawberry jam (1 tbsp.) | 0 | 0 | 13 |
| Carrots (cooked, 1/8 cup) | 0 | 0 | 2 |
| Applesauce (sweetened, 1/4 cup) | 0 | 0 | 12 |
| Milk (1%, 4 fl. oz) | 4 | 1.25 | 5.5 |
| Afternoonsnack | Bagel (1/2) | 3 | 1 | 20 |
| American cheese product (1 slice) | 3 | 5 | 1 |
| Water | 0 | 0 | 0 |
| Dinner | Scrambled egg (1) | 11 | 5 | 1 |
| Baby food spinach (3 oz) | 2 | 0.5 | 5.5 |
| Whole-wheat toast (1 slice) | 1.5 | 0.5 | 10 |
| Mandarin orange slices (1/4 cup) | 0.5 | 0 | 10 |
| Milk (1%, 4 fl. oz) | 4 | 1.25 | 5.5 |

Calculate the percentage of Ethan's Calories that come from protein, fat, and carbohydrate (the numbers may not add up to exactly 100% because of rounding). In what areas are Ethan's parents doing well, and where can they improve?

*Note:* This activity focuses on the macronutrients. It does not ask you to consider Ethan's intake of micronutrients or fluids.

***Calculations:***

There is a total of 47.5 g protein in Ethan's menu.

47.5 g × 4 kcal/g = 190 kcal

190 kcal protein/1,168 total kcal × 100 = 16% protein

There is a total of 25.75 g fat in Ethan's menu.

25.75 g × 9 kcal/g = 232 kcal

232 kcal fat/1,168 total kcal × 100 = 20% fat

There is a total of 186.5 g carbohydrate in Ethan's menu.

186.5 g × 4 kcal/g = 746 kcal

746 kcal carbohydrate/1,168 total kcal × 100

= 64% carbohydrate

***Analysis:***

Ethan's parents are doing very well at offering a wide variety of foods from various food groups; they are especially doing well with fruits and vegetables. Also, according to his estimated energy requirement, Ethan requires about 970 kcal/day, and he is consuming 1,168 kcal/day, thus meeting his energy needs.

Ethan's total carbohydrate intake for the day is 186.5 g, which is higher than the RDA of 130 g/day; however, this value falls within the recommended 45% to 65% of total energy intake that should come from carbohydrates. Thus, high carbohydrate intake is adequate to meet his energy needs.

However, Ethan is being offered far more than enough protein. The DRI for protein for toddlers is about 13 g/day, and Ethan is eating more than three times that much!

It is also readily apparent that Ethan is being offered too little fat for his age. Toddlers need at least 30% to 40% of their total energy intake from fat, and Ethan is consuming only about 20% of his Calories from fat. He should be drinking whole milk, not 1 % milk. He should occasionally be offered higher-fat foods, such as cheese for his snacks or macaroni and cheese for a meal. Yogurt is fine, but it shouldn't be nonfat at Ethan's age. In conclusion, Ethan's parents should continue to offer a variety of nutritious foods but should shift some of the energy Ethan currently consumes as protein and carbohydrate to fat.]

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The recommended fluid intake for toddlers--about 4 cups as beverages, including drinking water--is listed in Table 15.1.6 Suggested beverages are plain water, milk and calcium-fortified milk alternatives and 100% juices, and foods high in water content, such as vegetables and fruits.

**Encourage Nutritious Food Choices with Toddlers**

Parents and pediatricians have long known that toddlers tend to be choosy about what they eat. Some avoid entire food groups, such as all meats or vegetables. Others will refuse all but one or two favorite foods (such as peanut butter on crackers) for several days or longer. These behaviors frustrate and worry many parents, but in fact, as long as a variety of healthful food is available, most toddlers have the ability to match their food intake with their needs. A toddler will most likely make up for one day's deficiency later on in the week. Parents who offer only nutritious foods can usually feel confident that their children are being well fed, even if a child's choices seem odd or erratic on any particular day. Food should never be "forced" on a child because doing so sets the stage for eating and control issues later in life.

Toddlers' stomachs are very small, and they cannot consume all of the Calories they need in three meals. They need small meals alternated with nutritious snacks every 2 to 3 hours. A successful technique is to create a snack tray filled with small portions of nutritious food choices, such as one-third of a banana, a few cubes of tofu, and two whole-grain crackers, and leave it within reach of the child's play area. The child can then "graze" on these healthful foods while he or she plays. A snack tray plus a spill-proof cup of milk or water is particularly useful on car trips. Even at mealtime, portion sizes should be small. One tablespoon of a food for each year of age constitutes a serving throughout the toddler and preschool years **(FIGURE 15.1).** Realistic portion sizes can give toddlers a sense of accomplishment when they "eat it all up" and minimize parents' fears that their child is not eating enough.

Foods prepared for toddlers should be developmentally appropriate. Nuts, carrots, grapes, raisins, cherry tomatoes, and firm cheese are difficult for a toddler to chew and pose a choking hazard. Foods should be soft and sliced into thin strips or wedges that are easy for children to grasp. As the child develops more teeth and becomes more coordinated, the range of food can expand.

**[FIGURE 15.1** Portion sizes for preschoolers are much smaller than those for older children. Use the following guideline: 1 tbsp. of the food for each year of age equals 1 serving. For example, 2 tbsp. of rice, 2 tbsp. of black beans, and 2 tbsp. of chopped tomatoes is appropriate for a 2-year-old.]

