Thiamin (B_1)

Thiamin is especially important in glucose metabolism. It acts as a cofactor for enzymes that break down glucose for energy production (Figure 9.7 "Enzyme Active Site for Cofactors"). Thiamin plays a key role in nerve cells as the glucose that is catabolized by thiamin is needed for an energy source. Additionally, thiamin plays a role in the synthesis of neurotransmitters and is therefore required for RNA, DNA, and ATP synthesis.

The brain and heart are most affected by a deficiency in thiamin. Thiamin deficiency, also known as beriberi, can cause symptoms of fatigue, confusion, movement impairment, pain in the lower extremities, swelling, and heart failure. It is prevalent in societies whose main dietary staple is white rice. During the processing of white rice, the bran is removed, along with what were called in the early nineteenth century, "accessory factors," that are vital for metabolism. Dutch physician Dr. Christiaan Eijkman cured chickens of beriberi by feeding them unpolished rice bran in 1897. By 1912, Sir Frederick Gowland Hopkins determined from his experiments with animals that the "accessory factors," eventually renamed vitamins, are needed in the diet to support growth, since animals fed a diet of pure carbohydrates, proteins, fats, and minerals failed to grow.[4] Eijkman and Hopkins were awarded the Nobel Prize in Physiology (or Medicine) in 1929 for their discoveries in the emerging science of nutrition.

Another common thiamin deficiency known as Wernicke-

4. Frederick Gowland Hopkins and his Accessory Food Factors. Encyclopedia Brittanica Blog. http://www.britannica.com/blogs/2011/06/frederick-gowland-hopkins-accessory-food-factors/.Published June 20, 2011. Accessed October 1, 2011.

Korsakoff syndrome can cause similar symptoms as beriberi such as confusion, loss of coordination, vision changes, hallucinations, and may progress to coma and death. This condition is specific to alcoholics as diets high in alcohol can cause thiamin deficiency. Other individuals at risk include individuals who also consume diets typically low in micronutrients such as those with eating disorders, elderly, and individuals who have gone through gastric bypass surgery.[5]

Figure 9.10 The Role of Thiamin

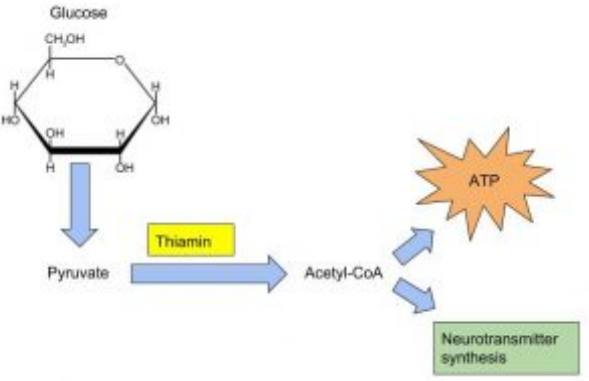


Image by Allison Calabrese / CC BY 4.0

Figure 9.11 Beriberi, Thiamin Deficiency

5. Fact Sheets for Health Professionals: Thiamin. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Thiamin-HealthProfessional/. Updated Feburary 11, 2016. Accessed October 22, 2017.

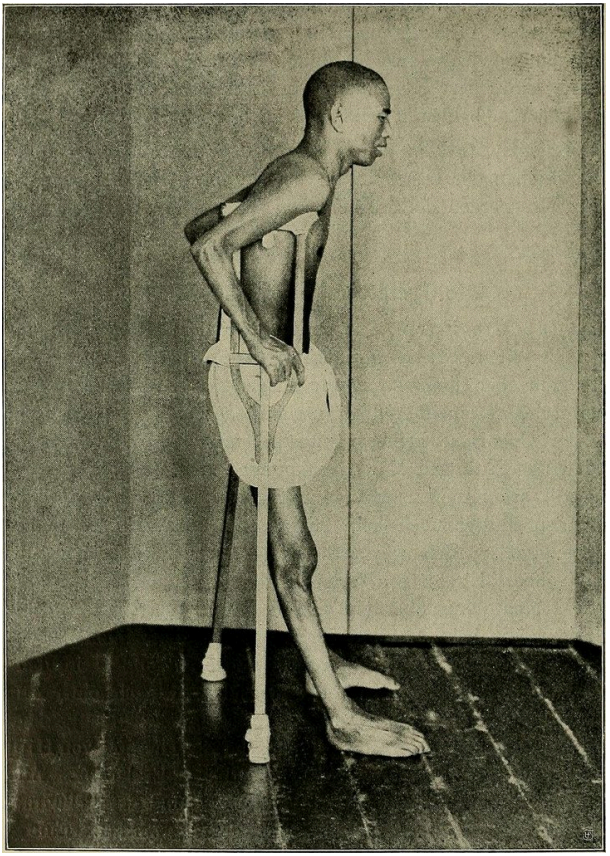


Image by Casimir Funk (1914) / No known copyright restrictions

Dietary Reference Intakes

The RDAs and ULs for different age groups for thiamin are listed in Table 9.13 "Dietary Reference Intakes for Thiamin". There is no UL for thiamin because there has not been any reports on toxicity when excess amounts are consumed from food or supplements.

Table 9.13 Dietary Reference Intakes for Thiamin

Age Group	RDA Males and Females mg/day
Infants (0–6 months)	0.2 *
Infants (7–12 months)	0.3
Children (1–3 years)	0.5
Children (4–8 years)	0.6
Children (9–13 years)	0.9
Adolescents (14–18 years)	1.2 (males), 1.0 (females)
Adults (> 19 years)	1.2 (males), 1.1 (females)
*denotes Adequate Intake	

Health Professional Fact Sheet: Thiamin. National Institutes of Health, Office of Dietary Supplements.https://ods.od.nih.gov/factsheets/Thiamin-HealthProfessional/ . Updated February 11, 2016 . Accessed October 5, 2017.

Dietary Sources

Whole grains, meat and fish are great sources of thiamin. The United States as well as many other countries, fortify their refined breads and cereals. For the thiamin content of various foods, see Table 9.14 “Thiamin Content of Various Foods”.

Table 9.14 Thiamin Content of Various Foods

Food	Serving	Thiamin (mg)	Percent Daily Value
Breakfast cereals, fortified	1 serving	1.5	100
White rice, enriched	½ c.	1.4	73
Pork chop, broiled	3 oz.	0.4	27
Black beans, boiled	½ c.	0.4	27
Tuna, cooked	3 oz.	0.2	13
Brown rice, cooked, not enriched	½ c.	0.1	7
Whole wheat bread	1 slice	0.1	7
2% Milk	8 oz.	0.1	7
Cheddar cheese	1 ½ oz	0	0
Apple, sliced	1 c.	0	0

Health Professional Fact Sheet: Thiamin. National Institutes of Health, Office of Dietary Supplements.https://ods.od.nih.gov/factsheets/Thiamin-HealthProfessional/ . Updated February 11, 2016 . Accessed October 5, 2017.

Riboflavin (B2)

Riboflavin is an essential component of flavoproteins, which are coenzymes involved in many metabolic pathways of carbohydrate, lipid, and protein metabolism. Flavoproteins aid in the transfer of electrons in the electron transport chain. Furthermore, the functions of other B-vitamin coenzymes, such as vitamin B_6 and folate, are dependent on the actions of flavoproteins. The “flavin” portion of riboflavin gives a bright yellow color to riboflavin, an attribute that helped lead to its discovery as a vitamin. When riboflavin is taken in excess amounts (supplement form) the excess will be excreted through your kidneys and show up in your urine.

Although the color may alarm you, it is harmless. There are no adverse effects of high doses of riboflavin from foods or supplements that have been reported.

Riboflavin deficiency, sometimes referred to as ariboflavinosis, is often accompanied by other dietary deficiencies (most notably protein) and can be common in people that suffer from alcoholism. This deficiency will usually also occur in conjunction with deficiencies of other B vitamins because the majority of B vitamins have similar food sources. Its signs and symptoms include dry, scaly skin, cracking of the lips and at the corners of the mouth, sore throat, itchy eyes, and light sensitivity.

Dietary Reference Intakes

The RDAs for different age groups for riboflavin are listed in Table 9.15 "Dietary Reference Intakes for Riboflavin". There is no UL for riboflavin because no toxicity has been reported when an excess amount has been consumed through foods or supplements.

Table 9.15 Dietary Reference Intakes for Riboflavin

Age Group	RDA Males and Females mg/day
Infants (0–6 months)	0.3 *
Infants (7–12 months)	0.4*
Children (1–3 years)	0.5
Children (4–8 years)	0.6
Children (9–13 years)	0.9
Adolescents (14–18 years)	1.3 (males), 1.0 (females)
Adults (> 19 years)	1.3 (males), 1.1 (females)
*denotes Adequate Intake	

Fact Sheet for Health Professionals, Riboflavin. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/

factsheets/Riboflavin-HealthProfessional/. Updated February 11, 2016. Accessed October 22, 2017.

Dietary Sources

Riboflavin can be found in a variety of different foods but it is important to remember that it can be destroyed by sunlight. Milk is one of the best sources of riboflavin in the diet and was once delivered and packaged in glass bottles. This packaging has changed to cloudy plastic containers or cardboard to help block the light from destroying the riboflavin in milk. For the riboflavin content of various foods, see Table 9.16 Riboflavin Content of Various Foods".

Table 9.16 Riboflavin Content of Various Foods

Food	Serving	Riboflavin (mg)	Percent Daily Value
Beef liver	3 oz.	2.9	171
Breakfast cereals, fortified	1 serving	1.7	100
Instant oats, fortified	1 c.	1.1	65
Plain yogurt, fat free	1 c.	0.6	35
2% milk	8 oz.	0.5	29
Beef, tenderloin steak	3 oz.	0.4	24
Portabella mushrooms, sliced	½ c.	0.3	18
Almonds, dry roasted	1 oz.	0.3	18
Egg, scrambled	1 large	0.2	12
Quinoa	1 c.	0.2	12
Salmon, canned	3 oz.	0.2	12
Spinach, raw	1 c.	0.1	6
Brown rice	½ c.	0	0

Fact Sheet for Health Professionals, Riboflavin. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Riboflavin-HealthProfessional/. Updated February 11, 2016. Accessed October 22, 2017.

Niacin (B_3)

Niacin is a component of the coenzymes NADH and NADPH, which are involved in the catabolism and/or anabolism of carbohydrates, lipids, and proteins. NADH is the predominant electron carrier and transfers electrons to the electron-transport chain to make ATP. NADPH is also required for the anabolic pathways of fatty-acid and cholesterol synthesis. In contrast to other vitamins, niacin can be synthesized by humans from the amino acid tryptophan in an anabolic process requiring enzymes dependent on riboflavin, vitamin B_6, and iron. Niacin is made from tryptophan only after tryptophan has met all of its other needs in the body. The contribution of tryptophan-derived niacin to niacin needs in the body varies widely and a few scientific studies have demonstrated that diets high in tryptophan have very little effect on niacin deficiency. Niacin deficiency is commonly known as pellagra and the symptoms include fatigue, decreased appetite, and indigestion. These symptoms are then commonly followed by the four D's: diarrhea, dermatitis, dementia, and sometimes death.

Figure 9.12 Conversion of Tryptophan to Niacin

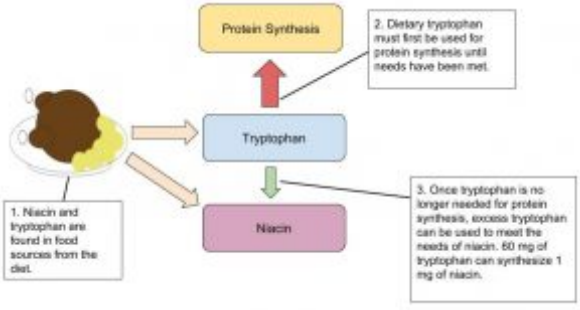


Image by Allison Calabrese / CC BY 4.0

Figure 9.13 Niacin Deficiency, Pellagra

Image by Herbert L. Fred, MD, Hendrik A. van Dijk / CC BY-SA 3.0

Dietary Reference Intakes

The RDAs and ULs for different age groups for Niacin are listed in Table 9.17 "Dietary Reference Intakes for Niacin ". Because Niacin needs can be met from tryptophan, The RDA is expressed in niacin equivalents (NEs). The conversions of NE, Niacin, and tryptophan are: 1 mg NE= 60 mg tryptophan= 1 mg niacin

Table 9.17 Dietary Reference Intakes for Niacin

Age Group	RDA Males and Females mg NE/day)	UL
Infants (0–6 months)	2 *	Not possible to establish
Infants (7–12 months)	4*	Not possible to establish
Children (1–3 years)	6	10
Children (4–8 years)	8	15
Children (9–13 years)	12	20
Adolescents (14–18 years)	16 (males), 14 (females)	30
Adults (> 19 years)	16 (males), 14 (females)	35
*denotes Adequate Intake		

Micronutrient Information Center: Niacin. Oregon State University, Linus Pauling Institute. http://lpi.oregonstate.edu/mic/vitamins/niacin. Updated in July 2013. Accessed October 22, 2017.

Dietary Sources

Niacin can be found in a variety of different foods such as yeast, meat, poultry, red fish, and cereal. In plants, especially mature grains, niacin can be bound to sugar molecules which can significantly decrease the niacin bioavailability. For the niacin content of various foods, see Table 9.18 "Niacin Content of Various Foods".

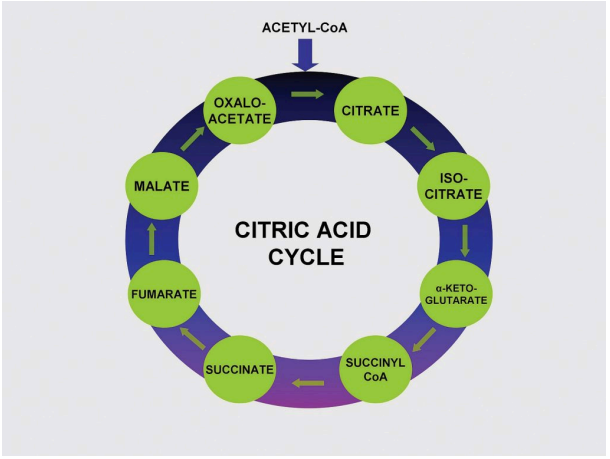
Table 9.18 Niacin Content of Various Foods

Food	Serving	Niacin (mg)	Percent Daily Value
Chicken	3 oz.	7.3	36.5
Tuna	3 oz.	8.6	43
Turkey	3 oz.	10.0	50
Salmon	3 oz.	8.5	42.5
Beef (90% lean)	3 oz.	4.4	22
Cereal (unfortified)	1 c.	5	25
Cereal (fortified)	1 c.	20	100
Peanuts	1 oz.	3.8	19
Whole wheat bread	1 slice	1.3	6.5
Coffee	8 oz.	0.5	2.5

Micronutrient Information Center: Niacin. Oregon State University, Linus Pauling Institute. http://lpi.oregonstate.edu/mic/vitamins/niacin. Updated in July 2013. Accessed October 22, 2017.

Pantothenic Acid (B5)

Figure 9.14 Pantothenic Acid's Role in the Citric Acid Cycle



Pantothenic Acid (Vitamin B5) makes up coenzyme A, which carries the carbons of glucose, fatty acids, and amino acids into the citric acid cycle as Acetyl-CoA.

Pantothenic acid forms coenzyme A, which is the main carrier of carbon molecules in a cell. Acetyl-CoA is the carbon carrier of glucose, fatty acids, and amino acids into the citric acid cycle (Figure 9.14 "Pantothenic Acid's Role in the Citric Acid Cycle"). Coenzyme A is also involved in the synthesis of lipids, cholesterol, and acetylcholine (a neurotransmitter). A Pantothenic Acid deficiency is exceptionally rare. Signs and symptoms include fatigue, irritability, numbness, muscle pain, and cramps. You may have seen pantothenic acid on many ingredients lists for skin and hair care products; however there is no good scientific evidence that pantothenic acid improves human skin or hair.

Dietary Reference Intakes

Because there is little information on the requirements for pantothenic acids, the Food and Nutrition Board (FNB) has developed Adequate Intakes (AI) based on the observed dietary intakes in healthy population groups. The AI for different age groups

for pantothenic acid are listed in Table 9.19 “Dietary Reference Intakes for Pantothenic Acid “.

Table 9.19 Dietary Reference Intakes for Pantothenic Acid

Age Group	AI Males and Females mg/day)
Infants (0–6 months)	1.7
Infants (7–12 months)	1.8
Children (1–3 years)	2
Children (4–8 years)	3
Children (9–13 years)	4
Adolescents (14–18 years)	5
Adults (> 19 years)	5

Micronutrient Information Center: Pantothenic Acid. Oregon State University, Linus Pauling Institute. http://lpi.oregonstate.edu/mic/vitamins/patothenic-acid . Updated in July 2013. Accessed October 22, 2017.

Dietary Sources

Pantothenic Acid is widely distributed in all types of food, which is why a deficiency in this nutrient is rare. Pantothenic Acid gets its name from the greek word “pantothen” which means “from everywhere”. For the pantothenic acid content of various foods, see Table 9.20 Pantothenic Acid Content of Various Foods”.

Table 9.20 Pantothenic Acid Content of Various Foods

Food	Serving	Pantothenic Acid (mg)	Percent Daily Value
Sunflower seeds	1 oz.	2	20
Fish, trout	3 oz.	1.9	19
Yogurt, plain nonfat	8 oz.	1.6	16
Lobster	3 oz.	1.4	14
Avocado	½ fruit	1	10
Sweet potato	1 medium	1	10
Milk	8 fl oz.	0.87	8.7
Egg	1 large	0.7	7
Orange	1 whole	0.3	3
Whole wheat bread	1 slice	0. 21	2.1

Micronutrient Information Center: Pantothenic Acid. Oregon State University, Linus Pauling Institute. http://lpi.oregonstate.edu/mic/vitamins/patothenic-acid . Updated in July 2013. Accessed October 22, 2017.

Biotin

Biotin is required as a coenzyme in the citric acid cycle and in lipid metabolism. It is also required as an enzyme in the synthesis of glucose and some nonessential amino acids. A specific enzyme, biotinidase, is required to release biotin from protein so that it can be absorbed in the gut. There is some bacterial synthesis of biotin that occurs in the colon; however this is not a significant source of biotin. Biotin deficiency is rare, but can be caused by eating large amounts of egg whites over an extended period of time. This is because a protein in egg whites tightly binds to biotin

making it unavailable for absorption. A rare genetic disease-causing malfunction of the biotinidase enzyme also results in biotin deficiency. Symptoms of biotin deficiency are similar to those of other B vitamins, but may also include hair loss when severe.

Dietary Reference Intakes

Because there is little information on the requirements for biotin, the FNB has developed Adequate Intakes (AI) based on the observed dietary intakes in healthy population groups. The AI for different age groups for biotin are listed in Table 9.21 "Dietary Reference Intakes for Biotin".

Table 9.21 Dietary Reference Intakes for Biotin

Age Group	AI Males and Females mcg/day)
Infants (0–6 months)	5
Infants (7–12 months)	6
Children (1–3 years)	8
Children (4–8 years)	12
Children (9–13 years)	20
Adolescents (14–18 years)	25
Adults (> 19 years)	30

Fact Sheet for Health Professionals: Biotin. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Biotin-HealthProfessional/. Updated October 3, 2017. Accessed November 10, 2017.

Dietary Sources

Biotin can be found in foods such as eggs, fish, meat, seeds, nuts and certain vegetables. For the pantothenic acid content of various foods, see Table 9.22 Biotin Content of Various Foods".