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Foods prepared for toddlers can also be fun **(FIGURE 15.2).** Parents can use cookie cutters to turn a peanut butter sandwich into a pumpkin face, or arrange cooked peas or carrot slices to look like a smiling face on top of mashed potatoes. Juice and yogurt can be frozen into "popsicles" or blended into "milkshakes."

New foods should be introduced gradually. Most toddlers are leery of new foods, spicy foods, hot (temperature) foods, mixed foods such as casseroles, and foods with strange textures. A helpful rule is to encourage the child to eat at least one bite of a new food: if the child does not want the rest, nothing negative should be said and the child should be praised just for the willingness to try. The food should be reintroduced a few weeks later. Toddlers may need as many as 15 exposures to a new food before accepting it. Parents should never bribe with food--for example, promising dessert if the child finishes her squash. Bribing teaches children that food can be used to reward and manipulate. Instead, parents can try to positively reinforce good behaviors--for example, "Wow! You ate every bite of your squash! That's going to help you grow big and strong!"

Role modeling is important because toddlers mimic older children and adults: if they see their parents eating a variety of healthful foods, they are likely to do so as well. Adults have a major impact on the nutritional quality of their children's choices.7

Offering two different but healthful snacks will also help toddlers make nutritious food choices. For example, parents might say, "It's snack time! Would you like apples and cottage cheese or bananas and yogurt?"

Finally, toddlers are more likely to eat food they help prepare. Encourage them to assist in the preparation of simple foods, such as helping to pour a bowl of cereal or arrange vegetables on a plate.

**Vegan Diets May Not Be Healthful for Toddlers**

For toddlers, a lacto-ovo-vegetarian diet, in which dairy foods and eggs are included, can be as wholesome as a diet that includes meats and fish.8 However, because red meat is an important source of zinc and heme iron, families who do not serve red meat must be careful to include enough zinc and iron from other sources in their child's diet.

In contrast, a vegan diet, in which no foods of animal origin are consumed, poses several potential nutritional risks for toddlers:

**-** **Protein.** Vegan diets can be too low in total protein or protein quality for toddlers, who need adequate amounts of high-quality protein for growth and increasing activity. Few toddlers can consume enough legumes and whole grains to provide sufficient protein. The high fiber content of legumes and whole grains results in a rapid sense of fullness for toddlers, decreasing their total food intake. Soymilk, tofu, and other soy-based products are excellent sources of complete dietary protein.

**-** **Calcium.** Children who consume no milk, yogurt, or cheese are at risk for calcium deficiency. As with protein, few children can consume enough calcium from plant sources to meet their daily requirement. Although most brands of soymilk and other milk alternatives, and certain fruit juices and cereals, are now fortified with calcium, supplementation may be necessary.

**-** **Zinc and Iron.** These minerals, which are abundant in meat, poultry, and seafood, are commonly low in vegan diets. Although both zinc and iron are found in legumes, young children simply cannot eat enough legumes to meet their needs, and supplementation is advised.

**-** **Vitamins** D **and** B12. Children consuming strict vegan diets are at risk for deficiencies of both of these vitamins. Some cereals and soymilks are fortified with vitamin D; however, many toddlers may still need a vitamin D-containing supplement. Vitamin B12 is not available in any amount from plant foods and must be obtained from fortified foods such as soymilk or from supplements.

**-** **Fiber.** Vegan diets often contain a higher amount of fiber than is recommended for toddlers, resulting in lowered absorption of iron and zinc, as well as the early onset of fullness or satiety.

**[FIGURE 15.2** Most toddlers are delighted by food prepared in a fun way.]

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Although adults who follow a vegan diet have the ability to choose alternative foods and/or supplements to meet the demands for these nutrients, toddlers depend on their parents to make appropriate food choices for them. If parents are determined to maintain a vegan diet for their toddler, choosing to include fortified juices, soymilk, and other soy products, along with an appropriate pediatric supplement and ongoing consultation with a pediatrician or pediatric dietitian, can ensure adequate nutrition in the toddler's diet. With proper planning, vegan children demonstrate appropriate growth, comparable with that of nonvegetarian children.9

**[recap**

Growth during toddlerhood is slower than it is during infancy; however, toddlers are highly active, and total energy, fat, and protein requirements are higher for toddlers than for infants. Although all forms of milk can be used to meet calcium requirements, until age 2, toddlers should drink whole milk. Iron deficiency can be avoided by feeding toddlers lean meats/fish/ poultry, eggs, and iron-fortified foods. Toddlers need to drink about 4 cups of water or other beverages per day. Toddlers require small, frequent, nutritious meals and snacks, and food should be soft and cut in small pieces, so that it is easy to handle, mash, and swallow without choking. Role modeling by parents and access to ample healthful foods can help toddlers make nutritious choices. Feeding vegan diets to toddlers poses the potential for deficiencies in protein, calcium, zinc, iron, vitamin D, and vitamin B12.]

**LO 2** Discuss the nutrient needs of children, the role of school attendance, and nutrition-related concerns of childhood.

## **What** **are the nutritional needs and concerns of childhood?**

During the preschool and school-age years, children become even more active, but their growth rate slows. Children grow at a slow and steady rate, averaging 2 to 4 inches per year until the rapid growth of adolescence begins.

**Growth and Development Increase Children's Nutrient Needs**

Until the age of 8 or 9 years, the nutrient needs of young boys and girls do not differ; because of this, the Dietary Reference Intake (DRI) values for the macronutrients, fiber, and micronutrients are grouped together for children ages 4 to 8 years. The beginning of sexual maturation, however, has a dramatic impact on the nutrient needs of children. Boys' and girls' bodies develop differently in response to gender-specific hormones. These changes in sexual maturation can begin subtly between the ages of 8 and 9 years; thus, the DRI values are separately defined for boys and girls ages 9 to 13 years.2,4-6,10 Table 15.1 identifies the nutrient needs of children and adolescents.

[Image: Enriched and fortified foods, such as fortified soymilk, should be given to toddlers consuming vegan diets to ensure they get adequate amounts of key nutrients.]

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**Energy and Macronutrient Recommendations for Children**

Total energy requirements continue to increase throughout childhood because of increasing body size and, for some children, higher levels of physical activity.2 The EER varies according to the child's age, body weight, and level of activity. Activity levels among children vary dramatically; however, all children can be encouraged to have fun using their muscles in various ways that suit their interests. Parents should provide diets that support normal growth and appropriate physical activity while minimizing the risk for excess weight gain. The U.S. Department of Agriculture (USDA) has produced a Daily Food Plan for preschoolers, helping parents to support their children in maintaining a healthful eating pattern **(FIGURE 15.3).**

Although dietary fat remains a key macronutrient in the preschool years, total fat intake should gradually be reduced to a level closer to that of an adult, 25% to 35% of total energy.2 One easy way to start reducing saturated fat is to serve lean protein choices, introduce lower-fat dairy products, such as 2% or 1% milk, and minimize the intake of fried foods. A diet providing less than 25% of Calories from fat is not recommended for children because they are still growing, developing, and maturing. In fact, parents should avoid putting too much emphasis on fat at this age. Impressionable and peer-influenced children may be prone to categorize foods as "good" or "bad," leading to skewed views of food and inappropriate eating habits.

The RDA for carbohydrate for children is 130 g/day, which is about 45% to 65% of total daily energy intake.2 Complex carbohydrates from whole grains, fruits, vegetables, and legumes should be emphasized. Simple sugars should come from fruits and 100% fruit juices, with foods high in refined sugars, such as cakes, cookies, and candies, saved for occasional indulgences. The AI for fiber for children is 14 g/1,000 kcal of energy consumed.2 As is the case with toddlers, too much fiber can be harmful because it can make a child feel prematurely full and interfere with adequate food intake and nutrient absorption.

As seen in Table 15.1, the protein recommendation for boys and girls is 0.95 g/kg body weight per day.2 Lean meats, fish, poultry, lower-fat dairy products, soy-based foods, and legumes are nutritious sources of protein that can be provided to children of all ages.

**Micronutrient Recommendations for Children**

The need for most micronutrients increases slightly for children up to age 8 because of their increasing size. A sharper increase in micronutrient needs occurs during the transition into full adolescence; this increase is due to the beginning of sexual maturation and in preparation for the impending adolescent growth spurt. Children who fail to consume the USDA-recommended 4 cups of fruits and vegetables each day may become deficient in vitamins A, C, and E. Offering fresh fruits and vegetables during meals or as snacks will also improve intakes of fiber and potassium, which are often low in the diets of low-income children. Minerals of concern continue to be calcium, iron, and zinc, which come primarily from animal-based foods.4,5 Notice that the RDA for iron is based on the assumption that most girls do not begin menstruation until after age 13.5 Refer again to Table 15.1 for a review of the nutrient needs of children.

If there is any concern that a child's nutrient needs are not being met for any reason (for instance, breakfasts are skipped, lunches are traded, or parents lack money for nourishing food), a pediatric vitamin/mineral supplement that provides no more than 100 % of the Daily Value for the micronutrients may help correct any existing deficit.

**Fluid Recommendations for Children**

The daily fluid recommendations for children are about 5 to 8 cups of beverages, including drinking water (see Table 15.1).6 The exact amount of fluid needed varies according to a child's level of physical activity and the weather conditions.

[Image: Children's multivitamins often appear in shapes or bright colors.]

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**Healthy Eating for Preschoolere Daily Food Plan**

**Use this Plan as a general guide.**

- These food plans are based on average needs. Do not be concerned if your child does not eat the exact amounts suggested. Your child may need more or less than average. For example, food needs increase during growth spurts.

- Children's appetites vary from day to day. Some days they may eat less than these amounts; other days they may want more. Offer these amounts and let your child decide how much to eat.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Food group** | **2 year olds** | **3 year olds** | **4 and 5 year olds** | **What counts as:** |
| **Fruits**[Image Removed] | 1 cup | 1 - 1½ cups | 1 - 1½ cups | ½ cup of fruit?½ cup mashed, sliced, or chopped fruit ½ cup 100% fruit juice ½ medium banana 4-5 large strawberries |
| **Vegetables**[Image Removed] | 1 cup | 1½ cups | 1½ *-* 2 cups | ½ cup of veggies?½ cup mashed, sliced, or chopped vegetables1 cup raw leafy greens ½ cup vegetable juice 1 small ear of corn |
| **Grains**Make half your grains whole[Image Removed] | 3 ounces | 4 - 5 ounces  | 4 - 5 ounces | 1 ounce of grains? 1 slice bread1 cup ready-to-eat cereal flakes ½ cup cooked rice or pasta 1 tortilla (6" across) |
| **Protein Foods**[Image Removed] | 2 ounces | 3 - 4 ounces  | 3 - 5 ounces | 1 ounce of protein foods? 1 ounce cooked meat, poultry, or seafood 1 egg1 Tablespoon peanut butter ¼ cup cooked beans or peas (kidney, pinto, lentils) |
| **Dairy**Choose low-fat or fat-free [Image Removed] | 2 cups | 2 cups | 2½ cups | ½ cup of dairy?½ cup milk 4 ounces yogurt ¾ ounce cheese 1 string cheese |

[Some foods are easy for your child to choke on while eating. Skip hard, small, whole foods, such as popcorn, nuts, seeds, and hard candy. Cut up foods such as hot dogs, grapes, and raw carrots into pieces smaller than the size of your child's throat--about the size of a nickel.]