Table 9.22 Biotin Content of Various Foods

Food	Serving	Biotin (mcg)	Percent Daily Value*
Eggs	1 large	10	33.3
Salmon, canned	3 oz.	5	16.6
Pork chop	3 oz.	3.8	12.6
Sunflower seeds	¼ c.	2.6	8.6
Sweet potato	½ c.	2.4	8
Almonds	¼ c.	1.5	5
Tuna, canned	3 oz.	0.6	2
Broccoli	½ c.	0.4	1.3
Banana	½ c.	0.2	0.6
* Current AI used to determine Percent Daily Value			

Fact Sheet for Health Professionals: Biotin. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Biotin-HealthProfessional/. Updated October 3, 2017. Accessed November 10, 2017.

Vitamin B_6 (Pyridoxine)

Vitamin B_6 is the coenzyme involved in a wide variety of functions in the body. One major function is the nitrogen transfer between amino acids which plays a role in amino-acid synthesis and

catabolism. Also, it functions to release glucose from glycogen in the catabolic pathway of glycogenolysis and is required by enzymes for the synthesis of multiple neurotransmitters and hemoglobin (Figure 9.15 "The Function of Vitamin B_6 in Amino Acid Metabolism").

Vitamin B_6 is also a required coenzyme for the synthesis of hemoglobin. A deficiency in vitamin B_6 can cause anemia, but it is of a different type than that caused by insufficient folate, cobalamin, or iron; although the symptoms are similar. The size of red blood cells is normal or somewhat smaller but the hemoglobin content is lower. This means each red blood cell has less capacity for carrying oxygen, resulting in muscle weakness, fatigue, and shortness of breath. Other deficiency symptoms of vitamin B_6 can cause dermatitis, mouth sores, and confusion.

Figure 9.15 The Function of Vitamin B6 in Amino Acid Metabolism

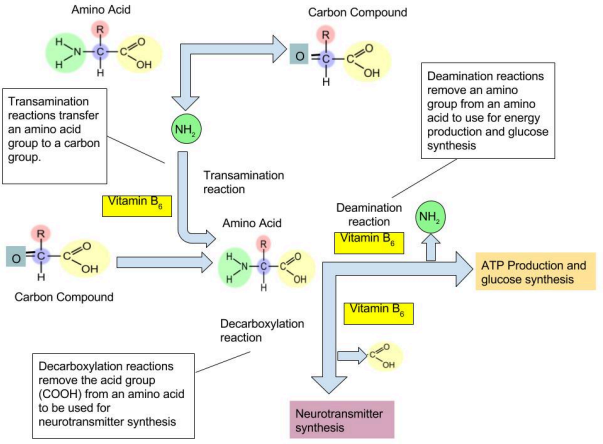


Image by Allison Calabrese / CC BY 4.0

The vitamin B6 coenzyme is needed for a number of different reactions that are essential for amino acid synthesis, catabolism for energy, and the synthesis of glucose and neurotransmitters.

Figure 9.16 Vitamin B_6 Functional Coenzyme Role

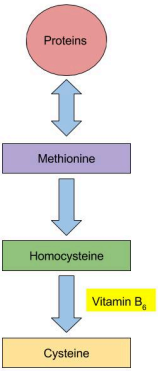


Image by Allison Calabrese / CC BY 4.0

Vitamin B6 coenzyme is essential for the conversion of amino acid methionine into cysteine. With low levels of Vitamin B6, homocysteine will build up in the blood. High levels of homocysteine increases the risk for heart disease.

Vitamin B_6 Toxicity

Currently, there are no adverse effects that have been associated with a high dietary intake of vitamin B6, but large supplemental doses can cause severe nerve impairment. To prevent this from occurring, the UL for adults is set at 100 mg/day.

Dietary Reference Intakes

The RDAs and ULs for different age groups for vitamin B_6 are listed in Table 9.23 "Dietary Reference Intakes for Vitamin B_6".

Table 9.23 Dietary Reference Intakes for Vitamin B_6

Age Group	RDA Males and Females mg/day	UL
Infants (0–6 months)	0.1*	Not possible to determine
Infants (7–12 months)	0.3*	Not possible to determine
Children (1–3 years)	0.5	30
Children (4–8 years)	0.6	40
Children (9–13 years)	1	60
Adolescents (14–18 years)	1.3 (males), 1.2 (females)	80
Adults (> 19 years)	1.3	100
*denotes Adequate Intake		

Dietary Supplement Fact Sheet: Vitamin B_6. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/VitaminB6-HealthProfessional/. Updates February 11, 2016. Accessed October 22, 2017.

Dietary Sources

Vitamin B_6 can be found in a variety of foods. The richest sources include fish, beef liver and other organ meats, potatoes, and other starchy vegetables and fruits. For the Vitamin B_6 content of various foods, see Table 9.24 Vitamin B_6 Content of Various Foods".

Table 9.24 Vitamin B_6 Content of Various Foods

Food	Serving	Vitamin B6 (mg)	Percent Daily Value
Chickpeas	1 c.	1.1	55
Tuna, fresh	3 oz.	0.9	45
Salmon	3 oz.	0.6	30
Potatoes	1 c.	0.4	20
Banana	1 medium	0.4	20
Ground beef patty	3 oz.	0.3	10
White rice, enriched	1 c.	0.1	5
Spinach	½ c	0.1	5

Dietary Supplement Fact Sheet: Vitamin B_6. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/VitaminB6-HealthProfessional/. Updates February 11, 2016. Accessed October 22, 2017.

Folate

Folate is a required coenzyme for the synthesis of the amino acid methionine, and for making RNA and DNA. Therefore, rapidly dividing cells are most affected by folate deficiency. Red blood cells, white blood cells, and platelets are continuously being synthesized in the bone marrow from dividing stem cells. When folate is deficient, cells cannot divide normally A consequence of folate deficiency is macrocytic or megaloblastic anemia. Macrocytic and megaloblastic mean "big cell," and anemia refers to fewer red blood cells or red blood cells containing less hemoglobin. Macrocytic anemia is characterized by larger and fewer red blood cells. It is caused by red blood cells being unable to produce DNA and RNA fast enough—cells grow but do not divide, making them large in size. (Figure 9.17 "Folate and the Formation of Macrocytic Anemia")

Figure 9.17 Folate and the Formation of Macrocytic Anemia

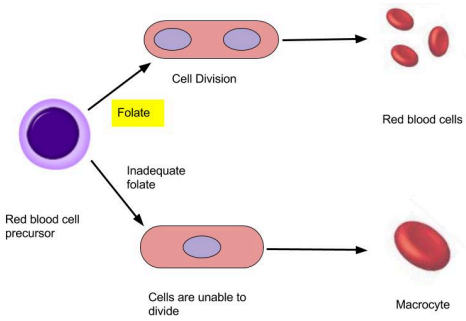


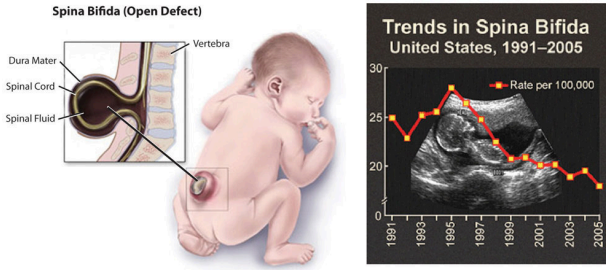
Image by Allison Calabrese / CC BY 4.0

Folate is especially essential for the growth and specialization of cells of the central nervous system. Children whose mothers were folate-deficient during pregnancy have a higher risk of neural-tube birth defects. Folate deficiency is causally linked to the development of spina bifida, a neural-tube defect that occurs when the spine does not completely enclose the spinal cord. Spina bifida can lead to many physical and mental disabilities (Figure 9.18 “Spina Bifida in Infants”). Observational studies show that the prevalence of neural-tube defects was decreased after the fortification of enriched cereal grain products with folate in 1996 in the United States (and 1998 in Canada) compared to before grain products were fortified with folate.

Additionally, results of clinical trials have demonstrated that neural-tube defects are significantly decreased in the offspring of mothers who began taking folate supplements one month prior to becoming pregnant and throughout the pregnancy. In response to the scientific evidence, the Food and Nutrition Board of the Institute of Medicine (IOM) raised the RDA for folate to 600 micrograms per day for pregnant women. Some were concerned

that higher folate intakes may cause colon cancer, however scientific studies refute this hypothesis.

Figure 9.18 Spina Bifida in Infants



Spina bifida is a neural-tube defect that can have severe health consequences.

Dietary Reference Intakes

The RDAs and ULs for different age groups for folate are listed in Table 9.25 "Dietary Reference Intakes for Folate ". Folate is a compound that is found naturally in foods. Folic acid however is the chemical structure form that is used in dietary supplements as well as enriched foods such as grains. The FNB has developed dietary folate equivalents (DFE) to reflect the fact that folic acid is more bioavailable and easily absorbed than folate found in food. The conversions for the different forms are listed below.

1 mcg DFE = 1 mcg food folate

1mcg DFE = 0.6 mcg folic acid from fortified foods or dietary supplements consumed with foods

1 mcg DFE = 0.5 mcg folic acid from dietary supplements taken on an empty stomach

Table 9.25 Dietary Reference Intakes for Folate

Age Group	RDA Males and Females mcg DFE/day	UL
Infants (0–6 months)	65*	Not possible to determine
Infants (7–12 months)	80*	Not possible to determine
Children (1–3 years)	150	300
Children (4–8 years)	200	400
Children (9–13 years)	300	600
Adolescents (14–18 years)	400	800
Adults (> 19 years)	400	1000
*denotes Adequate Intake		

Dietary Supplement Fact Sheet: Folate. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Folate-HealthProfessional/. Updated April 20, 2016. Accessed October 22, 2017.

Dietary Sources

Folate is found naturally in a wide variety of food especially in dark leafy vegetables, fruits, and animal products. The U.S. Food and Drug Administration (FDA) began requiring manufacturers to fortify enriched breads, cereals, flours, and cornmeal to increase the consumption of folate in the American diet. For the folate content of various foods, see Table 9.26 “Folate Content of Various Foods”.

Table 9.26 Folate Content of Various Foods

Food	Serving	Folate (mcg DFE)	Percent Daily Value
Beef Liver	3 oz.	215	54
Fortified breakfast cereals	¾ c.	400	100
Spinach	½ c.	131	33
White rice, enriched	½ c.	90	23
Asparagus	4 spears	85	20
White bread, enriched	1 slice	43	11
Broccoli	2 spears	45	10
Avocado	½ c.	59	15
Orange juice	6 oz.	35	9
Egg	1 large	22	6

Dietary Supplement Fact Sheet: Folate. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Folate-HealthProfessional/. Updated April 20, 2016. Accessed October 22, 2017.

Vitamin B12 (Cobalamin)

Vitamin B_{12} contains cobalt, making it the only vitamin that contains a metal ion. Vitamin B_{12} is an essential part of coenzymes. It is necessary for fat and protein catabolism, for folate coenzyme function, and for hemoglobin synthesis. An enzyme requiring vitamin B_{12} is needed by a folate-dependent enzyme to synthesize DNA. Thus, a deficiency in vitamin B_{12} has similar consequences to health as folate deficiency. In children and adults vitamin B_{12} deficiency causes macrocytic anemia, and in babies born to cobalamin-deficient mothers there is an increased risk for neural-

tube defects. In order for the human body to absorb vitamin B_{12}, the stomach, pancreas, and small intestine must be functioning properly. Cells in the stomach secrete a protein called intrinsic factor that is necessary for vitamin B_{12} absorption, which occurs in the small intestine. Impairment of secretion of this protein either caused by an autoimmune disease or by chronic inflammation of the stomach (such as that occurring in some people with H.pylori infection), can lead to the disease pernicious anemia, a type of macrocytic anemia. Vitamin B_{12} malabsorption is most common in the elderly, who may have impaired functioning of digestive organs, a normal consequence of aging. Pernicious anemia is treated by large oral doses of vitamin B_{12} or by putting the vitamin under the tongue, where it is absorbed into the bloodstream without passing through the intestine. In patients that do not respond to oral or sublingual treatment vitamin B_{12} is given by injection.

Vitamin B_{12} Relationship with Folate and Vitamin B_6

Figure 9.19 B Vitamins Coenzyme Roles

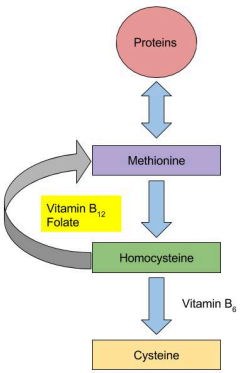
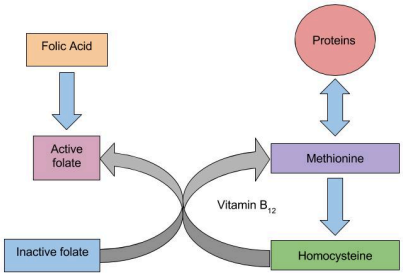


Image by Allison Calabrese / CC BY 4.0

Vitamin B_{12} and folate play key roles in converting homocysteine to amino acid methionine. As mentioned in Figure 9.19 " Vitamin B6 Functional Coenzyme Role", high levels of homocysteine in the blood increases the risk for heart disease. Low levels of vitamin B_{12}, folate or vitamin B6 will increase homocysteine levels therefore increasing the risk of heart disease.

Figure 9.20 The Relationship Between Folate and Vitamin B_{12}

Image by Allison Calabrese / CC BY 4.0



When there is a deficiency in vitamin B_{12} , inactive folate (from food) is unable to be converted to active folate and used in the body for the synthesis of DNA. Folic Acid however (that comes from supplements or fortified foods) is available to be used as active folate in the body without vitamin B_{12} .Therefore, if there is a deficiency in vitamin B_{12} macrocytic anemia may occur. With the fortification of foods incorporated into people's diets, the risk of an individual developing macrocytic anemia is decreased.

Dietary Reference Intakes

The RDAs and ULs for different age groups for Vitamin B_{12} are listed in Table 9.27 "Dietary Reference Intakes for Vitamin B_{12}".

Table 9.27 Dietary Reference Intakes for Vitamin B_{12}

Age Group	RDA Males and Females mcg/day
Infants (0–6 months)	0.4*
Infants (7–12 months)	0.5*
Children (1–3 years)	0.9
Children (4–8 years)	1.2
Children (9–13 years)	1.8
Adolescents (14–18 years)	2.4
Adults (> 19 years)	2.4
*denotes Adequate Intake	

Dietary Fact Sheet: Vitamin B12. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/VitaminB12-HealthProfessional/. Updated February 11, 2016. Accessed October 28, 2017.

Dietary Sources

Vitamin B_{12} is found naturally in animal products such as fish, meat, poultry, eggs, and milk products. Although vitamin B_{12} is not generally present in plant foods, fortified breakfast cereals are also a good source of vitamin B_{12}. For the vitamin B_{12} content of various foods, see Table 9.28 "Vitamin B_{12} Content of Various Foods".

Table 9.28 Vitamin B_{12} Content of Various Foods

Food	Serving	Vitamin B12 (mcg)	Percent Daily Value
Clams	3 oz.	84.1	1,402
Salmon	3 oz.	4.8	80
Tuna, canned	3 oz.	2.5	42
Breakfast cereals, fortified	1 serving	1.5	25
Beef, top sirloin	3 oz.	1.4	23
Milk, lowfat	8 fl oz.	1.2	18
Yogurt, lowfat	8 oz.	1.1	18
Cheese, swiss	1 oz.	0.9	15
Egg	1 large	0.6	10

Dietary Fact Sheet: Vitamin B_{12}. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/VitaminB12-HealthProfessional/. Updated February 11, 2016. Accessed October 28, 2017.

Choline

Choline is a water-soluble substance that is not classified as a vitamin because it can be synthesized by the body. However, the synthesis of choline is limited and therefore it is recognized as an essential nutrient. Choline is need to perform functions such as the synthesis of neurotransmitter acetylcholine, the synthesis of phospholipids used to make cell membranes, lipid transport, and also homocysteine metabolism. A deficiency in choline may lead to interfered brain development in the fetus during pregnancy, and in adults cause fatty liver and muscle damage.

Dietary Reference Intakes

There is insufficient data on choline so the FNB has developed AIs for all ages in order to prevent fatty liver disease. The AI and UL for different age groups for choline are listed in Table 9.29 "Dietary Reference Intakes for Choline".

Table 9.29 Dietary Reference Intakes for Choline

Age Group	AI Males and Females mg/day)	UL
Infants (0–6 months)	125	–
Infants (7–12 months)	150	–
Children (1–3 years)	200	1000
Children (4–8 years)	250	1000
Children (9–13 years)	375	2000
Adolescents (14–18 years)	550 (males), 400 (females)	3000
Adults (> 19 years)	550 (males), 425 (females)	3500

Fact Sheet for Health Professionals: Choline. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Choline-HealthProfessional/. Updated January 25, 2017. Accessed October 28, 2017.

Dietary Sources

Choline can be found in a variety of different foods. The main dietary sources of choline in the United States consist of primarily animal based products. For the Choline content of various foods, see Table 9.30 "Choline Content of Various Foods".

Table 9.30 Choline Content of Various Foods

Food	Serving	Choline (mg)	Percent Daily Value
Egg	1 large	147	27
Soybeans	½ cup	107	19
Chicken breast	3 oz.	72	13
Mushrooms, shiitake	½ c.	58	11
Potatoes	1 large	57	10
Kidney beans	½ c.	45	8
Peanuts	¼ c.	24	4
Brown rice	1 c.	19	3

Fact Sheet for Health Professionals: Choline. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Choline-HealthProfessional/. Updated January 25, 2017. Accessed October 28, 2017.

Summary of Water-Soluble Vitamins

Table 9.31 Water-Soluble vitamins

Vitamin	Sources	Recommended Intake for adults	Major Functions	Deficiency diseases and symptoms	Gro risk def
Vitamin C (ascorbic acid)	Orange juice, grapefruit juice, strawberries, tomato, sweet red pepper	75-90 mg/day	Antioxidant, collagen synthesis, hormone and neurotransmitter synthesis	Scurvy, bleeding gums, joint pain, poor wound healing,	Sm alc eld
Thiamin (B1)	Pork, enriched and whole grains, fish, legumes	1.1-1.2 mg/day	Coenzyme: assists in glucose metabolism, RNA, DNA, and ATP synthesis	Beriberi: fatigue, confusion, movement impairment, swelling, heart failure	Alc old adu eat dis
Riboflavin (B2)	Beef liver, enriched breakfast cereals, yogurt, steak, mushrooms, almonds, eggs	1.1-1.3 mg/day	Coenzyme: assists in glucose, fat and carbohydrate metabolism, electron carrier, other B vitamins are dependent on	Ariboflavinosis: dry scaly skin, mouth inflammation and sores, sore throat, itchy eyes, light sensitivity	No
Niacin (B3)	Meat, poultry, fish, peanuts, enriched grains	14-16 NE/day	Coenzyme: assists in glucose, fat, and protein metabolism, electron carrier	Pellagra: diarrhea, dermatitis, dementia, death	Alc
Pantothenic Acid (B5)	Sunflower seeds, fish, dairy products, widespread in foods	5 mg/day	Coenzyme: assists in glucose, fat, and protein metabolism, cholesterol and neurotransmitter synthesis	Muscle numbness and pain, fatigue, irritability	Alc
B6(Pyridoxine)	Meat, poultry, fish, legumes, nuts	1.3-1.7 mg/day	Coenzyme; assists in amino-acid synthesis, glycogneolysis, neurotransmitter and hemoglobin synthesis	Muscle weakness, dermatitis, mouth sores, fatigue, confusion	Alc

Biotin	Egg yolks, fish, pork, nuts and seeds	30 mcg/day	Coenzyme; assists in glucose, fat, and protein metabolism, amino-acid synthesis	Muscle weakness, dermatitis, fatigue, hair loss	The cor raw wh
Folate	Leafy green vegetables, enriched grains, orange juice	400 mcg/day	Coenzyme; amino acid synthesis, RNA, DNA, and red blood cell synthesis	Diarrhea, mouth sores, confusion, anemia, neural-tube defects	Pre wo alc
B12(cobalamin)	Meats, poultry, fish	2.4 mcg/day	Coenzyme; fat and protein catabolism, folate function, red-blood-cell synthesis	Muscle weakness, sore tongue, anemia, nerve damage, neural-tube defects	Veg eld
Choline	Egg yolk, wheat, meat, fish, synthesis in the body	425-550 mg/day	Synthesis of neurotransmitters and cell membranes, lipid transport	Non-alcoholic fatty liver disease, muscle damage, interfered brain development in fetus	No

Do B-Vitamin Supplements Provide an Energy Boost?