[There are many ways to divide the Daily Food Plan into meals and snacks. View the "Meal and Snack Patterns and Ideas" to see how these amounts might look on your preschooler's plate at www.choosemyplate.gov/preschoolers.html.]

**[FIGURE 15.3** The MyPlate Healthy Eating for Preschoolers: Daily Food Plan provides families with an easy-to-use guide to healthful meals.

*Source:* U.S. Department of Agriculture Food and Nutrition Service.]

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At this point in life, children are mostly in control of their own fluid intake. However, as they engage in physical activity at school and in sports and play, young children in particular may need reminders to drink in order to stay properly hydrated, especially if the weather is hot.

**Encourage Nutritious Food Choices with Children**

Peer pressure can be extremely difficult for both parents and their children to deal with during this life stage. Most children want to feel as if they "belong," and they admire and like to mimic children they believe to be popular. If the popular children at school are eating chips and drinking grape soda, it may be hard for a child to consume a peanut butter on whole-wheat sandwich, an apple, and a low-fat milk without embarrassment. One strategy for combating peer pressure is to introduce kids to appropriate role models, such as star athletes and popular entertainers who follow nutritious diets.

In addition, adults should consistently model healthful eating patterns, and involve children in growing their own food, shopping, and planning and preparing meals. If children have input into what is going into their body, they may be more likely to take an active role in their health. Research suggests that children whose families who prepare and eat meals together on average consume a better quality diet and have a healthier body weight.11 Moreover, family meals encourage shared conversations that help family members connect. The "Eat Better, Eat Together" nutrition education program promotes family mealtime **(FIGURE 15.4).**

**School Attendance Influences Children's Nutrition**

Children's school attendance can affect their nutrition in several ways. First, hectic morning schedules cause many children to minimize or skip breakfast completely. Many nutrition and education experts believe that children who skip breakfast are at increased risk for behavioral and learning problems associated with hunger in the classroom.

Second, with no one monitoring what they eat, children in school do not always consume appropriate types or amounts of food. If they purchase a school lunch, they might not like all the foods being served, or their friends might influence them to skip certain foods with comments such as "This broccoli's nasty!" Even homemade lunches that contain nutritious foods may be left uneaten or traded for less nutritious fare. Some children rush through lunch in order to spend more time on the playground. For this reason, some schools send students to the playground first, giving them time to burn off their excess energy as well as build their hunger and thirst.

Finally, some schools continue to sell foods with low nutrient value at bake sales and other fund-raisers.

**[FIGURE 15.4** *Eat Better, Eat Together* promotes family mealtimes as a way to improve children's diets.

*Source*: Eat Together, Eat Better image courtesy of Washington State University.]

[Find games, coloring sheets, videos, and songs promoting nutrition and physical activity at the MyPlate Kids' Place. Go to **www .choosemyplate.gov/kids.]**

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Also, despite recent legislation and industry-sponsored initiatives, some schools still have vending machines offering snacks that are high in empty Calories.

The federally funded School Breakfast Program (SBP) and the National School Lunch Program (NSLP) are administered by the USDA's Food and Nutrition Service. Meals for all students are subsidized; in addition, students from families with incomes at or below 185% of the federal poverty level qualify for reduced-price or free meals. Most research suggests that participation in the School Breakfast Program improves academic achievement,12,13 particularly among children at risk for food insecurity. A growing number of schools now offer a free "in-class breakfast" to all students, regardless of family income, improving school attendance and program participation as compared to cafeteria-based breakfasts offered only to qualified students.12 The impact of the SBP and NSLP on children's diets is enormous: over 100,000 schools, including 99% of public schools, participate, serving over 32 million children in 2015.14

SBP and NSLP meals must meet the nutritional standards of the 2010 Healthy, Hunger-Free Kids Act:

- Students must be offered both fruits and vegetables every day and must *select* at least one serving for the school to be reimbursed for the meal. In addition, schools must offer dark green and red/orange vegetables and legumes each week. Breakfast meals must offer at least one cup of fruit daily.

- Milk must be fat-free or low fat.

- All grains must be whole-grain-rich.

- Calories, averaged over a week, and portion sizes must be appropriate for the age of the children being served.

- Sodium, saturated fats, and *trans* fats must be reduced to specified levels.

In addition, vending machines and other sources of food on school campuses must meet specific nutrient guidelines.

To comply with these standards, schools nationwide are introducing innovations such as salad bars, baked potato bars, and soup stations to entice students into more healthful choices. Many schools now cultivate a garden on school grounds or even on the school rooftop where children help to grow the vegetables that will be used in their lunches.15 Many have implemented USDA programs that encourage children to increase their consumption of fruits and vegetables by providing less familiar choices they might not otherwise have the chance to try. Schools that succeed in improving their meals earn additional federal funding.

On the surface, it would appear that, by following these standards, school meals would improve children's diets. However, the nutrients a student *gets* depends on what the student actually *eats.* So, a child might eat the slice of whole-wheat veggie pizza and the low-fat milk but skip the carrot sticks and apple. Also keep in mind that children can still bring high-fat and high-sugar snacks and beverages from home or trade with classmates who bring them.

**Childhood Brings Unique Nutrition-Related Concerns**

In addition to the potential nutrient deficiencies that have already been discussed, new concerns arise during childhood. Foremost among these are overweight and obesity, a topic we discuss in detail ahead.

**Dental Caries**

*Dental caries,* or cavities, occur when bacteria in the mouth feed on carbohydrates deposited on teeth. As a result of metabolizing the carbohydrates, the bacteria then secrete acid, which begins to erode tooth enamel, leading to tooth decay. The development of dental caries can be minimized by limiting children's intake of sweets, especially those such as jelly beans that stick to teeth, and of sugary drinks. Among one group of third-grade students, one additional serving of a sugar-sweetened beverage per day increased the incidence of caries by over 20%.16 Finally, frequent brushing helps eliminate the sugars on teeth as well as the bacteria that feed on them.

[Image: School-age children may receive a standard school lunch, but many choose less healthful foods when given the opportunity.]

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Fluoride, through a municipal water supply, through fluoridated toothpaste or mouthwash, or through supplements, also helps deter the development of dental caries. Even though the teeth of a young child will be replaced by permanent teeth in several years, it is critical to keep them healthy and strong. This is because they make room for and guide the permanent teeth into position. Children should start having regular dental visits at the age of 3.

**Inadequate Calcium Intake**

Another nutrition-related concern for children is an inadequate intake of calcium. Adequate calcium is necessary to achieve optimal bone density as well as for numerous other critical body and cell functions. Because peak bone mass is achieved by the late teens or early twenties, inadequate calcium intake during childhood and adolescence can set the stage for poor bone health and potentially osteoporosis in later years.

Dairy products are the most common source of calcium for children in the United States.4 However, nearly 60% of U.S. children consume fewer than two servings of dairy per day.17 During the infant, toddler, and preschool years, milk consumption can largely be monitored by parents and other caregivers. Older children often choose soft drinks, sports beverages, fruit punch, and other sugary drinks in place of milk. This "milk displacement" is associated with lower intakes of protein, calcium, phosphorus, magnesium, potassium, and vitamin A, increasing subsequent risk for poor bone health.

**Childhood Food Insecurity**

Although most children in the United States grow up with an abundant and healthful supply of food, nearly 4 million households with children, representing 16 million American children, are faced with *food insecurity* and hunger.18 Food insecurity occurs when a household lacks a consistent, dependable supply of safe and nutritious food. Rates of food insecurity are more than double among African-American and Latino households compared to Caucasian households. These statistics are definitely at odds with America's image as "the land of plenty."

The effects of food insecurity can be very harmful to children, including poorer health, more hospitalizations, greater emotional distress and lower academic achievement.19,20 Many, but not all, studies find a link between child food insecurity and obesity or overweight.20 Impaired nutrient status can blunt children's immune responses, making them more susceptible to common childhood illnesses, as well as anemia and poor bone density.

Options for families facing food insecurity include a number of government and privately funded programs, including school breakfast and lunch programs and the Supplemental Nutrition Assistance Program (SNAP; previously known as the Food Stamp program). Community food pantries and kitchens can provide a narrow range of foods for a limited period but cannot be relied on to meet the nutritional needs of children and their families over a prolonged time.

**[recap**

Although total energy and protein needs are high for growing, active children, their intake of dietary fat should be gradually reduced to 25% to 35% of total energy. Calcium, iron, and zinc requirements are high, and children need to drink from 5 to 8 cups of water and other beverages throughout the day. Peer pressure has a strong influence on children's nutritional choices. Involving children in growing, purchasing, and preparing foods can help them make more healthful food choices. School breakfasts and lunches must meet strict federal guidelines, but the foods that children choose to eat at school can still be higher in fat, sugar, and energy and lower in complex carbohydrates and micronutrients than desired. To prevent dental caries, children should brush their teeth regularly, limit sweets, and visit the dentist regularly beginning at age 3. Consuming adequate calcium to support the development of optimal bone mass is also a primary concern for school-age children. About 16 million American children are faced with *food* insecurity and hunger.]

[Image: Both children and adults were food insecure in about 9.4% of U.S. households in 2014.

*Source*: Economic Research Service, September 8, 2015, *Food Security Status of U.S. Households with Children,* www.ers.usda.gov.]

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**LO 3** Explain how puberty influences the nutrient needs and health concerns of adolescents.

## **What** **are the nutritional needs and concerns of adolescence?**

Although there is no consensus on the exact age range corresponding to the term *adolescence,* this life stage begins with the onset of **puberty,** the period in life in which secondary sexual characteristics develop and we become capable of reproducing, and continues through age 18. The nutritional needs of adolescents are influenced by their rapid growth in height, increased weight, changes in body composition, and individual levels of physical activity.

**Puberty Triggers Dramatic Growth and Maturation**

Growth during adolescence is driven primarily by hormonal changes, including increased levels of testosterone for boys and estrogen for girls. Both boys and girls experience growth spurts, or periods of accelerated increase in height, during later childhood and adolescence. The timing and length of these growth spurts vary by race, gender, nutritional status, and other factors. Growth spurts for girls tend to begin between 10 to 11 years of age, and for boys around 12 to 13 years.