Although some marketers claim taking a vitamin that contains one-thousand times the daily value of certain B vitamins boosts energy and performance, this is a myth that is not backed by science. The "feeling" of more energy from energy-boosting supplements stems from the high amount of added sugars, caffeine, and other herbal stimulants that accompany the high doses of B vitamins. As discussed, B vitamins are needed to support energy metabolism and growth, but taking in more than required does not supply you with more energy. A great analogy of this phenomenon is the gas in your

car. Does it drive faster with a half-tank of gas or a full one? It does not matter; the car drives just as fast as long as it has gas. Similarly, depletion of B vitamins will cause problems in energy metabolism, but having more than is required to run metabolism does not speed it up. Buyers of B-vitamin supplements beware; B vitamins are not stored in the body and all excess will be flushed down the toilet along with the extra money spent.

B vitamins are naturally present in numerous foods, and many other foods are enriched with them. In the United States, B-vitamin deficiencies are rare; however in the nineteenth century some vitamin-B deficiencies plagued many people in North America. Niacin deficiency, also known as pellagra, was prominent in poorer Americans whose main dietary staple was refined cornmeal. Its symptoms were severe and included diarrhea, dermatitis, dementia, and even death. Some of the health consequences of pellagra are the result of niacin being in insufficient supply to support the body's metabolic functions.

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Antioxidants

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The market is flooded with advertisements for "super antioxidant" supplements teeming with molecules that block free radical production, stimulate the immune system, prevent cancer, and reduce the signs of aging. Based on the antioxidant-supplement industry's success, the general public appears to believe these health claims. However, these claims are not backed by scientific evidence; rather, there is some evidence suggesting supplements can actually cause harm. While scientists have found evidence supporting the consumption of antioxidant-rich foods as a method of reducing the risk of chronic disease, there is no "miracle cure"; no pill or supplement alone can provide the same benefits as a healthy diet. Remember, it is the combination of antioxidants and other nutrients in healthy foods that is beneficial. In this section, we will review how particular antioxidants function in the body, learn how they work together to protect the body against free radicals, and explore the best nutrient-rich dietary sources of antioxidants. One dietary source of antioxidants is vitamins. In our discussion of antioxidant vitamins, we will focus on vitamins E, C, and A.

Figure 9.21 Antioxidants' Role

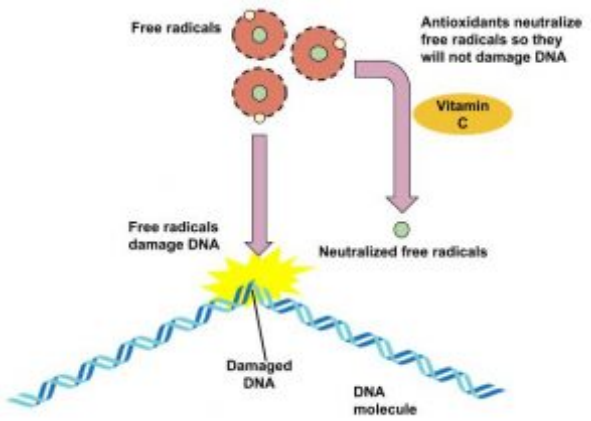

Image by Allison Calabrese / CC BY 4.0

Antioxidant Chemicals Obtained from the Diet

There are many different antioxidants in food, including selenium, which is one of the major antioxidants. However, the antioxidants you may be the most familiar with are vitamins. The "big three" vitamin antioxidants are vitamins E, A, and C, although it may be that they are called the "big three" only because they are the most studied.

Table 9.32 Some Antioxidants Obtained from Diet and Their Related Functions

Antioxidant	Antioxidant Source	Antioxidant Function
Vitamin A	Karat banana, beef liver, chicken liver	Protects cellular membranes, prevents glutathione depletion, maintains free radical detoxifying enzyme systems, reduces inflammation
Vitamin E	Sunflower seeds, almonds, sunflower oil	Protects cellular membranes, prevents glutathione depletion
Vitamin C	Oranges, grapefruit	Protects DNA, RNA, proteins, and lipids, aids in regenerating vitamin E
Vitamin D	Swordfish, salmon, tuna fish canned in water and drained	Regulates blood calcium levels in concert with parathyroid hormone
Carotenoids	Pumpkin, carrots	Free radical scavenger

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The Body's Offense

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While our bodies have acquired multiple defenses against free radicals, we also use free radicals to support its functions. For example, the immune system uses the cell-damaging properties of free radicals to kill pathogens. First, immune cells engulf an invader (such as a bacterium), then they expose it to free radicals such as hydrogen peroxide, which destroys its membrane. The invader is thus neutralized. Scientific studies also suggest hydrogen peroxide acts as a signaling molecule that calls immune cells to injury sites, meaning free radicals may aid with tissue repair when you get cut.

Free radicals are necessary for many other bodily functions as well. The thyroid gland synthesizes its own hydrogen peroxide, which is required for the production of thyroid hormone. Reactive oxygen species and reactive nitrogen species, which are free radicals containing nitrogen, have been found to interact with proteins in cells to produce signaling molecules. The free radical nitric oxide has been found to help dilate blood vessels and act as a chemical messenger in the brain. By acting as signaling molecules, free radicals are involved in the control of their own synthesis, stress responses, regulation of cell growth and death, and metabolism.

Sources of Free Radicals in the Environment

Substances and energy sources from the environment can add to or accelerate the production of free radicals within the body. Exposure

to excessive sunlight, ozone, smoke, heavy metals, ionizing radiation, asbestos, and other toxic chemicals increase the amount of free radicals in the body. They do so by being free radicals themselves or by adding energy that provokes electrons to move between atoms. Excessive exposure to environmental sources of free radicals can contribute to disease by overwhelming the free radical detoxifying systems and those processes involved in repairing oxidative damage.

Oxidative Stress

Oxidative stress refers to an imbalance in any cell, tissue, or organ between the amount of free radicals and the capabilities of the detoxifying and repair systems. Sustained oxidative damage results only under conditions of oxidative stress—when the detoxifying and repair systems are insufficient. Free radical-induced damage, when left unrepaired, destroys lipids, proteins, RNA, and DNA, and can contribute to disease. Oxidative stress has been implicated as a contributing factor to cancer, atherosclerosis (hardening of arteries), arthritis, diabetes, kidney disease, Alzheimer's disease, Parkinson's disease, schizophrenia, bipolar disorder, emphysema, and cataracts.

Aging is a process that is genetically determined but modulated by factors in the environment. In the process of aging, tissue function declines. The idea that oxidative stress is the primary contributor to age-related tissue decline has been around for decades, and it is true that tissues accumulate free radical-induced damage as we age. Recent scientific evidence slightly modifies this theory by suggesting oxidative stress is not the initial trigger for age-related decline of tissues; it is suggested that the true culprit is progressive dysfunction of metabolic processes, which leads to increases in free radical production, thus influencing the stress response of tissues as they age.

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Phytochemicals

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Phytochemicals are chemicals in plants that may provide some health benefit. Carotenoids are one type of phytochemical. Phytochemicals also include indoles, lignans, phytoestrogens, stanols, saponins, terpenes, flavonoids, carotenoids, anthocyanidins, phenolic acids, and many more. They are found not only in fruits and vegetables, but also in grains, seeds, nuts, and legumes.

Many phytochemicals act as antioxidants, but they have several other functions, such as mimicking hormones, altering absorption of cholesterol, inhibiting inflammatory responses, and blocking the actions of certain enzymes.

Phytochemicals are present in small amounts in the food supply, and although thousands have been and are currently being scientifically studied, their health benefits remain largely unknown. Also largely unknown is their potential for toxicity, which could be substantial if taken in large amounts in the form of supplements. Moreover, phytochemicals often act in conjunction with each other and with micronutrients. Thus, supplementing with only a few may impair the functions of other phytochemicals or micronutrients. As with the antioxidant vitamins, it is the mixture and variety of phytochemicals in foods that are linked to health benefits.

Table 9.33 Some Phytochemical's Obtained from Diet and Their Related Functions

Phytochemical	Phytochemical Source	Phytochemical Function:
Carotenoid	Yellow-orange fruits, dark green leafy vegetables	May possess strong cancer-fighting properties
Indoles	Cruciferous vegetables (i.e. bok choy, broccoli, choy sum)	May inhibit the development of cancer-causing hormones and prevent tumor growth
Phytoestrogen	Grapes, berries, plums, soybeans, tofu, garlic	May lower the risk for osteoporosis, heart disease, breast cancer, and menopausal symptoms
Stanols	Grains, nuts, legumes	May lower blood cholesterol levels and reduce the risk of heart disease and stroke
Saponins	Broad beans, kidney beans, lentils	May decrease blood lipids, lower cancer risks, and lower blood glucose response
Terpenes	Citrus fruits	May slow cancer cell growth, aid in immune system support, and prevent virus related illness
Flavonoids	Fruits, vegetables, chocolates, wines, teas, nuts, seeds	May benefit the immune system and prevent cancer cell growth.
Anthocyanidins	Fruits and vegetables with vibrant colors of orange, red, purple, and blue	May prevent cardiovascular disease, reduce cancer cell proliferation (growth/ multiplication) and inhibit tumor formation.
Phenolic acids	Coffee, fruits, vegetables, nuts, cereals, legumes, oilseeds, beverages and herbs	May prevent cellular damage due to free-radical oxidation reaction and promote anti-inflammatory conditions in the body.

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PART X

CHAPTER 10. MAJOR MINERALS

Introduction

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He pūkoʻa kani ʻāina

A coral reef strengthens into land.

Choy Sum by pxhere.com / CCO

Learning Objectives

By the end of this chapter you will be able to:

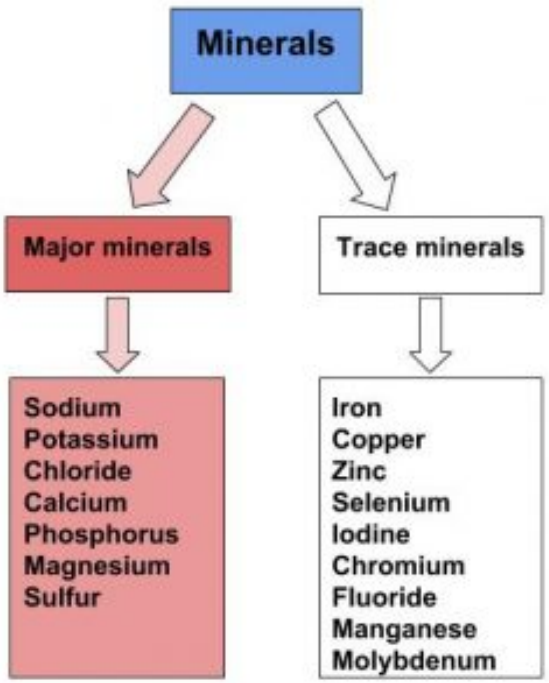
- Describe the functional role, intake recommendations and sources of major minerals

Similarly to vitamins, minerals are essential to human health and can be obtained in our diet from different types of food. Minerals are abundant in our everyday lives. From the soil in your front yard to the jewelry you wear on your body, we interact with minerals constantly. There are 20 essential minerals that must be consumed in our diets to remain healthy. The amount of each mineral found in our bodies vary greatly and therefore, so does consumption of those minerals. When there is a deficiency in an essential mineral, health problems may arise.

Major minerals are classified as minerals that are required in the diet each day in amounts larger than 100 milligrams. These include sodium, potassium, chloride, calcium, phosphorus, magnesium, and sulfur. These major minerals can be found in various foods. For example, in Guam, the major mineral, calcium, is consumed in the diet not only through dairy, a common source of calcium, but also through through the mixed dishes, desserts and vegetables that they consume. Consuming a varied diet significantly improves an individual's ability to meet their nutrient needs. [1]

Figure 10.1 The Major Minerals

1. Pobocik RS, Trager A, Monson LM. (2008). Dietary Patterns and Food Choices of a Population Sample of Adults on Guam. *Asia Pacific Journal of Clinical Nutrition.*, *17*(1), 94-100. http://apjcn.nhri.org.tw/server/APJCN/17/1/94.pdf. Accessed February 16, 2018.



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Bioavailability

Minerals are not as efficiently absorbed as most vitamins and so the bioavailability of minerals can be very low. Plant-based foods often contain factors, such as oxalate and phytate, that bind to minerals and inhibit their absorption. In general, minerals are better absorbed from animal-based foods. In most cases, if dietary intake of a particular mineral is increased, absorption will decrease. Some minerals influence the absorption of others. For instance, excess zinc in the diet can impair iron and copper absorption. Conversely, certain vitamins enhance mineral absorption. For example, vitamin C boosts iron absorption, and vitamin D boosts calcium and magnesium absorption. As is the case with vitamins, certain

gastrointestinal disorders and diseases, such as Crohn's disease and kidney disease, as well as the aging process, impair mineral absorption, putting people with malabsorption conditions and the elderly at higher risk for mineral deficiencies.

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Calcium

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Calcium's Functional Roles

Calcium is the most abundant mineral in the body and greater than 99 percent of it is stored in bone tissue. Although only 1 percent of the calcium in the human body is found in the blood and soft tissues, it is here that it performs the most critical functions. Blood calcium levels are rigorously controlled so that if blood levels drop the body will rapidly respond by stimulating bone resorption, thereby releasing stored calcium into the blood. Thus, bone tissue sacrifices its stored calcium to maintain blood calcium levels. This is why bone health is dependent on the intake of dietary calcium and also why blood levels of calcium do not always correspond to dietary intake.

Calcium plays a role in a number of different functions in the body like bone and tooth formation. The most well-known calcium function is to build and strengthen bones and teeth. Recall that when bone tissue first forms during the modeling or remodeling process, it is unhardened, protein-rich osteoid tissue. In the osteoblast-directed process of bone mineralization, calcium phosphates (salts) are deposited on the protein matrix. The calcium salts typically make up about 65 percent of bone tissue. When your diet is calcium deficient, the mineral content of bone decreases causing it to become brittle and weak. Thus, increased calcium intake helps to increase the mineralized content of bone tissue. Greater mineralized bone tissue corresponds to a greater BMD, and to greater bone strength. The remaining calcium plays a role in nerve impulse transmission by facilitating electrical impulse transmission from one nerve cell to another. Calcium in muscle cells

is essential for muscle contraction because the flow of calcium ions are needed for the muscle proteins (actin and myosin) to interact. Calcium is also essential in blood clotting by activating clotting factors to fix damaged tissue.

In addition to calcium's four primary functions calcium has several other minor functions that are also critical for maintaining normal physiology. For example, without calcium, the hormone insulin could not be released from cells in the pancreas and glycogen could not be broken down in muscle cells and used to provide energy for muscle contraction.

Maintaining Calcium Levels

Because calcium performs such vital functions in the body, blood calcium level is closely regulated by the hormones parathyroid hormone (PTH), calcitriol, and calcitonin. When blood calcium levels are low, PTH is secreted to increase blood calcium levels via three different mechanisms. First, PTH stimulates the release of calcium stored in the bone. Second, PTH acts on kidney cells to increase calcium reabsorption and decrease its excretion in the urine. Third, PTH stimulates enzymes in the kidney that activate vitamin D to calcitriol. Calcitriol is the active hormone that acts on the intestinal cells and increases dietary calcium absorption. When blood calcium levels become too high, the hormone calcitonin is secreted by certain cells in the thyroid gland and PTH secretion stops. At higher nonphysiological concentrations, calcitonin lowers blood calcium levels by increasing calcium excretion in the urine, preventing further absorption of calcium in the gut and by directly inhibiting bone resorption.

Figure 10.2 Maintaining Blood Calcium Levels

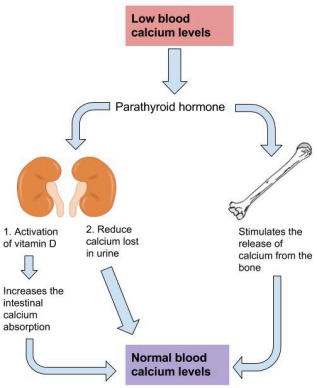

Image by Allison Calabrese / CC BY 4.0

Other Health Benefits of Calcium in the Body

Besides forming and maintaining strong bones and teeth, calcium has been shown to have other health benefits for the body, including:

- **Cancer**. The National Cancer Institute reports that there is enough scientific evidence to conclude that higher intakes of calcium decrease colon cancer risk and may suppress the growth of polyps that often precipitate cancer. Although higher calcium consumption protects against colon cancer, some studies have looked at the relationship between calcium and prostate cancer and found higher intakes may increase the risk for prostate cancer; however the data is inconsistent and more studies are needed to confirm any negative association.
- Blood pressure. Multiple studies provide clear evidence that higher calcium consumption reduces blood pressure. A review of twenty-three observational studies concluded that for every

100 milligrams of calcium consumed daily, systolic blood pressure is reduced 0.34 millimeters of mercury (mmHg) and diastolic blood pressure is decreased by 0.15 mmHg.[1]

- **Cardiovascular health**. There is emerging evidence that higher calcium intakes prevent against other risk factors for cardiovascular disease, such as high cholesterol and obesity, but the scientific evidence is weak or inconclusive.
- **Kidney stones**. Another health benefit of a high-calcium diet is that it blocks kidney stone formation. Calcium inhibits the absorption of oxalate, a chemical in plants such as parsley and spinach, which is associated with an increased risk for developing kidney stones. Calcium's protective effects on kidney stone formation occur only when you obtain calcium from dietary sources. Calcium supplements may actually increase the risk for kidney stones in susceptible people.

Figure 10. 3 Calcium's Effect on Aging

1. Birkett NJ. (1998). Comments on a Meta-Analysis of the Relation between Dietary Calcium Intake and Blood Pressure. *American Journal of Epidemiology*, 148(3), 223–28. http://aje.oxfordjournals.org/content/148/3/223.long. Accessed October 10, 2017.

Image by James Heilman, MD / CC BY-SA 3.0

Calcium inadequacy is most prevalent in adolescent girls and the elderly. Proper dietary intake of calcium is critical for proper bone health.

Despite the wealth of evidence supporting the many health benefits of calcium (particularly bone health), the average American diet falls short of achieving the recommended dietary intakes of

calcium. In fact, in females older than nine years of age, the average daily intake of calcium is only about 70 percent of the recommended intake. Here we will take a closer look at particular groups of people who may require extra calcium intake.