Skeletal growth ceases once closure of the **epiphyseal plates** occurs **(FIGURE 15.5).** These are plates of cartilage located toward the end of the long bones that provide for their growth in length. Although most girls reach their full adult height by about age 18, some continue to increase in height past age 19, although the rate of growth slows considerably. Most boys continue to grow up to the age of 21, although their rate of growth also slows over time.

In some circumstances, the epiphyseal plates close early and the adolescent fails to reach full stature. The most common causes of this failure are malnutrition, such as may occur with an eating disorder, and the use of anabolic steroids during this critical growth period.

Weight and body composition also change dramatically. The average weight gained by girls and boys during this time is 35 and 45 pounds, respectively; however, weight gain is extremely variable, reflecting the adolescent's energy intake, physical activity level, and genetics. The weight gained by girls and boys is dramatically different in terms of its composition. Girls tend to gain significantly more body fat than boys, with this fat accumulating around the buttocks, hips, breasts, thighs, and upper arms. Although many girls are uncomfortable or embarrassed by these changes, they are a natural result of maturation. Boys gain significantly more muscle mass than girls, and they experience an increase in muscle definition.

The physical activity levels of adolescents are highly variable. Many are physically active in sports or other organized physical activities, whereas others become less interested in sports and more interested in intellectual or artistic pursuits. This variability in activity levels results in highly individual energy needs. Although the rapid growth and maturation that occur during puberty require a significant amount of energy, adolescence is often a time in which overweight begins.

**Rapid Growth Increases an Adolescent's Nutrient Needs**

The nutrient needs of adolescents are influenced by rapid growth, weight gain, and sexual maturation, in addition to the demands of physical activity (see Table 15.1).

**Energy and Macronutrient Recommendations for Adolescents**

Adequate energy intake is necessary to maintain adolescents' health, support their dramatic growth and maturation, and fuel their physical activity. Because of these competing demands, the energy needs of adolescents can be quite high. Although it is possible to calculate estimated energy requirements of an adolescent by using a published equation, it is more practical to monitor the growth pattern of the adolescent to ensure that weight remains in proportion to height.2

**[FIGURE 15.5** Skeletal growth ceases once closure of the epiphyseal plates occurs.]

[Sidebar: **puberty** The period of life in which secondary sexual characteristics develop and people become biologically capable of reproducing.]

[Sidebar: **epiphyseal** plates Plates of cartilage located toward the end of long bones that provide for growth in the length of long bones.]

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The AMDR for fat is 25% to 35% of total energy. Like adults, adolescents should consume less than 10 % of total energy from saturated fats.2

The RDA for carbohydrate for adolescents is 130 g/day.2 As with adults, this amount of carbohydrate covers what is needed to supply adequate glucose to the brain, but it does not cover the amount of carbohydrate needed to support daily activities. Thus, it is recommended that adolescents consume about 45 % to 65 % of their total energy as carbohydrate, and most should come from fiber-rich carbohydrates. The AI for fiber for adolescents is 26 g/day, which is similar to adult values.

The RDA for protein for adolescents is only slightly higher than that of adults, 0.85 g of protein per kilogram of body weight per day.2 This amount is assumed to be sufficient to support health and to cover the additional needs of growth and development during the adolescent stage. As with adults, most U.S. adolescents consume protein in amounts that far exceed the RDA.

**Micronutrient Recommendations for Adolescents**

The micronutrients of particular concern for adolescents are calcium, iron, and vitamins A and D.

**Calcium** Adolescence is a critical time to support the achievement of optimal peak bone density. The RDA for calcium for adolescents 14 to 18 years of age therefore increases to 1,300 mg/day.4 This amount of calcium can be difficult for adolescents to consume if they don't follow a healthful eating pattern. Milk is the leading food source of both calcium and vitamin D, yet average milk intake has decreased significantly over the past decade.21,22 By age 18, average milk consumption has fallen by more than 25 % compared to intake at age 8 years, whereas soda intake has tripled.

**Vitamin D** The RDA for vitamin D for adolescents is 600 IU/day.4 Most foods are naturally low in vitamin D; thus, fortified foods, such as milk and cereals, are important sources of this vitamin. If an adolescent is not consuming adequate vitamin D and does not get enough sunlight year-round, he or she may need to take a supplement.

**Iron** The iron requirements of adolescents are relatively high; this is because iron is needed to replace the blood lost during menstruation in girls and to support the increase in blood volume and growth of muscle mass in boys. Between the ages of 14 and 18 years, the RDA for iron for boys is 11 mg/day, whereas the RDA for girls is 15 mg/day.5 If energy intake is adequate and adolescents consume food sources of heme iron, such as lean meat/fish/poultry, each day, they should be able to meet the RDA for iron. However, many young people adopt a vegetarian lifestyle during this life stage, or they consume foods that have limited amounts of iron. Both of these situations can prevent adolescents from meeting the RDA for iron and, particularly in females, can increase their risk for iron-deficiency anemia.