- **Adolescent teens**. A calcium-deficient diet is common in teenage girls as their dairy consumption often considerably drops during adolescence.
- **Amenorrheic women and the "female athlete triad"**. Amenorrhea refers to the absence of a menstrual cycle. Women who fail to menstruate suffer from reduced estrogen levels, which can disrupt and have a negative impact on the calcium balance in their bodies. The "female athlete triad" is a combination of three conditions characterized by amenorrhea, disrupted eating patterns, and osteoporosis. Exercise-induced amenorrhea and anorexia nervosa-related amenorrhea can decrease bone mass.[23] In female athletes, as well as active women in the military, low BMD, menstrual irregularities, and individual dietary habits together with a history of previous

2. Drinkwater B, Bruemner B, Chesnut C. (1990). Menstrual History As a Determinant of Current Bone Density in Young Athletes. *The Journal of the American Medical Association*, 263(4), 545–8. http://www.ncbi.nlm.nih.gov/pubmed/2294327?dopt=Abstract. . Accessed November 22, 2017.
3. Marcus R. et al. (1985). Menstrual Function and Bone Mass in Elite Women Distance Runners: Endocrine and Metabolic Features. *The Annuals of Internal Medicine*, 102(2), 58–63. http://www.ncbi.nlm.nih.gov/pubmed/3966752?dopt=Abstract. Accessed November 22, 2017.

stress issues are related to an increased susceptibility to future stress fractures.[45]

- **The elderly**. As people age, calcium bioavailability is reduced, the kidneys lose their capacity to convert vitamin D to its most active form, the kidneys are no longer efficient in retaining calcium, the skin is less effective at synthesizing vitamin D, there are changes in overall dietary patterns, and older people tend to get less exposure to sunlight. Thus the risk for calcium inadequacy is great.[6]
- **Postmenopausal women**. Estrogen enhances calcium absorption. The decline in this hormone during and after menopause puts postmenopausal women especially at risk for calcium deficiency. Decreases in estrogen production are responsible for an increase in bone resorption and a decrease

4. Nattiv A. Stress (2000). Fractures and Bone Health in Track and Field Athletes. *The Journal of Science & Medicine in Sport*, 3(3), 268–79. http://www.ncbi.nlm.nih.gov/pubmed/11101266?dopt=Abstract.,.Accessed November 22, 2017.
5. Johnson AO, et al. (1993). Correlation of Lactose Maldigestion, Lactose Intolerance, and Milk Intolerance. *American Journal of Clinical Nutrition*, 57(3), 399–401. http://www.ncbi.nlm.nih.gov/pubmed/8438774?dopt=Abstract. Accessed November 22, 2017.
6. Calcium and Vitamin D in the Elderly. International Osteoporosis Foundation. http://www.iofbonehealth.org/patients-public/about-osteoporosis/prevention /nutrition/calcium-and-vitamin-d-in-the-elderly.html. Published 2012. Accessed November 22, 2017.

in calcium absorption. During the first years of menopause, annual decreases in bone mass range from 3–5 percent. After age sixty-five, decreases are typically less than 1 percent.[7]

- **Lactose-intolerant people**. Groups of people, such as those who are lactose intolerant, or who adhere to diets that avoid dairy products, may not have an adequate calcium intake.
- **Vegans**. Vegans typically absorb reduced amounts of calcium because their diets favor plant-based foods that contain oxalates and phytates.[8]

In addition, because vegans avoid dairy products, their overall consumption of calcium-rich foods may be less.

If you are lactose intolerant, have a milk allergy, are a vegan, or you simply do not like dairy products, remember that there are many plant-based foods that have a good amount of calcium and there are also some low-lactose and lactose-free dairy products on the market.

Calcium Supplements: Which One to Buy?

Many people choose to fulfill their daily calcium requirements by taking calcium supplements. Calcium supplements are sold

7. Daniels CE. (2000). Estrogen Therapy for Osteoporosis Prevention in Postmenopausal Women. National Institute of Health: *Pharmacy*. Update March/April 2000.
8. Dietary Reference Intakes for Calcium and Vitamin D.Food and Nutrition Board, Institute of Medicine. Washington, DC: National Academy Press. 2010.

primarily as calcium carbonate, calcium citrate, calcium lactate, and calcium phosphate, with elemental calcium contents of about 200 milligrams per pill. It is important to note that calcium carbonate requires an acidic environment in the stomach to be used effectively. Although this is not a problem for most people, it may be for those on medication to reduce stomach-acid production or for the elderly who may have a reduced ability to secrete acid in the stomach. For these people, calcium citrate may be a better choice. Otherwise, calcium carbonate is the cheapest. The body is capable of absorbing approximately 30 percent of the calcium from these forms.

Beware of Lead

There is public health concern about the lead content of some brands of calcium supplements, as supplements derived from natural sources such as oyster shell, bone meal, and dolomite (a type of rock containing calcium magnesium carbonate) are known to contain high amounts of lead. In one study conducted on twenty-two brands of calcium supplements, it was proven that eight of the brands exceeded the acceptable limit for lead content. This was found to be the case in supplements derived from oyster shell and refined calcium carbonate. The same study also found that brands claiming to be lead-free did, in fact, show very low lead levels. Because lead levels in supplements are not disclosed on labels, it is important to know that products not derived from oyster shell or other natural substances are generally low in lead content. In addition, it was also found that one brand did not disintegrate as is necessary for absorption, and one brand contained only 77 percent of the stated calcium content.[9]

9. Ross EA, Szabo NJ, Tebbett IR. (2000). Lead Content of

Diet, Supplements, and Chelated Supplements

In general, calcium supplements perform to a lesser degree than dietary sources of calcium in providing many of the health benefits linked to higher calcium intake. This is partly attributed to the fact that dietary sources of calcium supply additional nutrients with health-promoting activities. It is reported that chelated forms of calcium supplements are easier to absorb as the chelation process protects the calcium from oxalates and phytates that may bind with the calcium in the intestines. However, these are more expensive supplements and only increase calcium absorption up to 10 percent. In people with low dietary intakes of calcium, calcium supplements have a negligible benefit on bone health in the absence of a vitamin D supplement. However, when calcium supplements are taken along with vitamin D, there are many benefits to bone health: peak bone mass is increased in early adulthood, BMD is maintained throughout adulthood, the risk of developing osteoporosis is reduced, and the incidence of fractures is decreased in those who already had osteoporosis. Calcium and vitamin D pills do not have to be taken at the same time for effectiveness. But remember that vitamin D has to be activated and in the bloodstream to promote calcium absorption. Thus, it is important to maintain an adequate intake of vitamin D.

The Calcium Debate

A recent study published in the British Medical Journal reported that people who take calcium supplements at doses equal to or

Calcium Supplements. *The Journal of the American Medical Association*, 284, 1425–33.

greater than 500 milligrams per day in the absence of a vitamin D supplement had a 30 percent greater risk for having a heart attack.[10]

Does this mean that calcium supplements are bad for you? If you look more closely at the study, you will find that 5.8 percent of people (143 people) who took calcium supplements had a heart attack, but so did 5.5 percent of the people (111) people who took the placebo. While this is one study, several other large studies have not shown that calcium supplementation increases the risk for cardiovascular disease. While the debate over this continues in the realm of science, we should focus on the things we do know:

1. There is overwhelming evidence that diets sufficient in calcium prevent osteoporosis and cardiovascular disease.
2. People with risk factors for osteoporosis are advised to take calcium supplements if they are unable to get enough calcium in their diet. The National Osteoporosis Foundation advises that adults age fifty and above consume 1,200 milligrams of calcium per day. This includes calcium both from dietary sources and supplements.
3. Consuming more calcium than is recommended is not better for your health and can prove to be detrimental. Consuming too much calcium at any one time, be it from diet or supplements, impairs not only the absorption of calcium itself, but also the absorption of other essential minerals, such as iron and zinc. Since the GI tract can only handle about 500 milligrams of calcium at one time, it is recommended to have split doses of calcium supplements rather than taking a few all

10. Bolland MJ. et al. (2010). Effect of Calcium Supplements on Risk of Myocardial Infarction and Cardiovascular Events: Meta-Analysis. *British Medical Journal*, 341(c3691).

at once to get the RDA of calcium.

Dietary Reference Intake for Calcium

The recommended dietary allowances (RDA) for calcium are listed in Table 10.1 "Dietary Reference Intakes for Calcium". The RDA is elevated to 1,300 milligrams per day during adolescence because this is the life stage with accelerated bone growth. Studies have shown that a higher intake of calcium during puberty increases the total amount of bone tissue that accumulates in a person. For women above age fifty and men older than seventy-one, the RDAs are also a bit higher for several reasons including that as we age, calcium absorption in the gut decreases, vitamin D3 activation is reduced, and maintaining adequate blood levels of calcium is important to prevent an acceleration of bone tissue loss (especially during menopause). Currently, the dietary intake of calcium for females above age nine is, on average, below the RDA for calcium. The Institute of Medicine (IOM) recommends that people do not consume over 2,500 milligrams per day of calcium as it may cause adverse effects in some people.

Table 10.1 Dietary Reference Intakes for Calcium

Age Group	RDA (mg/day)	UL (mg/day)
Infants (0–6 months)	200*	–
Infants (6–12 months)	260*	–
Children (1–3 years)	700	2,500
Children (4–8 years)	1,000	2,500
Children (9–13 years)	1,300	2,500
Adolescents (14–18 years)	1,300	2,500
Adults (19–50 years)	1,000	2,500
Adult females (50–71 years)	1,200	2,500
Adults, male & female (> 71 years)	1,200	2,500
* denotes Adequate Intake		

Source: Ross AC, Manson JE, et al. The 2011 Report on Dietary Reference Intakes for Calcium and Vitamin D from the Institute of Medicine: What Clinicians Need to Know. J Clin Endocrinol Metab. 2011; 96(1), 53–8. http://www.ncbi.nlm.nih.gov/pubmed/21118827. Accessed October 10, 2017.

Dietary Sources of Calcium

In the typical American diet, calcium is obtained mostly from dairy products, primarily cheese. A slice of cheddar or Swiss cheese contains just over 200 milligrams of calcium. One cup of nonfat milk contains approximately 300 milligrams of calcium, which is about a third of the RDA for calcium for most adults. Foods fortified with calcium such as cereals, soy milk, and orange juice also provide one third or greater of the calcium RDA. Although the typical American diet relies mostly on dairy products for obtaining calcium, there are other good non-dairy sources of calcium.

Tools for Change

If you need to increase calcium intake, are a vegan, or have a food allergy to dairy products, it is helpful to know that there are some plant-based foods that are high in calcium. Tofu (made with calcium sulfate), turnip greens, mustard greens, and chinese cabbage are good sources. For a list of non-dairy sources you can find the calcium content for thousands of foods by visiting the USDA National Nutrient Database (http://www.nal.usda.gov/fnic/foodcomp/search/). When obtaining your calcium from a vegan diet, it is important to know that some plant-based foods significantly impair the absorption of calcium. These include spinach, Swiss chard, rhubarb, beets, cashews, and peanuts. With careful planning and good selections, you can ensure that you are getting enough calcium in your diet even if you do not drink milk or consume other dairy products.

Calcium Bioavailability

In the small intestine, calcium absorption primarily takes place in the duodenum (first section of the small intestine) when intakes are low, but calcium is also absorbed passively in the jejunum and ileum (second and third sections of the small intestine), especially when intakes are higher. The body doesn't completely absorb all the calcium in food. Interestingly, the calcium in some vegetables such as kale, brussel sprouts, and bok choy is better absorbed by the body

than are dairy products. About 30 percent of calcium is absorbed from milk and other dairy products.

The greatest positive influence on calcium absorption comes from having an adequate intake of vitamin D. People deficient in vitamin D absorb less than 15 percent of calcium from the foods they eat. The hormone estrogen is another factor that enhances calcium bioavailability. Thus, as a woman ages and goes through menopause, during which estrogen levels fall, the amount of calcium absorbed decreases and the risk for bone disease increases. Some fibers, such as inulin, found in jicama, onions, and garlic, also promote calcium intestinal uptake.

Chemicals that bind to calcium decrease its bioavailability. These negative effectors of calcium absorption include the oxalates in certain plants, the tannins in tea, phytates in nuts, seeds, and grains, and some fibers. Oxalates are found in high concentrations in spinach, parsley, cocoa, and beets. In general, the calcium bioavailability is inversely correlated to the oxalate content in foods. High-fiber, low-fat diets also decrease the amount of calcium absorbed, an effect likely related to how fiber and fat influence the amount of time food stays in the gut. Anything that causes diarrhea, including sickness, medications, and certain symptoms related to old age, decreases the transit time of calcium in the gut and therefore decreases calcium absorption. As we get older, stomach acidity sometimes decreases, diarrhea occurs more often, kidney function is impaired, and vitamin D absorption and activation is compromised, all of which contribute to a decrease in calcium bioavailability.

Table 10.2 Calcium Content and Bioavailability of Various Foods

Food	Serving	Calcium (mg)	Absorption (%)	Estimated Calcium Absorbed (mg)	% Daily Value[1]	% Daily Value[2]
Yogurt, low fat	8.5 oz.	300	32	96	7.4	9.6
Mozzarella, part skim	1.5 oz.	333	32	107	8.2	10.7
Sardines, canned with bones	3 oz.	325	27	88	6.8	8.8
Cheddar Cheese	1.5 oz.	303	32	97	7.5	9.7
Milk, nonfat	8.5 oz.	300	32	96	7.4	9.6
Soymilk, calcium fortified	8.5 oz.	300	24	72	5.5	7.2
Orange juice, calcium fortified	8.5 oz.	300	36	109	8.4	10.9
Tofu, firm, made with calcium sulfate	½ c.	258	31	80	6.2	8.0
Salmon, canned with bones	3 oz.	181	27	49	3.8	4.9
Turnip Greens	½ c.	99	52	51	4.0	5.1
Kale, cooked	1 c.	94	49	30	2.3	3.0
Vanilla Ice Cream, light	½ c.	84	32	27	2.1	2.7
Broccoli, cooked	1 c.	35	61	19	1.5	1.9
Cauliflower, cooked	1 c.	10	69	6.9	0.5	0.7
Red Beans, cooked	1 c.	41	24	9.84	0.8	1.0

[1]Based on DV = 1000 mg

[2]Based on DV = 1300 mg

Source:

Office of Dietary Supplements. (2020, March 26). Calcium. https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/

Titchenal, C. A., & Dobbs, J. (2007). A system to assess the quality of food sources of calcium. Journal of Food Composition and Analysis, 20(8), 717–724. doi: 10.1016/j.jfca.2006.04.013

Learning Activities

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Phosphorus

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Phosphorus's Functional Role

Phosphorus is present in our bodies as part of a chemical group called a phosphate group. These phosphate groups are essential as a structural component of cell membranes (as phospholipids), DNA and RNA, energy production (ATP), and regulation of acid-base homeostasis. Phosphorus however is mostly associated with calcium as a part of the mineral structure of bones and teeth. Blood phosphorus levels are not controlled as strictly as calcium so the PTH stimulates renal excretion of phosphate so that it does not accumulate to toxic levels.

Dietary Reference Intakes for Phosphorus

In comparison to calcium, most Americans are not at risk for having a phosphate deficiency. Phosphate is present in many foods popular in the American diet including meat, fish, dairy products, processed foods, and beverages. Phosphate is added to many foods because it acts as an emulsifying agent, prevents clumping, improves texture and taste, and extends shelf-life. The average intake of phosphorus in US adults ranges between 1,000 and 1,500 milligrams per day, well above the RDA of 700 milligrams per day. The UL set for phosphorous is 4,000 milligrams per day for adults and 3,000 milligrams per day for people over age seventy.

Table 10.3 Dietary Reference Intakes for Phosphorus

Age Group	RDA (mg/day)	UL (mg/day)
Infants (0–6 months)	100*	–
Infants (6–12 months)	275*	–
Children (1–3 years)	460	3,000
Children (4–8 years)	500	3,000
Children (9–13 years)	1,250	4,000
Adolescents (14–18 years)	1,250	4,000
Adults (19–70 years)	700	4,000
Adults (> 70 years)	700	3,000
* denotes Adequate Intake		

Micronutrient Information Center: Phosphorus. Oregon State University, Linus Pauling Institute. http://lpi.oregonstate.edu/mic/minerals/phosphorus. Updated in July 2013. Accessed October 22, 2017.

Dietary Sources of Phosphorus

Table 10.4 Phosphorus Content of Various Foods

Foods	Serving	Phosphorus (mg)	Percent Daily Value 1000
Salmon	3 oz.	315	32
Yogurt, nonfat	8 oz.	306	31
Turkey, light meat	3 oz.	217	22
Chicken, light meat	3 oz.	135	14
Beef	3 oz.	179	18
Lentils*	½ c.	178	18
Almonds*	1 oz.	136	14
Mozzarella	1 oz.	131	13
Peanuts*	1 oz.	108	11
Whole wheat bread	1 slice	68	7
Egg	1 large	86	9
Carbonated cola drink	12 oz.	41	4
Bread, enriched	1 slice	25	3

Micronutrient Information Center: Phosphorus. Oregon State University, Linus Pauling Institute. http://lpi.oregonstate.edu/mic/minerals/phosphorus. Updated in July 2013. Accessed October 22, 2017.

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Sulfur

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Sulfur is incorporated into protein structures in the body. Amino acids, methionine and cysteine contain sulfur which are essential for the antioxidant enzyme glutathione peroxidase. Some vitamins like thiamin and biotin also contain sulfur which are important in regulating acidity in the body. Sulfur is a major mineral with no recommended intake or deficiencies when protein needs are met. Sulfur is mostly consumed as a part of dietary proteins and sulfur containing vitamins.

Sulfur's Functional Role

Sulfur is the third most abundant mineral in our body after calcium and phosphorus.[1] Sulfur is incorporated into protein structures in the body such as keratin in hair and provides stabilization to these protein structures. One of it's key roles is the synthesis of 3'-phosphoadenosine-5'phosphosulfate (PAPS)[2] which is used in the

1. Nimni, M. E., Han, B., & Cordoba, F. (2007). Are we getting enough sulfur in our diet?. *Nutrition & Metabolism*, 4,24. https://doi.org/10.1186/1743-7075-4-24.
2. Weiss, M., Steiner, D. F., & Philipson, L. H. (2000). Insulin biosynthesis, secretion, structure, and structure-activity

biosynthesis of compounds essential in chondroitin in bones and cartilage, heparin and insulin.[3] Additionally, sulfur is an important component of the antioxidant enzyme glutathione peroxidase. Excess cysteine and methionine are oxidized to sulfate and excreted in the urine or stored as glutathione.[4]

Dietary Reference Intakes for Sulfur

Sulfur is a major mineral with no recommended intake. Deficiencies are not found in those that meet protein requirements or in those with adequate consumption of sulfur-containing amino acids. Adverse effects were reported in individuals that ingest water sources with high levels of inorganic sulfur. Osmotic diarrhea may result and is of particular concern in infants. Animal studies showed that growth is stunted with inadequate sulfur intake from foods and beverages. Current data is insufficient to establish a Tolerable Upper Intake Level (UL).[5]

relationships. In K. R. Feingold (Eds.) et. al., Endotext. MDText.com, Inc.
3. Weiss, M., Steiner, D. F., & Philipson, L. H. (2000). Insulin biosynthesis, secretion, structure, and structure-activity relationships. In K. R. Feingold (Eds.) et. al., Endotext. MDText.com, Inc.
4. Nimni, M. E., Han, B., & Cordoba, F. (2007). Are we getting enough sulfur in our diet?. *Nutrition & Metabolism*, 4,24. https://doi.org/10.1186/1743-7075-4-24.
5. Institute of Medicine. (2006). *Dietary Reference Intakes:*

Dietary Sources of Sulfur

Dietary sources mainly come from sulfur-containing amino acids methionine and cysteine. Some vitamins like thiamin and biotin contain sulfur which are important in regulating acidity in the body. Sulfur can also be obtained from sulfur-containing foods such as garlic, onion and cruciferous vegetables.[6] Tap water also supplies sulfur but its concentration varies depending on location.[7] Dietary supplements such as chondroitin sulfate or glucosamine sulfate commonly used to aid bone and joint health also contain sulfur.[8]

Table 10.5 Sulfur Content in Various Foods

The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537.