**Vitamin A** Vitamin A is critical to support the rapid growth and development that occur during adolescence. The RDA for vitamin A is 900 µg/day for boys and 700 µg/day for girls ages 14 to 18 years.5 The RDA can be met by consuming at least 5 servings of dark-green, yellow, and orange fruits and vegetables each day. As with iron and calcium, meeting the RDA for vitamin A can be a challenging goal if the adolescent fails to make healthful food choices. In such cases, a multivitamin and mineral supplement that provides no more than 100 % of the Daily Value for the micronutrients can be beneficial as a safety net. As with younger children and adults, a supplement should never be considered to be a substitute for a balanced, healthful diet.

**Fluid Recommendations for Adolescents**

The fluid needs of adolescents are higher than those of children because of their higher physical activity levels and the extensive growth and development that occur during this phase of life.

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The AI for total fluid for adolescent girls and boys is listed in Table 15.1; it includes about 9 and 11 cups, respectively, as beverages, including drinking water.6 Boys require a higher fluid intake because they are often more active than girls and have more lean tissue. Highly active adolescents of either gender who are exercising in the heat may have higher fluid needs than the AI, and these individuals should be encouraged to drink water and other unsweetened beverages often to quench their thirst and avoid dehydration.

**Encourage Nutritious Food Choices with Adolescents**

At this point in their lives, adolescents are making most of their own food choices, and many are buying and preparing a significant amount of the foods they consume. Although parents can still be effective role models, adolescents are generally strongly influenced by their peers, their personal food preferences, and their own developing sense of which foods constitute a healthful and adequate diet. Adolescents are anxious to develop their own identity and establish a more self-reliant lifestyle. The decision to adopt a vegetarian diet, for example, may represent an adolescent's effort to establish some distance from the family unit.

One area of concern in most adolescents' diets is a lack of vegetables, fruits, and whole grains. Many teens eat on the run, skip meals, and select fast foods and convenience foods because they are inexpensive, are accessible, and taste good. High school students are often allowed to leave campus for lunch, increasing their opportunities to eat high-fat, low-nutrient fast foods. Parents and school food service personnel can capitalize on adolescents' preferences for pizza, burgers, spaghetti, and sandwiches by providing more healthful meat and cheese alternatives, whole-grain breads, and plenty of appealing vegetable-based sides or additions to these foods. In addition, keeping healthful snacks accessible, such as fruits and vegetables that are cleaned and prepared in easy-to-eat pieces, may encourage adolescents to choose more of these foods as between-meal snacks. Teens should also be encouraged to consume adequate milk and other calcium-enriched beverages, while minimizing sodas, sports drinks, and other sugary drinks.

As adolescents leave the family home for college or their own apartments, it is important that they set the foundation for healthful eating. One question teens often have is how to stock their first kitchen. What basic foods--or staples--should they always have on hand, so that they can quickly and easily assemble healthful meals and snacks? The **Quick Tips** list (page 544) includes the foods that many Americans consider to be staples. It can be modified to include items that are staples in non-Western cultures and to address vegetarian, vegan, low-fat, low-sodium, or other diets.

**Appearance and Substance Use Are Key Concerns of Adolescence**

Nutrition-related concerns for adolescents include body image and acne, as well as cigarette smoking and the use of alcohol and illegal drugs.

**Body Image and Eating Disorders**

Preoccupation with body weight, height, muscle mass, complexion, hair, and other aspects of physical appearance is common and normal among adolescent boys and girls. But in some teens, an initially healthful concern about body image and weight can turn into a dangerous obsession during this emotionally challenging life stage. Body image and eating disorders frequently begin during adolescence and can occur in boys as well as in girls. Parents, teachers, and friends should be aware of the warning signs, which include restricted eating patterns; excessive exercise; rapid and extreme weight loss; regular trips to the bathroom after meals; and signs of frequent vomiting or laxative use. (For more information, see the **In Depth** essay following Chapter 11.)

[Image: Adolescents have higher fluid needs than younger children.]

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**[Stocking Your First Kitchen**

**Keep your refrigerator stocked with:**

Low-fat or skim milk or soymilk

Calcium-enriched orange juice Hard cheeses

Eggs

Lean deli meats or soy meat alternatives

Hummus, peanut butter, and other healthful, perishable spreads

A 2- to 3-day supply of dark-green lettuce and other salad fixings, or ready-to-eat salads

A 2- to 3-day supply of other fresh veggies

A 2- to 3-day supply of fresh fruits

Low-fat salad dressings, mustards, and salsas

Whole-grain breads, rolls, bagels, pizza crusts, and tortillas

**Stock your freezer with:**

Individual servings of chicken breast, extra-lean ground beef, pork loin chops, fish fillets, or soy meat alternatives

Lower-fat frozen entrees ("boost" with salad, whole-grain roll, and extra veggies)

Frozen veggies (no sauce)

Frozen cheese or veggie pizza ("boost" with added mushrooms, green peppers, and other veggie toppings)

Low-fat ice cream, sherbet, or 1 sorbet

**Stock your pantry with:**

Staples such as potatoes, sweet potatoes, onions, and garlic

Canned or vacuum-packed tuna, salmon, and crab (in water, not oil)

Canned legumes, such as black beans, refried beans, pinto/kidney beans, and garbanzo beans

Low-sodium, low-fat, high-fiber canned soups (read the label!)