6. Institute of Medicine. (2006). *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537.
7. Doleman, J. F., Grisar, K., Van Liedekerke, L., Saha, S., Roe, M., Tapp, H. S., & Mithen, R. F. (2017). The contribution of alliaceous and cruciferous vegetables to dietary sulphur intake. *Food Chemistry*, 234, 38–45. https://doi.org/10.1016/j.foodchem.2017.04.098.
8. Nimni, M. E., Han, B., & Cordoba, F. (2007). Are we getting enough sulfur in our diet?. *Nutrition & Metabolism*, 4,24. https://doi.org/10.1186/1743-7075-4-24.

Food	Serving	Methionine (mg)	Cystine (mg)
Turkey breast	1 breast	7102	2442
Brazil nuts	1 cup	1495	407
Canned tuna	1 cup	1259	456
Swiss Cheese, diced	1 cup	1035	383
Canned green peas	1 can	257	0.172
Egg, whole	1 large	189	136
Dried peaches	1 cup	139	46
Sweet potatoes	1 cup	134	43
Russet potatoes, baked	1 large potato (3" to 4-¼" diameter)	123	93
Whole-grain bread	1 slice	36	46
Broccoli	½ cup	34	24
Cauliflower	½ cup	16	13

Source: USDA Standard Reference Legacy Nutrient Search

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Magnesium

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Magnesium's Functional Role

Approximately 60 percent of magnesium in the human body is stored in the skeleton, making up about 1 percent of mineralized bone tissue. Magnesium is not an integral part of the hard mineral crystals, but it does reside on the surface of the crystal and helps maximize bone structure. Observational studies link magnesium deficiency with an increased risk for osteoporosis. A magnesium-deficient diet is associated with decreased levels of parathyroid hormone and the activation of vitamin D, which may lead to an impairment of bone remodeling. A study in nine hundred elderly women and men did show that higher dietary intakes of magnesium correlated to an increased BMD in the hip.[1] Only a few clinical trials have evaluated the effects of magnesium supplements on bone health and their results suggest some modest benefits on BMD.

In addition to participating in bone maintenance, magnesium has several other functions in the body. In every reaction involving the

1. Tucker KL, Hannan MT, et al.(1994). Potassium, Magnesium, and Fruit and Vegetable Intakes Are Associated with Greater Bone Mineral Density in Elderly Men and Women. *American Journal of Clinical Nutrition*, 69(4), 727–36. http://www.ajcn.org/cgi/pmidlookup?view=long&pmid=10197575. Accessed October 6, 2017.

cellular energy molecule, ATP, magnesium is required. More than three hundred enzymatic reactions require magnesium. Magnesium plays a role in the synthesis of DNA and RNA, carbohydrates, and lipids, and is essential for nerve conduction and muscle contraction. Another health benefit of magnesium is that it may decrease blood pressure.

Many Americans do not get the recommended intake of magnesium from their diets. Some observational studies suggest mild magnesium deficiency is linked to increased risk for cardiovascular disease. Signs and symptoms of severe magnesium deficiency may include tremor, muscle spasms, loss of appetite, and nausea.

Dietary Reference Intakes for Magnesium

The RDAs for magnesium for adults between ages nineteen and thirty are 400 milligrams per day for males and 310 milligrams per day for females. For adults above age thirty, the RDA increases slightly to 420 milligrams per day for males and 320 milligrams for females.

Table 10.6 Dietary Reference Intakes for Magnesium

Age Group	RDA (mg/day)	UL from non-food sources (mg/day)
Infants (0–6 months)	30*	–
Infants (6–12 months)	75*	–
Children (1–3 years)	80	65
Children (4–8 years)	130	110
Children (9–13 years)	240	350
Adolescents (14–18 years)	410	350
Adults (19–30 years)	400	350
Adults (> 30 years)	420	350
* denotes Adequate Intake		

Source: Dietary Supplement Fact Sheet: Magnesium. National Institutes of Health, Office of Dietary Supplements. http://ods.od.nih.gov/factsheets/Magnesium-HealthProfessional/. Updated July 13, 2009. Accessed November 12, 2017.

Dietary Sources of Magnesium

Magnesium is part of the green pigment, chlorophyll, which is vital for photosynthesis in plants; therefore green leafy vegetables are a good dietary source for magnesium. Magnesium is also found in high concentrations in fish, dairy products, meats, whole grains, and nuts. Additionally chocolate, coffee, and hard water contain a good amount of magnesium. Most people in America do not fulfill the RDA for magnesium in their diets. Typically, Western diets lean toward a low fish intake and the unbalanced consumption of refined grains versus whole grains.

Table 10.7 Magnesium Content of Various Foods

Food	Serving	Magnesium (mg)	Percent Daily Value
Almonds	1 oz.	80	20
Cashews	1 oz.	74	19
Soymilk	1 c.	61	15
Black beans	½ c.	60	15
Edamame	½ c.	50	13
Bread	2 slices	46	12
Avocado	1 c.	44	11
Brown rice	½ c.	42	11
Yogurt	8 oz.	42	11
Oatmeal, instant	1 packet	36	9
Salmon	3 oz.	26	7
Chicken breasts	3 oz.	22	6
Apple	1 medium	9	2

Source: Dietary Supplement Fact Sheet: Magnesium. National Institutes of Health, Office of Dietary Supplements. http://ods.od.nih.gov/factsheets/Magnesium-HealthProfessional/. Updated July 13, 2009. Accessed November 12, 2017.

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Summary of Major Minerals

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Table 10.8 A Summary of the Major Minerals

Micronutrient	Sources	Recommended Intakes for adults	Major functions	Deficiency diseases and symptoms	Groups a for defic
Calcium	Yogurt, cheese, sardines, milk, orange juice, turnip	1,000 mg/day	Component of mineralized bone, provides structure and microarchitecture	Increased risk of osteoporosis	Postmen women, who are actosein or vegan
Phosphorus	Salmon, yogurt, turkey, chicken, beef, lentils	700 mg/day	Structural component of bones, cell membrane, DNA and RNA, and ATP	Bone loss, weak bones	Older ad alcoholi
Magnesium	Whole grains and legumes, almonds, cashews, hazelnuts, beets, collards, and kelp	420 mg/day	Component of mineralized bone, ATP synthesis and utilization, carbohydrate, lipid,protein, RNA, and DNA synthesis	Tremor, muscle spasms, loss of appetite, nausea	Alcoholi individu kidney a gastroin disease
Sulfur	Protein foods	None specified	Structure of some vitamins and amino acids, acid-base balance	None when protein needs are met	None
Sodium	Processed foods, table salt, pork, chicken	< 2,300 mg/ day; ideally 1,500 mg/day	Major positive extracellular ion, nerve transmission, muscle contraction, fluid balance	Muscle cramps	People consumi much wa excessiv sweating with vom diarrhea
Potassium	Fruits, vegetables, legumes, whole grains, milk	4700 mg/day	Major positive intracellular ion, nerve transmission, muscle contraction, fluid balance	Irregular heartbeat, muscle cramps	People consumi high in processe meats, th with vom diarrhea
Chloride	Table salt, processed foods	<3600 mg/ day; ideally 2300 mg/day	Major negative extracellular ion, fluid balance	Unlikely	none

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PART XI

CHAPTER 11. TRACE MINERALS

Introduction

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Liʻiliʻi ka ʻōhiki, loloa ka lua

Small is the crab, large is the hole

Wakame Salad Seaweed Food Cooking by maxpixel.com / CCO

Learning Objectives

By the end of this chapter you will be able to:

- Describe the functional role, intake

recommendations and sources of trace minerals

Trace minerals are classified as minerals required in the diet each day in smaller amounts, specifically 100 milligrams or less. These include copper, zinc, selenium, iodine, chromium, fluoride, manganese, molybdenum, and others. Although trace minerals are needed in smaller amounts it is important to remember that a deficiency in a trace mineral can be just as detrimental to your health as a major mineral deficiency. Iodine deficiency is a major concern in countries around the world such as Fiji. In the 1990's, almost 50% of the population had signs of iodine deficiency also known as goiter. To combat this national issue, the government of Fiji banned non-iodized salt and allowed only fortified iodized salt into the country in hopes of increasing the consumption of iodine in people's diets. With this law, and health promotion efforts encouraging the consumption of seafood, great progress has been made in decreasing the prevalence of iodine deficiency in Fiji.[1]

Figure 11.1 The Trace Minerals

1. Micronutrient Deficiencies. (2015). Ministry of Health and Medical Services, Shaping Fiji's Health. http://www.health.gov.fj/?page_id=1406. Accessed November 12, 2017.

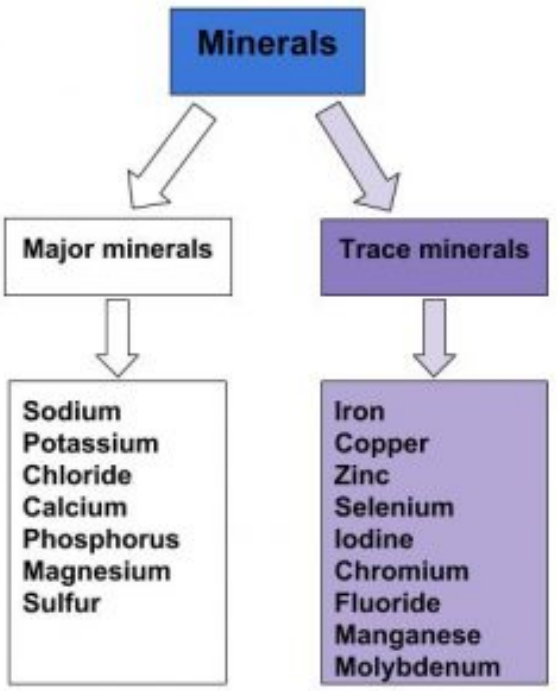

Image by Allison Calabrese / CC BY 4.0

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Iron

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Red blood cells contain the oxygen-carrier protein hemoglobin. It is composed of four globular peptides, each containing a heme complex. In the center of each heme, lies iron (Figure 11.2). Iron is needed for the production of other iron-containing proteins such as myoglobin. Myoglobin is a protein found in the muscle tissues that enhances the amount of available oxygen for muscle contraction. Iron is also a key component of hundreds of metabolic enzymes. Many of the proteins of the electron-transport chain contain iron–sulfur clusters involved in the transfer of high-energy electrons and ultimately ATP synthesis. Iron is also involved in numerous metabolic reactions that take place mainly in the liver and detoxify harmful substances. Moreover, iron is required for DNA synthesis. The great majority of iron used in the body is that recycled from the continuous breakdown of red blood cells.

Figure 11.2 The Structure of Hemoglobin

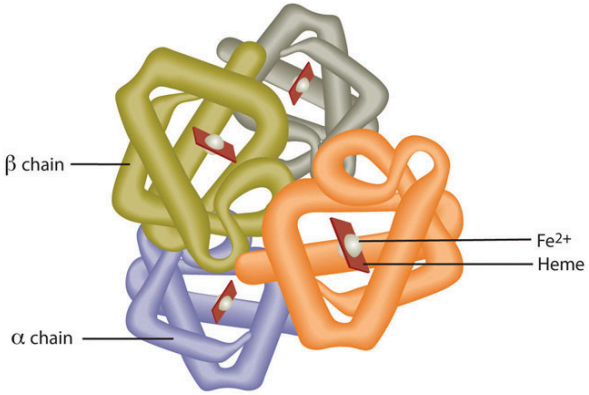

Image by Allison Calabrese / CC BY 4.0

Hemoglobin is composed of four peptides. Each contains a heme group with iron in the center.

The iron in hemoglobin binds to oxygen in the capillaries of the lungs and transports it to cells where the oxygen is released. If iron level is low hemoglobin is not synthesized in sufficient amounts and the oxygen-carrying capacity of red blood cells is reduced, resulting in anemia. When iron levels are low in the diet the small intestine more efficiently absorbs iron in an attempt to compensate for the low dietary intake, but this process cannot make up for the excessive loss of iron that occurs with chronic blood loss or low intake. When blood cells are decommissioned for use, the body recycles the iron back to the bone marrow where red blood cells are made. The body stores some iron in the bone marrow, liver, spleen, and skeletal muscle. A relatively small amount of iron is excreted when cells lining the small intestine and skin cells die and in blood loss, such as during menstrual bleeding. The lost iron must be replaced from dietary sources.

The bioavailability of iron is highly dependent on dietary sources. In animal-based foods about 60 percent of iron is bound to hemoglobin, and heme iron is more bioavailable than nonheme iron. The other 40 percent of iron in animal-based foods is nonheme, which is the only iron source in plant-based foods. Some plants contain chemicals (such as phytate, oxalates, tannins, and polyphenols) that inhibit iron absorption. Although, eating fruits and vegetables rich in vitamin C at the same time as iron-containing foods markedly increases iron absorption. A review in the American Journal of Clinical Nutrition reports that in developed countries iron bioavailability from mixed diets ranges between 14 and 18 percent, and that from vegetarian diets ranges between 5 and 12 percent.[1]

1. Centers for Disease Control and Prevention. “Iron and Iron Deficiency.” Accessed October 2, 2011.

Vegans are at higher risk for iron deficiency, but careful meal planning does prevent its development. Iron deficiency is the most common of all micronutrient deficiencies.

Table 11.1 Enhancers and Inhibitors of Iron Absorption

Enhancer	Inhibitor
Meat	Phosphate
Fish	Calcium
Poultry	Tea
Seafood	Coffee
Stomach acid	Colas
	Soy protein
	High doses of minerals (antacids)
	Bran/fiber
	Phytates
	Oxalates
	Polyphenols

Figure 11.3 Iron Absorption, Functions, and Loss

http://www.cdc.gov/nutrition/everyone/basics/vitamins/iron.html.

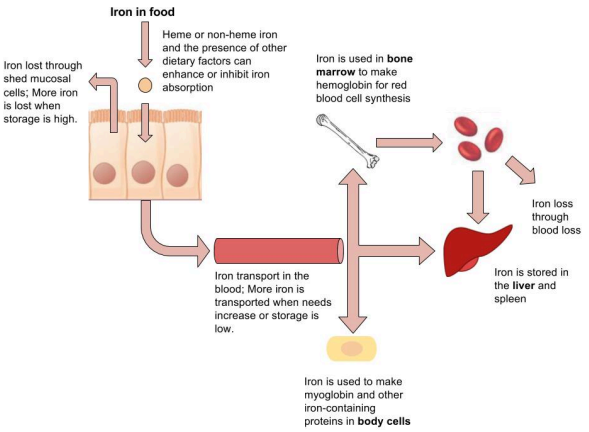

Image by Allison Calabrese / CC BY 4.0

Iron Toxicity

The body excretes little iron and therefore the potential for accumulation in tissues and organs is considerable. Iron accumulation in certain tissues and organs can cause a host of health problems in children and adults including extreme fatigue, arthritis, joint pain, and severe liver and heart toxicity. In children, death has occurred from ingesting as little as 200 mg of iron and therefore it is critical to keep iron supplements out of children's reach. The IOM has set tolerable upper intake levels of iron (Table 11.2 "Dietary Reference Intakes for Iron"). Mostly a hereditary disease, hemochromatosis is the result of a genetic mutation that leads to abnormal iron metabolism and an accumulation of iron in certain tissues such as the liver, pancreas, and heart. The signs and symptoms of hemochromatosis are similar to those of iron overload

in tissues caused by high dietary intake of iron or other non-genetic metabolic abnormalities, but are often increased in severity.

Dietary Reference Intakes for Iron

Table 11.2 Dietary Reference Intakes for Iron

Age Group	RDA(mg/day)	UL(mg/day)
Infant (0–6 months)	0.27*	40
Infants (6–12 months)	11*	40
Children (1–3 years)	7	40
Children (4–8 years)	10	40
Children (9–13 years)	8	40
Adolescents (14–18 years)	11 (males), 15 (females)	45
Adults (19–50 years)	8 (males), 18 (females)	45
Adults (> 50 years)	8	45
* denotes Adequate Intake		

Dietary Sources of Iron

Table 11.3 Iron Content of Various Foods

Food	Serving	Iron (mg)	Percent Daily Value
Breakfast cereals, fortified	1 serving	18	100
Oysters	3 oz.	8	44
Dark chocolate	3 oz.	7	39
Beef liver	3 oz.	5	28
Lentils	½ c.	3	17
Spinach, boiled	½ c.	3	17
Tofu, firm	½ c.	3	17
Kidney beans	½ c.	2	11
Sardines	3 oz.	2	11

Iron-Deficiency Anemia

Iron-deficiency anemia is a condition that develops from having insufficient iron levels in the body resulting in fewer and smaller red blood cells containing lower amounts of hemoglobin. Regardless of the cause (be it from low dietary intake of iron or via excessive blood loss), iron-deficiency anemia has the following signs and symptoms, which are linked to the essential functions of iron in energy metabolism and blood health:

- Fatigue
- Weakness
- Pale skin
- Shortness of breath
- Dizziness
- Swollen, sore tongue

- Abnormal heart rate

Iron-deficiency anemia is diagnosed from characteristic signs and symptoms and confirmed with simple blood tests that count red blood cells and determine hemoglobin and iron content in blood. Anemia is most often treated with iron supplements and increasing the consumption of foods that are higher in iron. Iron supplements have some adverse side effects including nausea, constipation, diarrhea, vomiting, and abdominal pain. Reducing the dose at first and then gradually increasing to the full dose often minimizes the side effects of iron supplements. Avoiding foods and beverages high in phytates and also tea (which contains tannic acid and polyphenols, both of which impair iron absorption), is important for people who have iron-deficiency anemia. Eating a dietary source of vitamin C at the same time as iron-containing foods improves absorption of nonheme iron in the gut. Additionally, unknown compounds that likely reside in muscle tissue of meat, poultry, and fish increase iron absorption from both heme and nonheme sources. See Table 17.2 "Enhancers and Inhibitors of Iron Absorption" for more enhancers and inhibitors for iron absorption.

Iron Deficiency: A Worldwide Nutritional Health Problem

The Centers for Disease Control and Prevention reports that iron deficiency is the most common nutritional deficiency worldwide.[2] The WHO estimates that 80 percent of people are iron

2. Iron and Iron Deficiency. Centers for Disease Control and Prevention. http://www.cdc.gov/nutrition/

deficient and 30 percent of the world population has iron-deficiency anemia.[3] The main causes of iron deficiency worldwide are parasitic worm infections in the gut causing excessive blood loss, and malaria, a parasitic disease causing the destruction of red blood cells. In the developed world, iron deficiency is more the result of dietary insufficiency and/or excessive blood loss occurring during menstruation or childbirth.

At-Risk Populations

Infants, children, adolescents, and women are the populations most at risk worldwide for iron-deficiency anemia by all causes. Infants, children, and even teens require more iron because iron is essential for growth. In these populations, iron deficiency (and eventually iron-deficiency anemia) can also cause the following signs and symptoms: poor growth, failure to thrive, and poor performance in school, as well as mental, motor, and behavioral disorders. Women who experience heavy menstrual bleeding or who are pregnant require more iron in the diet. One more high-risk group is the elderly. Both elderly men and women have a high incidence of

everyone/basics/vitamins/iron.html.Accessed October 2, 2011.
3. Anemia. The World Bank. http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTHEALTHNUTRITIONANDPOPULATION/EXTPHAAG/0,,contentMDK:20588506~menuPK:1314803~pagePK:64229817~piPK:64229743 ~theSitePK:672263,00.html. Accessed October 2, 2011.

anemia and the most common causes are dietary iron deficiency and chronic disease such as ulcer, inflammatory diseases, and cancer. Additionally, those who have recently suffered from traumatic blood loss, frequently donate blood, or take excessive antacids for heartburn need more iron in the diet.