Dried beans and/or lentils

Whole-grain pasta and rice

Tomato-based pasta sauces

Canned fruit in juice with no added sugar

Dried fruits, such as golden raisins, cranberries, and apricots

Nuts, such as peanuts, almonds, and walnuts

Whole-grain ready-to-eat cereals or oatmeal

Whole-grain, low-fat crackers

Low-salt pretzels, low-fat tortilla/ corn chips, and low-fat or nonfat microwave popcorn

Salt, pepper, balsamic vinegar, low-sodium soy sauce, and similar condiments and spices

Olive and canola oils]

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**Adolescent Acne**

Another concern related to appearance is the acne flare-ups that plague many adolescents. The hormonal changes that occur during puberty are largely responsible, although stress, genetic factors, and personal hygiene may be secondary contributors. But what about foods?

For years, chocolate, fried foods, and fatty foods were linked to acne. In the 1960s, however, these theories were discounted and researchers came to agree that diet had virtually no role in its development. However, there is now strong evidence that dietary choices may indeed influence the risk or severity of acne.23,24 Whereas some studies have found an association between a high glycemic-load diet and increased acne (see Chapter 4),23 others have found a reduced risk for acne among people following a Mediterranean dietary pattern (see the **In Depth** essay following Chapter 2).24 These studies are not conclusive; however, the Mediterranean diet is rich in fruits, vegetables, whole grains, olive oil, and fish--foods that provide vitamin A, vitamin C, zinc, and other nutrients that help to maintain skin health and immune function.

Prescription medications, including the vitamin A derivative 13-cis-retinoic acid (Accutane), effectively control severe forms of acne. Over-the-counter and prescription topical medications, applied directly to the skin, may also be used. Neither Accutane nor any other prescription vitamin A derivative should be used by women who are pregnant, are planning a pregnancy, or may become pregnant. Accutane is a known teratogen, causing severe fetal malformations. Adolescent females who treat their acne with vitamin A-derivative prescription drugs must protect themselves against pregnancy and immediately contact their physician if they discover or believe they are pregnant. Incidentally, vitamin A taken in supplement form is not effective in acne treatment and, due to its own risk for toxicity, should not be used in amounts that exceed 100% of the Daily Value.

**Use of Tobacco, Alcohol, and Illegal Drugs**

Adolescents are naturally curious and many are open to experimenting with tobacco, alcohol, and illegal drugs. Smoking, including tobacco and e-cigarettes, diminishes appetite and is often used by adolescent girls to achieve or maintain a lower body weight.25 Cigarettes can also interfere with nutrient metabolism. Other effects of smoking on young people include the following:

- Addiction to nicotine

- Reduced rate of lung growth

- Impaired athletic performance and endurance

- Shortness of breath

- Early signs of heart disease and stroke

- Increased risk for lung cancer and other smoking-related cancers

Among adolescents, smoking is also associated with an increased incidence of participation in other risky behaviors, such as abusing alcohol and other drugs, fighting, and engaging in unprotected sex. There is also a link between adolescent smoking and early onset of depression and anxiety disorders.26

Alcohol and illegal drug use can start at early ages, even in school-age children. Motor vehicle accidents are the leading cause of death among adolescents; the risk of being involved in an accident is greatly increased by using alcohol and illegal drugs. Alcohol can also interfere with proper nutrient absorption and metabolism, and it can take the place of foods in an adolescent's diet; these adverse effects of alcohol put adolescents at risk for various nutrient deficiencies. Alcohol consumption and the use of certain illegal drugs are also associated with "the munchies," a feeling of food craving that usually results in the intake of large quantities of high-fat, high-sugar, nutrient-poor foods. This behavior can result in overweight or obesity, and it increases the risk for nutrient imbalance. Teens who use illegal drugs and alcohol are often in poor physical condition, are either underweight or overweight, have poor appetites, and perform poorly in school.

Cigarette smoking can interfere with nutrient metabolism, in addition to having other harmful effects.

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## **nutri-case LIZ**

"High school was really hard for me. Because dance took up such a big part of my life, I just didn't make a lot of friends. When I looked at the popular girls, I always noticed how slender they all were. So I started skipping lunch and eating less at dinner. This went on until I went to an audition for a production of *The Nutcracker.* I wanted so badly to dance in it, but I was feeling so spaced out--I guess from hunger--that before I knew what had happened, I was on the floor! I sprained my ankle and didn't get to dance at all that year! So that's why, while I've been preparing for my audition with the City Ballet, I made sure I'm getting at least 1,000 Calories a day. The audition's tomorrow, and I'm not going to end up on the floor this time!"

Do you--or does someone you know--equate body weight with popularity and desirability? Why are adolescents or young adults particularly prone to this type of thinking? If Liz succeeds in getting into the City Ballet--given what you've learned throughout this text--what health risks do you think she is likely to face in the future? How could she reduce these risks?

**[recap**

Puberty is the period in life in which secondary sexual characteristics recap develop and the ability to reproduce begins. Adolescents experience rapid increases in height, weight, and lean body mass and fat mass. Energy needs can be very high. Fat intake should be 25% to 35% of total energy, and carbohydrate intake should be 45% to 65%. The RDA for protein is 0.85 g per kg body weight. Calcium is needed to optimize bone growth and to achieve peak bone density, and iron needs are increased due to increased muscle mass in boys and to menstruation in girls. Adolescents need to drink about 8 cups (girls) and 11 cups (boys) of water or other beverages daily. Adolescents are at risk of skipping meals and selecting fast foods and snack foods in place of whole grains, fruits, and vegetables. Milk is commonly replaced with sugary drinks. Body image and eating disorders, acne, cigarette smoking, and use of alcohol and illegal drugs are also concerns for this age group.]

**LO 4** Discuss the problem of pediatric obesity, including medical issues and preventive measures.