Preventing Iron-Deficiency Anemia

In young children iron-deficiency anemia can cause significant motor, mental, and behavioral abnormalities that are long-lasting. In the United States, the high incidence of iron-deficiency anemia in infants and children was a major public-health problem prior to the early 1970s, but now the incidence has been greatly reduced. This achievement was accomplished by implementing the screening of infants for iron-deficiency anemia in the health sector as a common practice, advocating the fortification of infant formulas and cereals with iron, and distributing them in supplemental food programs, such as that within Women, Infants, and Children (WIC). Breastfeeding, iron supplementation, and delaying the introduction of cow's milk for at least the first twelve months of life were also encouraged. These practices were implemented across the socioeconomic spectrum and by the 1980s iron-deficiency anemia in infants had significantly declined. Other solutions had to be introduced in young children, who no longer were fed breast milk or fortified formulas and were consuming cow's milk. The following solutions were introduced to parents: provide a diet rich in sources of iron and vitamin C, limit cow's milk consumption to less than twenty-four ounces per day, and a multivitamin containing iron.

In the third world, iron-deficiency anemia remains a significant public-health challenge. The World Bank claims that a million deaths occur every year from anemia and that the majority of those

occur in Africa and Southeast Asia. The World Bank states five key interventions to combat anemia:[4]

- Provide at-risk groups with iron supplements.
- Fortify staple foods with iron and other micronutrients whose deficiencies are linked with anemia.
- Prevent the spread of malaria and treat the hundreds of millions with the disease.
- Provide insecticide-treated bed netting to prevent parasitic infections.
- Treat parasitic-worm infestations in high-risk populations.

Also, there is ongoing investigation as to whether supplying iron cookware to at-risk populations is effective in preventing and treating iron-deficiency anemia.

Learning Activities

Technology Note: The second edition of the Human

4. Anemia. The World Bank. http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTHEALTHNUTRITIONANDPOPULATION/EXTPHAAG/0,,contentMDK:20588506~menuPK:1314803~pagePK:64229817~piPK:64229743~theSitePK:672263,00.html. Accessed October 2, 2011.

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Copper

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Copper, like iron, assists in electron transfer in the electron-transport chain. It is also an enzyme cofactor essential for iron absorption and transport. The other important function of copper is as an antioxidant. It is naturally present in several foods and is generally accessible as a dietary supplement.[1] A typical adult body has a total copper content of 50-120 mg.[2] The body maintains copper level balance through absorption from the intestine and the release of copper by the liver into bile. [3] Current studies indicate that copper deficiency may be more frequent than what was previously discovered, while copper toxicity is rare due to conventional diets. [4] Symptoms of mild to moderate copper

1. Collins JF. Copper. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, eds. Modern Nutrition in Health and Disease. 11th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2014:206-16.
2. Prohaska JR. Copper. In: Erdman JW, Macdonald IA, Zeisel SH, eds. Present Knowledge in Nutrition. 10th ed. Washington, DC: Wiley-Blackwell; 2012:540-53.
3. Institute of Medicine, Food and Nutrition Board. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: National Academies Press; 2001.
4. de Romaña, D. L., Olivares, M., Uauy, R., & Araya, M.

deficiency are uncommon. More severe copper deficiency can cause anemia from the lack of iron mobilization in the body for red blood cell synthesis. Other signs and symptoms include growth retardation in children and neurological problems because copper is a cofactor for an enzyme that synthesizes myelin, which surrounds many nerves.

Dietary Reference Intakes for Copper

Table 1: Dietary Reference Intakes for Copper

(2011). Risks and benefits of copper in light of new insights of copper homeostasis. Journal of Trace Elements in Medicine and Biology: Organ of the Society for Minerals and Trace Elements (GMS), 25(1), 3–13. https://doi.org/10.1016/j.jtemb.2010.11.004

	DRI values (µg/day)
Life stage group	RDA
Infants (0-12 months)	–
Children (1-3 years)	340
Children (4-8 years)	440
Children (9-13 years)	700
Adolescents (14-18 years)	890
Adults (>18 years)	900

[1] Not Determinable

Source:

The National Academies Press (2006). Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. *The National Academies of Sciences Engineering Medicine.*

Dietary Sources of Copper

Copper is distributed in many foods and is abundant in organ meats, seafoods, nuts, and seeds. Wheat bran cereals, whole grains and cocoa products are also good sources of copper. The absorption of copper from foods may be reduced by excess intakes of zinc and the amino acid histidine in addition to high intakes of iron and fructose. Copper is also available as part of other ingredients in a multimineral supplement or by itself in a copper only supplement.

Dietary supplements containing copper typically range from a few micrograms to 15 mg. [5]

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5. Institute of Medicine (US) Panel on Micronutrients. (2001). Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington (DC): National Academies Press (US); 7, Copper.

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Zinc

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Zinc is a cofactor for over two hundred enzymes in the human body and plays a direct role in RNA, DNA, and protein synthesis. Zinc also is a cofactor for enzymes involved in energy metabolism. As the result of its prominent roles in anabolic and energy metabolism, a zinc deficiency in infants and children blunts growth. The reliance of growth on adequate dietary zinc was discovered in the early 1960s in the Middle East where adolescent nutritional dwarfism was linked to diets containing high amounts of phytate. Cereal grains and some vegetables contain chemicals, one being phytate, which blocks the absorption of zinc and other minerals in the gut. It is estimated that half of the world's population has a zinc-deficient diet.[1]

This is largely a consequence of the lack of red meat and seafood in the diet and reliance on cereal grains as the main dietary staple. In adults, severe zinc deficiency can cause hair loss, diarrhea, skin sores, loss of appetite, and weight loss. Zinc is a required cofactor for an enzyme that synthesizes the heme portion of hemoglobin and severely deficient zinc diets can result in anemia.

1. Prasad, Ananda. (2003). Zinc deficiency. *British Medical Journal*, *326*(7386), 409–410. doi: 10.1136/bmj.326.7386.409. Accessed October 2, 2011. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1125304/?tool=pmcentrez.

Dietary Reference Intakes for Zinc

Table 11.4 Dietary Reference Intakes for Zinc

Age Group	RDA(mg/day)	UL(mg/day)
Infant (0–6 months)	2*	4
Infants (6–12 months)	3	5
Children (1–3 years)	3	7
Children (4–8 years)	5	12
Children (9–13 years)	8	23
Adolescents (14–18 years)	11 (males), 9 (females)	34
Adults (19 + years)	11 (males), 8 (females)	40
* denotes Adequate Intake		

Fact Sheet for Health Professionals: Zinc. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/. Updated February 11, 2016. Accessed November 10, 2017.

Dietary Sources of Zinc

Table 11.5 Zinc Content of Various Foods

Food	Serving	Zinc (mg)	Percent Daily Value
Oysters	3 oz.	74	493
Beef, chuck roast	3 oz.	7	47
Crab	3 oz.	6.5	43
Lobster	3 oz.	3.4	23
Pork loin	3 oz.	2.9	19
Baked beans	½ c.	2.9	19
Yogurt, low fat	8 oz.	1.7	11
Oatmeal, instant	1 packet	1.1	7
Almonds	1 oz.	0.9	6

Fact Sheet for Health Professionals: Zinc. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/. Updated February 11, 2016. Accessed November 10, 2017.

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Selenium

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Selenium is a cofactor of enzymes that release active thyroid hormone in cells and therefore low levels can cause similar signs and symptoms as iodine deficiency. The other important function of selenium is as an antioxidant.

Selenium Functions and Health Benefits

Around twenty-five known proteins require selenium to function. Some are enzymes involved in detoxifying free radicals and include glutathione peroxidases and thioredoxin reductase. As an integral functioning part of these enzymes, selenium aids in the regeneration of glutathione and oxidized vitamin C. Selenium as part of glutathione peroxidase also protects lipids from free radicals, and, in doing so, spares vitamin E. This is just one example of how antioxidants work together to protect the body against free-radical induced damage. Other functions of selenium-containing proteins include protecting endothelial cells that line tissues, converting the inactive thyroid hormone to the active form in cells, and mediating inflammatory and immune system responses.

Observational studies have demonstrated that selenium deficiency is linked to an increased risk of cancer. A review of forty-nine observational studies published in the May 2011 issue of the Cochrane Database of Systematic Reviews concluded that higher selenium exposure reduces overall cancer incidence by about 34 percent in men and 10 percent in women, but notes these studies had several limitations, including data quality, bias, and large

differences among different studies.[1] Additionally, this review states that there is no convincing evidence from six clinical trials that selenium supplements reduce cancer risk.

Because of its role as a lipid protector, selenium has been suspected to prevent cardiovascular disease. In some observational studies, low levels of selenium are associated with a decreased risk of cardiovascular disease. However, other studies have not always confirmed this association and clinical trials are lacking.

Figure 11.4 Selenium's Role in Detoxifying Free Radicals

1. Dennert G, Zwahlen M, et al. (2011). Selenium for Preventing Cancer. *Cochrane Database of Systematic Reviews*,5. http://www.ncbi.nlm.nih.gov/pubmed/21563143. Accessed November 22, 2017.

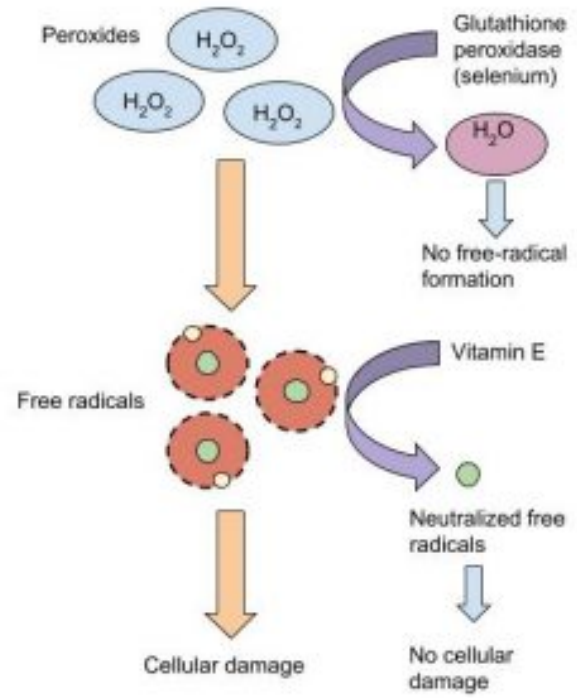

Image by Allison Calabrese / CC BY 4.0

Dietary Reference Intakes for Selenium

The IOM has set the RDAs for selenium based on the amount required to maximize the activity of glutathione peroxidases found in blood plasma. The RDAs for different age groups are listed in Table 11.6 "Dietary Reference Intakes for Selenium".

Table 11.6 Dietary Reference Intakes for Selenium

Age Group	RDA Males and Females mcg/day	UL
Infants (0–6 months)	15*	45
Infants (7–12 months)	20*	65
Children (1–3 years)	20	90
Children (4–8 years)	30	150
Children (9–13 years)	40	280
Adolescents (14–18 years)	55	400
Adults (> 19 years)	55	400
*denotes Adequate Intake		

Selenium at doses several thousand times the RDA can cause acute toxicity, and when ingested in gram quantities can be fatal. Chronic exposure to foods grown in soils containing high levels of selenium (significantly above the UL) can cause brittle hair and nails, gastrointestinal discomfort, skin rashes, halitosis, fatigue, and irritability. The IOM has set the UL for selenium for adults at 400 micrograms per day.

Dietary Sources of Selenium

Organ meats, muscle meats, and seafood have the highest selenium content. Plants do not require selenium, so the selenium content in fruits and vegetables is usually low. Animals fed grains from selenium-rich soils do contain some selenium. Grains and some nuts contain selenium when grown in selenium-containing soils. See Table 11.7 “Selenium Contents of Various Foods” for the selenium content of various foods.

Table 11.7 Selenium Contents of Various Foods

Food	Serving	Selenium (mcg)	Percent Daily Value
Brazil nuts	1 oz.	544	777
Shrimp	3 oz.	34	49
Crab meat	3 oz.	41	59
Ricotta cheese	1 c.	41	59
Salmon	3 oz.	40	57
Pork	3 oz.	35	50
Ground beef	3 oz.	18	26
Round steak	3 oz.	28.5	41
Beef liver	3 oz.	28	40
Chicken	3 oz.	13	19
Whole-wheat bread	2 slices	23	33
Couscous	1 c.	43	61
Barley, cooked	1 c.	13.5	19
Milk, low-fat	1 c.	8	11
Walnuts, black	1 oz.	5	7

Source: US Department of Agriculture, Agricultural Research Service. 2010. USDA National Nutrient Database for Standard Reference, Release 23. http://www.ars.usda.gov/ba/bhnrc/ndl.

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Iodine

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Recall the discovery of iodine and its use as a means of preventing goiter, a gross enlargement of the thyroid gland in the neck. Iodine is essential for the synthesis of thyroid hormone, which regulates basal metabolism, growth, and development. Low iodine levels and consequently hypothyroidism has many signs and symptoms including fatigue, sensitivity to cold, constipation, weight gain, depression, and dry, itchy skin and paleness. The development of goiter may often be the most visible sign of chronic iodine deficiency, but the consequences of low levels of thyroid hormone can be severe during infancy, childhood, and adolescence as it affects all stages of growth and development. Thyroid hormone plays a major role in brain development and growth and fetuses and infants with severe iodine deficiency develop a condition known as cretinism, in which physical and neurological impairment can be severe. The World Health Organization (WHO) estimates iodine deficiency affects over two billion people worldwide and it is the number-one cause of preventable brain damage worldwide.[1]

Figure 11.5 Deaths Due to Iodine Deficiency Worldwide in 2012

1. World Health Organization. “Iodine Status Worldwide.” Accessed October 2, 2011. http://whqlibdoc.who.int/publications/2004/9241592001.pdf.

Image by [Chris55](#) / [CC BY 4.0](#)

Figure 11.6 Iodine Deficiency: Goiter

A large goiter by [Dr. J.S.Bhandari, India](#) / [CC BY-SA 3.0](#)

Dietary Reference Intakes for Iodine

Table 11.8 Dietary Reference Intakes for Iodine

Age Group	RDA Males and Females mcg/day	UL
Infants (0–6 months)	110*	
Infants (7–12 months)	130*	
Children (1–3 years)	90	200
Children (4–8 years)	120	300
Children (9–13 years)	150	600
Adolescents (14–18 years)	150	900
Adults (> 19 years)	150	1,100
*denotes Adequate Intake		

Health Professional Fact Sheet: Iodine. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Iodine-HealthProfessional/. Updated June 24, 2011. Accessed November 10, 2017.

Dietary Sources of Iodine

The mineral content of foods is greatly affected by the soil from which it grew, and thus geographic location is the primary determinant of the mineral content of foods. For instance, iodine comes mostly from seawater so the greater the distance from the sea the lesser the iodine content in the soil.

Table 11.9 Iodine Content of Various Foods

Food	Serving	Iodine (mcg)	Percent Daily Value
Seaweed	1 g.	16 to 2,984	11 to 1,989
Cod fish	3 oz.	99	66
Yogurt, low fat	8 oz.	75	50
Iodized salt	1.5 g.	71	47
Milk, reduced fat	8 oz.	56	37
Ice cream, chocolate	½ c.	30	20
Egg	1 large	24	16
Tuna, canned	3 oz.	17	11
Prunes, dried	5 prunes	13	9
Banana	1 medium	3	2

Health Professional Fact Sheet: Iodine. National Institute of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Iodine-HealthProfessional/. Updated June 24, 2011. Accessed November 10, 2017.

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Chromium

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The functioning of chromium in the body is less understood than that of most other minerals. It enhances the actions of insulin so it plays a role in carbohydrate, fat, and protein metabolism. Currently, the results of scientific studies evaluating the usefulness of chromium supplementation in preventing and treating Type 2 diabetes are largely inconclusive. More research is needed to better determine if chromium is helpful in treating certain chronic diseases and, if so, at what doses. If a deficiency of chromium occurs in the body, signs and symptoms include weight loss, peripheral neuropathy, elevated plasma glucose concentrations or impaired glucose use, and high plasma free fatty acid concentrations. Although toxicity of the mineral is a low risk in humans, it can cause DNA damage, organ damage, and renal problems. Tissues that are high in chromium include the liver, spleen, and bone.[1]

Dietary Reference Intakes for Chromium

The recommended intake for chromium is 35 mcg per day for adult males and 25 mcg per day for adult females. There is insufficient evidence to establish an UL for chromium.

1. Gropper, S. A. S., Smith, J. L., & Carr, T. P. (2018). Advanced nutrition and human metabolism. Boston, MA: Cengage Learning.

Table 1: Dietary Reference Intakes for Chromium

Age Group	AI (µg/day)
Infants (0-6 months)	0.2
Infants (6-12 months)	5.5
Children (1-3 years)	11
Children (4-8 years)	15
Children (9-13 years)	25 (males), 21 (females)
Adolescents (14-18 years)	35 (males), 24 (females)
Adults (19-50 years)	35 (males), 25 (females)
Adults (>50 years)	30 (males), 20 (females)

Source: The National Academies Press (2006). Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. *The National Academies of Sciences Engineering Medicine*. 296.

Dietary Sources For Chromium:

Dietary sources of chromium include meats, nuts, and whole grains. [2]. Accessed December 5, 2019.

2. Anderson, R. A., Bryden, N. A., & Polansky, M. M. (1992). Dietary chromium intake. Freely chosen diets, institutional diet, and individual foods. *Biological Trace Element Research*, *32*, 117–121. https://doi.org/10.1007/bf02784595

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Manganese

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Manganese is a cofactor for enzymes that are required for carbohydrate and cholesterol metabolism, bone formation, and the synthesis of urea. Those who suffer from liver failure are at greater risk for manganese toxicity because the mineral's homeostasis is maintained largely by the liver with excretion of excess manganese occurring via bile. Manganese deficiency is uncommon. If a deficiency occurs from elimination from the diet, signs and symptoms include but are not limited to nausea, vomiting, dermatitis, decreased growth of hair and nails, and poor bone formation and skeletal defects.[1]

Dietary Reference Intake of Manganese

The recommended intake for manganese is 2.3 mg per day for adult males and 1.8 mg per day for adult females. The Tolerable Upper Intake Level for adults is 11 mg/day.

1. Gropper, S. A. S., Smith, J. L., & Carr, T. P. (2018). Advanced nutrition and human metabolism. Boston, MA: Cengage Learning.

Table 1: Dietary Reference Intakes for Manganese

Age group	AI (mg/day)	UL (mg/day)
Infants (0-6 months)	0.003	–
Infants (6-12 months)	0.6	–
Children (1-3 years)	1.2	2
Children (4-8 years)	1.5	3
Children (9-13 years)	1.9	6
Adolescents (14-18 years)	2.2 (males), 1.6 (females)	9
Adults (>18 years)	2.3 (males), 1.8 (females)	11

Source: The National Academies Press (2006). Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. The National Academies of Sciences Engineering Medicine. 350.

Dietary Sources of Manganese:

The best food sources for manganese are whole grains, nuts, legumes, and green vegetables.

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Molybdenum

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Molybdenum also acts as a cofactor that is required for the metabolism of sulfur-containing amino acids, nitrogen-containing compounds found in DNA and RNA, and various other functions. Deficiency of molybdenum is not seen in healthy people, however, a rare metabolic effect called molybdenum cofactor deficiency is the result of an insufficient amount of molybdoenzymes in the body. Due to rapid excretion rates in the urine of the mineral, molybdenum toxicity is low in humans.

Dietary Reference Intakes of Molybdenum:

The recommended intake for molybdenum is 45 mcg per day for both adult males and females.

Table 1: Dietary Reference Intakes for Molybdenum

Age group	RDA (µg/day)	UL (µg/day)
Infants (0-6 months)		–
Infants (6-12 months)		–
Children (1-3 years)	17	300
Children (4-8 years)	22	600
Children (9-13 years)	34	1,100
Adolescents (14-18 years)	43	1,700
Adults (19-50 years)	45	2,000
Adults (51-70 years)	45	2,000
Adults (>71 years)	45	2,000

Source: The National Academies Press (2006). Dietary Reference

Intakes: The Essential Guide to Nutrient Requirements. The National Academies of Sciences Engineering Medicine. 356.

Dietary Sources of Molybdenum:

The food sources of molybdenum varies depending on the content in the soil in the specific region. Legumes, grain products, and nuts are rich sources of dietary molybdenum. Animal products, fruits, and most vegetables are low in molybdenum.[1]

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1. Gropper, S. A. S., Smith, J. L., & Carr, T. P. (2018). Advanced nutrition and human metabolism. Boston, MA: Cengage Learning.

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Fluoride

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Fluoride's Functional Role

Fluoride is known mostly as the mineral that combats tooth decay. It assists in tooth and bone development and maintenance. Fluoride combats tooth decay via three mechanisms:

1. Blocking acid formation by bacteria
2. Preventing demineralization of teeth
3. Enhancing remineralization of destroyed enamel

Fluoride was first added to drinking water in 1945 in Grand Rapids, Michigan; now over 60 percent of the US population consumes fluoridated drinking water. The Centers for Disease Control and Prevention (CDC) has reported that fluoridation of water prevents, on average, 27 percent of cavities in children and between 20 and 40 percent of cavities in adults. The CDC considers water fluoridation one of the ten great public health achievements in the twentieth century[1].

The optimal fluoride concentration in water to prevent tooth

1. 10 Great Public Health Achievements in the 20th Century. (1999). *Centers for Disease Control, Morbidity and Mortality Weekly Report*, 48(12), 241–43. http://www.cdc.gov/about/history/tengpha.htm. Accessed November 22, 2017.

decay ranges between 0.7–1.2 milligrams per liter. Exposure to fluoride at three to five times this concentration before the growth of permanent teeth can cause fluorosis, which is the mottling and discoloring of the teeth.

Figure 11.7 A Severe Case of Fluorosis

Bellingham fluorosis by Editmore / Public Domain

Fluoride's benefits to mineralized tissues of the teeth are well substantiated, but the effects of fluoride on bone are not as well known. Fluoride is currently being researched as a potential treatment for osteoporosis. The data are inconsistent on whether consuming fluoridated water reduces the incidence of osteoporosis and fracture risk. Fluoride does stimulate osteoblast bone building activity, and fluoride therapy in patients with osteoporosis has been shown to increase BMD. In general, it appears that at low doses, fluoride treatment increases BMD in people with osteoporosis and is more effective in increasing bone quality when the intakes of calcium and vitamin D are adequate. The Food and Drug Administration has not approved fluoride for the treatment of osteoporosis mainly because its benefits are not sufficiently known and it has several side effects including frequent stomach upset and joint pain. The doses of fluoride used to treat osteoporosis are much greater than that in fluoridated water.

Dietary Reference Intake

The IOM has given Adequate Intakes (AI) for fluoride, but has not yet developed RDAs. The AIs are based on the doses of fluoride shown to reduce the incidence of cavities, but not cause dental fluorosis. From infancy to adolescence, the AIs for fluoride increase from 0.01 milligrams per day for ages less than six months to 2 milligrams per day for those between the ages of fourteen and eighteen. In adulthood, the AI for males is 4 milligrams per day and for females is 3 milligrams per day. The UL for young children is set at 1.3 and 2.2 milligrams per day for girls and boys, respectively. For adults, the UL is set at 10 milligrams per day.

Table 11.10 Dietary Reference Intakes for Fluoride

Age Group	AI (mg/day)	UL (mg/day)
Infants (0–6 months)	0.01	0.7
Infants (6–12 months)	0.50	0.9
Children (1–3 years)	0.70	1.3
Children (4–8 years)	1.00	2.2
Children (9–13 years)	2.00	10.0
Adolescents (14–18 years)	3.00	10.0
Adult Males (> 19 years)	4.00	10.0
Adult Females (> 19 years)	3.00	10.0

Source: Institute of Medicine. (1997). *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.* . http://www.iom.edu/Reports/1997/Dietary-Reference-Intakes-for-Calcium-Phosphorus-Magnesium-Vitamin-D-and-Fluoride.aspx.

Dietary Sources of Fluoride

Greater than 70 percent of a person's fluoride comes from drinking fluoridated water when they live in a community that fluoridates the drinking water. Other beverages with a high amount of fluoride include teas and grape juice. Solid foods do not contain a large amount of fluoride. Fluoride content in foods depends on whether it was grown in soils and water that contained fluoride or cooked with fluoridated water. Canned meats and fish that contain bones do contain some fluoride.

Table 11.11 Fluoride Content of Various Foods

Food	Serving	Fluoride (mg)	Percent Daily Value*
Fruit Juice	3.5 fl oz.	0.02-2.1	0.7-70
Crab, canned	3.5 oz.	0.21	7
Rice, cooked	3.5 oz.	0.04	1.3
Fish, cooked	3.5 oz.	0.02	0.7
Chicken	3.5 oz.	0.015	0.5
* Current AI used to determine Percent Daily Value			

Micronutrient Information Center: Fluoride. Oregon State University, Linus Pauling Institute. lpi.oregonstate.edu/mic/minerals/fluoride . Updated in April 29, 2015. Accessed October 22, 2017.

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Summary of Trace Minerals

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Table 11.12 Summary of the Trace Minerals

Micronutrient	Sources	Recommended Intakes for adults	Major Functions	Deficiency diseases and symptoms	G ri d
Iron	Red meat, egg yolks, dark leafy vegetables, dried fruit, iron-fortified foods	8-18 mg/day	Assists in energy production, DNA synthesis required for red blood cell function	Anemia: fatigue, paleness, faster heart rate	In pr ch ac w pr w at ve
Copper	Nuts, seeds, whole grains, seafood	900 mcg/day	Assists in energy production, iron metabolism	Anemia: fatigue, paleness, faster heart rate	Th co ex zi su
Zinc	Oysters, wheat germ, pumpkin seeds, squash,, beans, sesame seeds, tahini, beef, lamb	8-11 mg/day	Assists in energy production, protein, RNA and DNA synthesis; required for hemoglobinsynthesis	Growth retardation in children, hair loss, diarrhea, skin sores, loss of appetite, weight loss	Ve ol
Selenium	Meat, seafood, eggs, nuts	55 mcg/day	Essential for thyroid hormone activity	Fatigue, muscle pain, weakness, Keshan disease	Po w so se
Iodine	Iodized salt, seaweed, dairy products	150 mcg/day	Making thyroid hormone, metabolism, growth and development	Goiter, cretinism, other signs and symptoms include fatigue, depression, weight gain, itchy skin, low heart-rate	Po w so io io no
Chromium	Meats, nuts and whole grain	25-35 mcg/ day	Assists insulin in carbohydrate, lipid and protein metabolism	abnormal glucose metabolism	M ch

Fluoride	Fluoridated water, foods prepared in fluoridated water, seafood	3-4 mg/day	Component of mineralized bone, provides structure and microarchitecture, stimulates new bone growth	Increased risk of dental caries	Po w fl w
Manganese	Legumes, nuts, leafy green vegetables	1.8-2.3 mg/ day	Glucose synthesis, amino-acid catabolism	Impaired growth, skeletal abnormalities, abnormal glucose metabolism	N
Molybdenum	Milk, grains, legumes	45 mcg/day	Cofactor for a number of enzymes	Unknown	N

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PART XII

CHAPTER 12. NUTRITION APPLICATIONS

Introduction

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Pū'ali kalo i ka we 'ole

Taro, for lack of water, grows misshapen.

North Shore Taro by [*Richard Doyle*](#) / [CC BY-NC 3.0](#)

Learning Objectives

By the end of this chapter you will be able to:

- Describe the purpose and function of nutrition recommendations
- Describe steps towards building healthy eating patterns
- Interpret the Nutrition Facts labels found on food items
- Describe the purpose and use of the MyPlate Planner, the Secretariat of the Pacific Community (SPC) Guidelines and the Pacific Food Guide

Developing a healthful diet can be rewarding, but be mindful that all of the principles presented must be followed to derive maximal health benefits. For example, many Pacific Islanders have been unable to maintain their traditional diets for various environmental, social and demographic reasons. This has resulted in diets high in a variety of high-calorie, nutrient-poor foods. Frequent inadequate and/or excessive nutrient intake can lead to many health issues in a community such as obesity, diabetes, heart disease and cancer. Therefore, it is important to employ moderation and portion control by using all of the principles together to afford you lasting health benefits[1].

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1. Pacific Food Summit: Factsheet. (2010). *World Health Organization*. http://www.wpro.who.int/mediacentre/factsheets/fs14042010/en/. Accessed November 28, 2017.

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Understanding Dietary Reference Intakes

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Dietary Reference Intakes (DRI) are the recommendation levels for specific nutrients and consist of a number of different types of recommendations. This DRI system is used in both the United States and Canada.

Dietary Reference Intakes: A Brief Overview

"Dietary Reference Intakes" (DRI) is an umbrella term for four reference values:

- Estimated Average Requirements (EAR)
- Recommended Dietary Allowances (RDA)
- Adequate Intakes (AI)
- Tolerable Upper Intake Levels (UL)

The DRIs are not minimum or maximum nutritional requirements and are not intended to fit everybody. They are to be used as guides only for the majority of the healthy population[1].

1. Deng S, West BJ, Jensen CJ. (2010). A Quantitative Comparison of Phytochemical Components in Global Noni Fruits and Their Commercial Products. *Food*

DRIs are important not only to help the average person determine whether their intake of a particular nutrient is adequate, they are also used by health-care professionals and policy makers to determine nutritional recommendations for special groups of people who may need help reaching nutritional goals. This includes people who are participating in programs such as the Special Supplemental Food Program for Women, Infants, and Children. The DRI is not appropriate for people who are ill or malnourished, even if they were healthy previously.

Determining Dietary Reference Intakes

Each DRI value is derived in a different way. See below for an explanation of how each is determined:

1. **Estimated Average Requirements.** The EAR for a nutrient is determined by a committee of nutrition experts who review the scientific literature to determine a value that meets the requirements of 50 percent of people in their target group within a given life stage and for a particular sex. The requirements of half of the group will fall below the EAR and the other half will be above it. It is important to note that, for each nutrient, a specific bodily function is chosen as the criterion on which to base the EAR. For example, the EAR for calcium is set using a criterion of maximizing bone health. Thus, the EAR for calcium is set at a point that will meet the needs, with respect to bone health, of half of the population.

Chemistry, *122*(1), 267–70. http://www.sciencedirect.com/science/article/pii/S0308814610001111. Accessed December 4, 2017.

EAR values become the scientific foundation upon which RDA values are set.

2. **Recommended Daily Allowances.** Once the EAR of a nutrient has been established, the RDA can be mathematically determined. While the EAR is set at a point that meets the needs of half the population, RDA values are set to meet the needs of the vast majority (97 to 98 percent) of the target healthy population. It is important to note that RDAs are not the same thing as individual nutritional requirements. The actual nutrient needs of a given individual will be different than the RDA. However, since we know that 97 to 98 percent of the population's needs are met by the RDA, we can assume that if a person is consuming the RDA of a given nutrient, they are most likely meeting their nutritional need for that nutrient. The important thing to remember is that the RDA is meant as a recommendation and meeting the RDA means it is very likely that you are meeting your actual requirement for that nutrient.

Understanding the Difference

There is a distinct difference between a requirement and a recommendation. For instance, the DRI for vitamin D is a recommended 600 international units each day. However, in order to find out your true personal requirements for vitamin D, a blood test is necessary. The blood test will provide an accurate reading from which a medical professional can gauge your required daily vitamin D amounts. This may be considerably more or less than the DRI, depending on what your level actually is.

1. **Adequate Intake.** AIs are created for nutrients when there is insufficient consistent scientific evidence to set an EAR for the entire population. As with RDAs, AIs can be used as nutrient-intake goals for a given nutrient. For example, there has not

been sufficient scientific research into the particular nutritional requirements for infants. Consequently, all of the DRI values for infants are AIs derived from nutrient values in human breast milk. For older babies and children, AI values are derived from human milk coupled with data on adults. The AI is meant for a healthy target group and is not meant to be sufficient for certain at-risk groups, such as premature infants.

2. **Tolerable Upper Intake Levels.** The UL was established to help distinguish healthful and harmful nutrient intakes. Developed in part as a response to the growing usage of dietary supplements, ULs indicate the highest level of continuous intake of a particular nutrient that may be taken without causing health problems. When a nutrient does not have any known issue if taken in excessive doses, it is not assigned a UL. However, even when a nutrient does not have a UL it is not necessarily safe to consume in large amounts.

Figure 12.1 DRI Graph

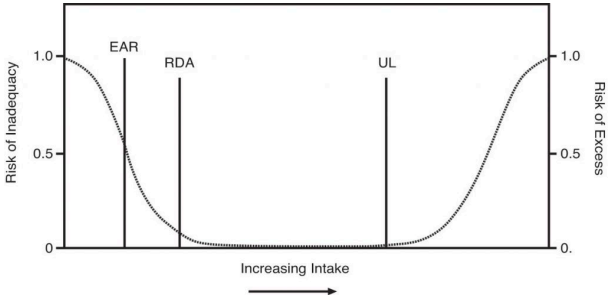

Image by Allison Calabrese / CC BY 4.0

This graph illustrates the risks of nutrient inadequacy and nutrient excess as we move from a low intake of a nutrient to a high intake. Starting on the left side of the graph, you can see that when you have a very low intake of a nutrient, your risk of nutrient deficiency is high. As your nutrient intake increases, the chances that you will be deficient in that nutrient decrease. The point at which 50

percent of the population meets their nutrient need is the EAR, and the point at which 97 to 98 percent of the population meets their needs is the RDA. The UL is the highest level at which you can consume a nutrient without it being too much—as nutrient intake increases beyond the UL, the risk of health problems resulting from that nutrient increases.

Source: Dietary Reference Intakes Tables and Application. The National Academies of Science, Engineering, and Medicine. Health and Medicine Division. http://nationalacademies.org/HMD/Activities/Nutrition/SummaryDRIs/DRI-Tables.aspx. Accessed November 22, 2017.

The Acceptable Macronutrient Distribution Range (AMDR) is the calculated range of how much energy from carbohydrates, fats, and protein is recommended for a healthy diet adequate of the essential nutrients and is associated with a reduced risk of chronic disease. The ranges listed in Table 12.1 "Acceptable Macronutrient Distribution Ranges (AMDR) For Various Age Groups" allows individuals to personalize their diets taking into consideration that different subgroups in a population often require different requirements. The DRI committee recommends using the midpoint of the AMDRs as an approach to focus on moderation[2].

Table 12.1 Acceptable Macronutrient Distribution Ranges (AMDR) For Various Age Groups

2. Dietary Reference Intakes Tables and Application. The National Academies of Science, Engineering, and Medicine. Health and Medicine Division. http://nationalacademies.org/HMD/Activities/Nutrition/SummaryDRIs/DRI-Tables.aspx. Accessed November 22, 2017.

Age Group	Protein (%)	Carbohydrates (%)	Fat (%)
Children (1–3)	5–20	45–65	30–40
Children and Adolescents (4–18)	10–30	45–65	25–35
Adults (>19)	10–35	45–65	20–35

Source: Food and Nutrition Board of the Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. http://www.nationalacademies.org/hmd/~/media/Files/Activity%20Files/Nutrition/DRI-Tables/8_Macronutrient%20Summary.pdf?la=en. Published 2002. Accessed November 22, 2017.

Tips for Using the Dietary Reference Intakes to Plan Your Diet

You can use the DRIs to help assess and plan your diet. Keep in mind when evaluating your nutritional intake that the values established have been devised with an ample safety margin and should be used as guidance for optimal intakes. Also, the values are meant to assess and plan average intake over time; that is, you don't need to meet these recommendations every single day—meeting them on average over several days is sufficient.

Learning Activities

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Discovering Nutrition Facts

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The Labels on Your Food

Understanding the significance of dietary guidelines and how to use DRIs in planning your nutrient intakes can make you better equipped to select the right foods the next time you go to the supermarket.

In the United States, the Nutrition Labeling and Education Act (NLEA) passed in 1990 and came into effect in 1994. In Canada, mandatory labeling came into effect in 2005. As a result, all packaged foods sold in the United States and Canada must have nutrition labels that accurately reflect the contents of the food products. There are several mandated nutrients and some optional ones that manufacturers or packagers include.

In May, 2016 a new Nutrition Facts label for packaged foods, beverages and dietary supplements was announced. This label reflects new scientific information and will make it easier for consumers to make informed food choices. Some of the changes made to the label include:

- Increased type size for “Calories,” “servings per container,” and “Serving size.”
- Bolded type for the number of calories and the “Serving size.”
- Actual amounts of vitamin D, calcium, iron, and potassium (in addition to the Daily Value amounts) are required to be listed. Vitamins A and C are now voluntary.
- Improved footnote to better explain that the Daily Value is based on a 2,000 calories a day diet.

- Changed “Sugars” to “Total Sugars”. Added “Includes” to clarify that “added sugars” is a subcomponent of “total sugars.”
- “Added sugars” in grams and percent Daily Value are required to be listed due to scientific data the impact of added sugars on caloric intake. Added sugars are either added during processing of foods, or are packaged as such, and include items such as: syrups, maltose, and invert sugar.
- “Total Fat,” “Saturated Fat,” “Trans Fat,” “Cholesterol,” “Total Carbohydrates” are still required on the label.
- “Calories from fat” has been removed because the type of fat is important.
- Updated values for sodium, dietary fiber, and vitamin D (which are all required on the label) based on newer scientific research.
- Updated serving sizes that reflect how much consumers are more likely eating today.
- Some packages with serving sizes between one and two are required to be labelled as one serving since most consumers will likely eat it in one sitting
- Dual columns for certain products that are larger than a single serving but could be consumed in one sitting will indicate “per serving” and “per package” amounts.
- Percent DV of some nutrients were updated due to newly available scientific data.
- The compliance date for manufacturers to adopt the new label was extended to January 1, 2020. Manufacturers with less than $10 million in annual food sales will have until January 1, 2021.

Reading the Label

The first part of the Nutrition Facts panel gives you information on the serving size and how many servings are in the container. For example, a label on a box of crackers might tell you that twenty

crackers equals one serving and that the whole box contains 10 servings. All other values listed thereafter, from the calories to the dietary fiber, are based on this one serving. On the panel, the serving size is followed by the number of calories and then a list of selected nutrients. You will also see "Percent Daily Value" on the far right-hand side. This helps you determine if the food is a good source of a particular nutrient or not.

The Daily Value (DV) represents the recommended amount of a given nutrient based on the RDA of that nutrient in a 2,000-kilocalorie diet. The DV was updated as part of the new nutrition facts label announced in May 2016. The updated DV applies to packaged food, beverages and dietary supplements that contain ingredients with a DV. The percentage of Daily Value (percent DV) represents the proportion of the total daily recommended amount that you will get from one serving of the food. For example, in the older food label in Figure 12.2 "Reading the Older Nutrition Label," the percent DV of calcium for one serving of macaroni-and-cheese is 20 percent, which means that one serving of macaroni and cheese provides 20 percent of the daily recommended calcium intake. Since the DV for calcium is 1,300 milligrams, the food producer determined the percent DV for calcium by taking the calcium content in milligrams in each serving, and dividing it by 1,300 milligrams, and then multiplying it by 100 to get it into percentage format. Whether you consume 2,000 calories per day or not you can still use the percent DV as a target reference.

Generally, a percent DV of 5 is considered low and a percent DV of 20 is considered high. This means, as a general rule, for fat, saturated fat, trans fat, cholesterol, or sodium, look for foods with a low percent DV. Alternatively, when concentrating on essential mineral or vitamin intake, look for a high percent DV. To figure out your fat allowance remaining for the day after consuming one serving of macaroni-and-cheese, look at the percent DV for fat, which is 18 percent, and subtract it from 100 percent. To know this amount in grams of fat, read the footnote of the food label to find that the recommended maximum amount of fat grams to consume

per day for a 2,000 kilocalories per day diet is 65 grams. Eighteen percent of sixty-five equals about 12 grams. This means that 53 grams of fat are remaining in your fat allowance. Remember, to have a healthy diet the recommendation is to eat less than this amount of fat grams per day, especially if you want to lose weight.

Table 12.2 Updated DVs Based on a Caloric Intake of 2,000 Calories (For Adults and Children Four or More Years of Age)

Nutrient	Original DV
Total Fat	65 g
Saturated Fat	20 g
Cholesterol	300 mg
Sodium	2400 mg
Potassium	3500 mg
Total Carbohydrate	300 g
Dietary Fiber	25 g
Protein	50 g
Vitamin A	5000 IU
Vitamin C	60 mg
Calcium	1000 mg

Iron	18 mg
Vitamin D	400 IU
Vitamin E	30 IU
Vitamin K	80 µg
Thiamin	1.5 mg
Riboflavin	1.7 mg
Niacin	20 mg
Vitamin B6	2 mg
Folate/Folic Acid	400 µg
Vitamin B12	6 µg
Biotin	300 µg
Pantothenic Acid	10 mg

Phosphorus	1000 mg
Iodine	150 µg
Magnesium	400 mg
Zinc	15 mg
Selenium	70 µg
Copper	2 mg
Manganese	2 mg
Chromium	120 µg
Molybdenum	75 µg
Chloride	3400 mg
	New Daily Values
Nutrient	Original DV

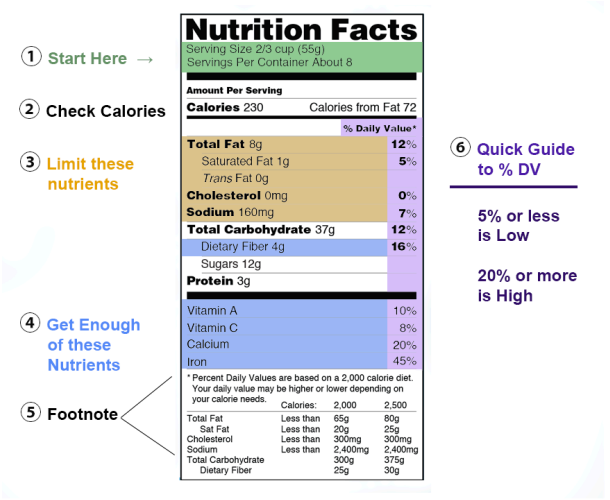
Added sugars	–
Choline	–

[1] %DV in the nutrition facts label will be reflected on January 1, 2020. Manufacturers with less than $10 million in annual food sales have until January 1, 2021 to comply.
[2] Indicates a unit of measure change.
[3] The DV decrease for vitamin E applies for natural forms of vitamin E in foods/supplements but not for the synthetic form. Food/supplement containing only the synthetic form of vitamin E, the DV is increased.
[4] The DV decrease for folate/folic acid applies only to foods/supplements with folic acid or a mixture of folic acid and naturally occuring folate. The original and updated DV is the same for foods/supplements containing only naturally occurring folate.

Units of Measure Key:
g = grams
mg = milligrams
µg = micrograms
mg NE = milligrams of niacin equivalents
µg DFE = micrograms of dietary folate equivalents
µg RAE = micrograms of retinol activity equivalents
IU = international units

Source: FDA. (2020). Daily Value on the New Nutrition and Supplement Facts Labels. https://www.fda.gov/food/new-nutrition-facts-label/daily-value-new-nutrition-and-supplement-facts-labels

Figure 12.2 Reading the Older Nutrition Label



Guide for reading older Nutrition Facts label

Adapted from: Image by FDA/Side by Side Comparison of Old and New Nutrition Facts Label

Of course, this is a lot of information to put on a label and some products are too small to accommodate it all. In the case of small packages, such as small containers of yogurt, candy, or fruit bars, permission has been granted to use an abbreviated version of the Nutrition Facts panel. To learn additional details about all of the information contained within the Nutrition Facts panel, see the following website: http://www.fda.gov/Food/ResourcesForYou/Consumers/NFLPM/ucm274593.htm

Original vs. New Format – Infographics to Help Understand the Changes

Figure 12.3 The Original vs. New Nutrition Facts Label

Image by FDA/Side by Side Comparison of Old and New Nutrition Facts Label

Figure 12.4 The New Nutrition Facts Label

Image by FDA/ Changes to the Nutrition Facts Label

Figure 12.5 Food Serving Sizes

Image by FDA/ [Changes to the Nutrition Facts Label]

Source: https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm

There are other types of information that are required by law to appear somewhere on the consumer packaging. They include[1]:

- Name and address of the manufacturer, packager, or distributor
- Statement of identity, what the product actually is
- Net contents of the package: weight, volume, measure, or numerical count
- Ingredients, listed in descending order by weight

The Nutrition Facts panel provides a wealth of information about the nutritional content of the product. The information also allows shoppers to compare products. Because the serving sizes are included on the label, you can see how much of each nutrient is in each serving to make the comparisons. Knowing how to read the label is important because of the way some foods are presented. For example, a bag of peanuts at the grocery store may seem like a healthy snack to eat on the way to class. But have a look at that label. Does it contain one serving, or multiple servings? Unless you are buying the individual serving packages, chances are the bag you picked up is at least eight servings, if not more.

According to the 2010 health and diet survey released by the FDA, 54 percent of first-time buyers of a product will check the food label and will use this information to evaluate fat, calorie, vitamin, and sodium content[2]. The survey also notes that more Americans

1. Food Labeling. US Food and Drug Administration. https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm#highlights. Updated November 11, 2017. Accessed November 22, 2017.
2. Consumer Research on Labeling, Nutrition, Diet and Health. US Food and Drug Administration.

are using food labels and are showing an increased awareness of the connection between diet and health. Having reliable food labels is a top priority of the FDA, which has a new initiative to prepare guidelines for the food industry to construct "front of package" labeling that will make it even easier for Americans to choose healthy foods. Stay tuned for the newest on food labeling by visiting the FDA website: https://www.fda.gov/food/nutrition-education-resources-materials/new-nutrition-facts-label

Claims on Labels

In addition to mandating nutrients and ingredients that must appear on food labels, any nutrient content claims must meet certain requirements. For example, a manufacturer cannot claim that a food is fat-free or low-fat if it is not, in reality, fat-free or low-fat. Low-fat indicates that the product has three or fewer grams of fat; low salt indicates there are fewer than 140 milligrams of sodium, and low-cholesterol indicates there are fewer than 20 milligrams of cholesterol and two grams of saturated fat[3]. See Table 12.3 "Common Label Terms Defined" for some examples.

Table 12.3 Common Label Terms Defined

https://www.fda.gov/food/foodscienceresearch/consumerbehaviorresearch/ucm275987.ht. Updated November 17, 2017.

3. Nutrient Content Claims. US Food and Drug Administration. https://www.fda.gov/food/ingredientspackaginglabeling/labelingnutrition/ucm2006880.htm. Updated December 9, 2014. Accessed December 10, 2017.

Term	Explanation
Lean	Fewer than a set amount of grams of fat for that particular cut of meat or seafood
High, Rich In, or Excellent Source Of	Contains 20% or more of the nutrient's DV
Good source, Contains or Provides	Contains 10 to 19% of the nutrient's DV
Light/lite	Contains ⅓ fewer calories or 50% less fat; if more than half of calories come from fat, then fat content must be reduced by 50% or more
Organic[1]	Contains 95% certified organic ingredients

[1] The term "Organic" is regulated by the USDA and appears as a USDA Organic Seal in the front of packaged food products, beverages and dietary supplements

Image by USDA/ [USDA Organic]

Source:

AMS, USDA. https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program.
Food Labeling Guide. US Food and Drug Administration. http://www.fda.gov. Updated February 10, 2012. Accessed November 28, 2017.

Health Claims

Often we hear news of a particular nutrient or food product that contributes to our health or may prevent disease. A health claim is a statement that links a particular food with a reduced risk of developing disease. Implied health claims include the use of symbols, statements and other forms of communication that suggest a relationship between a food substance and disease reduction. As such, health claims such as "Three grams of soluble fiber from oatmeal daily in combination with a diet low in cholesterol and saturated fat may reduce the risk of heart disease," must be evaluated by the FDA before it may appear on packaging. Prior to the passage of the NLEA products that made such claims were categorized as drugs and not food. All health claims must be substantiated by scientific evidence in order for it to be approved and put on a food label. To avoid having companies making false claims, laws also regulate how health claims are presented on food packaging. In addition to the claim being backed up by scientific evidence, it may never claim to diagnose, mitigate, cure or treat the disease. For a detailed list of approved health claims, visit: https://www.fda.gov/food/food-labeling-nutrition/authorized-health-claims-meet-significant-scientific-agreement-ssa-standard

Qualified Health Claims

While health claims must be backed up by hard scientific evidence, qualified health claims have supportive evidence, which is not as definitive as with health claims. The evidence may suggest that the food or nutrient is beneficial. Qualified health claims can be made for both dietary supplements and conventional food items. Wording for this type of claim may look like this: "Supportive but not conclusive research shows that consumption of EPA and DHA omega-3 fatty acids may reduce the risk of coronary artery disease. One serving of [name of food] provides [X] grams of EPA and DHA omega-3 fatty acids. [See nutrition information for total fat, saturated fat, and cholesterol content.] Dietary supplements may declare the amount of EPA and DHA per serving in their section for "supplement facts" instead.

Soure: FDA (2013). Guidance for Industry: Food Labeling Guide. http://www.fda.gov/foodlabelingguide

Structure/Function Claims

Some companies claim that certain foods and nutrients have benefits for health even though no scientific evidence exists. In these cases, food labels are permitted to claim that you may benefit from the food because it may boost your immune system, for example. There may not be claims of diagnosis, cures, treatment, or disease prevention, and there must be a disclaimer that the FDA has not evaluated the claim[4].

4. Claims That Can Be Made for Conventional Foods and Dietary Supplements. US Food and Drug Administration. https://www.fda.gov/food/

Allergy Warnings

Food manufacturers are required by the FDA to list on their packages if the product contains any of the eight most common ingredients that cause food allergies. These eight common allergens are as follows: milk, eggs, peanuts, tree nuts, fish, shellfish, soy, and wheat. (More information on these allergens will be discussed in Chapter 18 "Nutritional Issues".) The FDA does not require warnings that cross contamination may occur during packaging, however most manufacturers include this advisory as a courtesy. For instance, you may notice a label that states, "This product is manufactured in a factory that also processes peanuts." If you have food allergies, it is best to avoid products that may have been contaminated with the allergen.

When Enough Is Enough

Estimating Portion Size

Have you ever heard the expression, "Your eyes were bigger than your stomach?" This means that you thought you wanted a lot more food than you could actually eat. Amounts of food can be deceiving to the eye, especially if you have nothing to compare them to. It is very easy to heap a pile of mashed potatoes on your plate,

ingredientspackaginglabeling/labelingnutrition/ucm111447.htm. Updated September 2003. Accessed November 28,2017.

particularly if it is a big plate, and not realize that you have just helped yourself to three portions instead of one.

The food industry makes following the 2015 Dietary Guidelines a challenge. In many restaurants and eating establishments, portion sizes have increased, use of solid fats and added sugars (SoFAS) has increased, and consequently the typical meal contains more calories than it used to. In addition, our sedentary lives make it difficult to expend enough calories during normal daily activities. In fact, more than one-third of adults are not physically active at all.

Figure 12.6 A Comparison of Serving Sizes

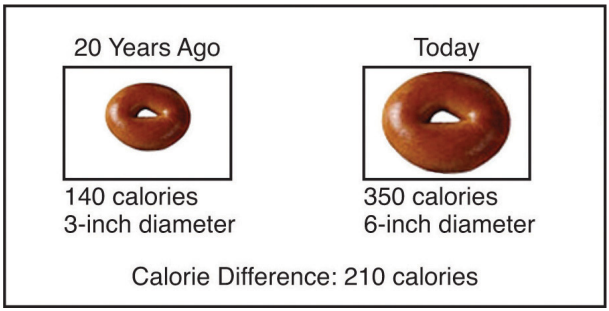


Image by FDA/ Portion Distortion

Source: National Heart, Lung, and Blood Institute Obesity Education Initiative. (2015). Do you know how food portions have changed in 20 years? https://www.nhlbi.nih.gov/health/educational/wecan/portion/documents/PD1.pdf

As food sizes and servings increase it is important to limit the portions of food consumed on a regular basis. Dietitians have come up with some good hints to help people tell how large a portion of food they really have. Some suggest using common items such as a deck of cards while others advocate using your hand as a measuring rule[5].

5. Controlling Portion Sizes. American Cancer Society.

Table 12.4 Determining Food Portions

Food Product	Amount	Object Comparison	Hand Comparison
Pasta, rice	½ c.	Tennis ball	Cupped hand
Fresh vegetables	1 c.	Baseball	–
Cooked vegetables	½ c.	–	Cupped hand
Meat, poultry, fish	3 oz.	Deck of cards	Palm of your hand
Milk or other beverages	1 c.	Fist	–
Salad dressing	1 Tbsp.	Thumb	–
Oil	1 tsp.	Thumb tip	–

Everyday Connections

If you wait many hours between meals, there is a good chance you will overeat. To refrain from overeating try consuming small meals at frequent intervals throughout the day as opposed to two or three large meals. Eat until you are satisfied, not until you feel "stuffed." Eating slowly and savoring your food allows you to both enjoy what you eat and have time to realize that you are full before you get overfull. Your stomach is about the size of your fist but it expands if you eat excessive amounts of food at one sitting.

http://www.cancer.org/Healthy/EatHealthyGetActive/TakeControlofYourWeight/controlling-portion-sizes. Updated January 12, 2012. Accessed November 30, 2017.

Eating smaller meals will diminish the size of your appetite over time so you will feel satisfied with smaller amounts of food.

Learning Activities

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Building Healthy Eating Patterns

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Helping People Make Healthy Choices

It is not just ourselves, the food industry, and federal government that shape our choices of food and physical activity, but also our sex, genetics, disabilities, income, religion, culture, education, lifestyle, age, and environment. All of these factors must be addressed by organizations and individuals that seek to make changes in dietary habits. The socioeconomic model incorporates all of these factors and is used by health-promoting organizations, such as the USDA and the HHS to determine multiple avenues through which to promote healthy eating patterns, to increase levels of physical activity, and to reduce the risk of chronic disease for all Americans. Lower economic prosperity influences diet specifically by lowering food quality, decreasing food choices, and decreasing access to enough food. The USDA reports that an estimated 12.3 percent or 15.6 million Americans were food insecure, meaning they had insufficient funds to feed all family members at least some time during the year in 2016[1].

1. Food Security in the U.S. United States Department of Agriculture, Economic Research Service. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/interactive-charts-

Figure 12.7 Social-Ecological Model

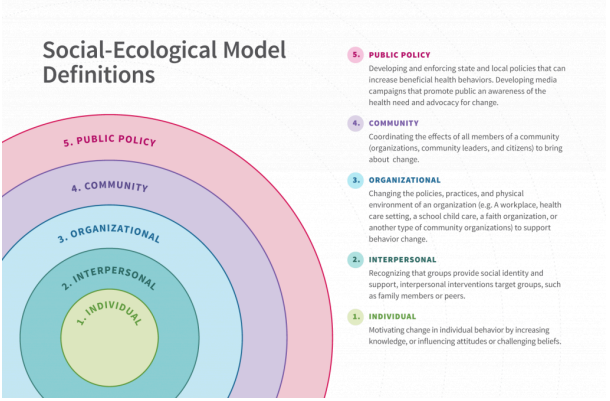

Image by Allison Calabrese / [CC BY 4.0]

Recommendations for Optimal Health

For many years, the US government has been encouraging Americans to develop healthful dietary habits. In 1992 the Food Pyramid was introduced, and in 2005 it was updated. This was the symbol of healthy eating patterns for all Americans. However, some felt it was difficult to understand, so in 2011, the pyramid was replaced with MyPlate.

The MyPlate program uses a tailored approach to give people the needed information to help design a healthy diet. The plate is divided according to the amount of food and nutrients you should consume for each meal. Each food group is identified with a different color, showing the food variety that all plates must have. Aside from educating people about the type of food that is best to

and-highlights/. Updated September 6, 2017. Accessed November 22, 2017.

support optimal health, the new food plan offers the advice that it is okay to enjoy food, just eat a diverse diet and in moderation[2].

Everyday Connections

Image by Got Nutrients?/ Got Nutrients website

Interested in another reliable source for nutrition and health information? The "Got Nutrients?" website highlights the importance of meeting essential nutrient needs in order to maintain optimum health. This website, geared for those interested in nutrition, fitness, and health, posts short daily nutrition and health messages. Each short "Daily Tip" includes links to both a popular article and to a related scientific resource. For more information about "Got

2. Choose MyPlate. US Department of Agriculture. http://www.choosemyplate.gov/. Accessed July 22, 2012.

Nutrients?" visit, http://www.gotnutrients.net. To receive the "Daily Tips" by email, visit http://www.gotnutrients.net/email_alerts/subscribe.cfm

Learning Activities

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MyPlate Planner

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Estimating portions can be done using the MyPlate Planner. Recall that the MyPlate symbol is divided according to how much of each food group should be included with each meal. Note the MyPlate Planner Methods of Use:

- Fill half of your plate with vegetables such as carrots, broccoli, salad, and fruit.
- Fill one-quarter of your plate with lean meat, chicken, or fish (about 3 ounces)
- Fill one-quarter of your plate with a whole grain such as ⅓ cup rice
- Choose one serving of dairy
- Add margarine or oil for preparation or addition at the table

Building a Healthy Plate: Choose Nutrient-Dense Foods

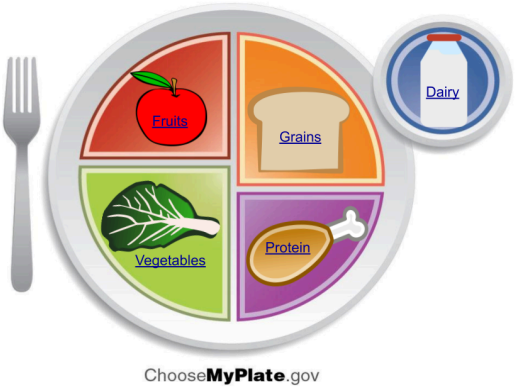

Image by Allison Calabrese / CC BY 4.0

Click on the different food groups listed to view their food gallery:

- Fruits
- Grains
- Dairy
- Vegetables
- Protein

Planning a healthy diet using the MyPlate approach is not difficult. According to the icon, half of your plate should have fruits and vegetables, one-quarter should have whole grains, and one-quarter should have protein. Dairy products should be low-fat or non-fat. The ideal diet gives you the most nutrients within the fewest calories. This means choosing nutrient-rich foods.

Fill half of your plate with red, orange, and dark green vegetables and fruits, such as kale, bok choy, kalo (taro), tomatoes, sweet

potatoes, broccoli, apples, mango, papaya , guavas, blueberries, and strawberries in main and side dishes. Vary your choices to get the benefit of as many different vegetables and fruits as you can. You may choose to drink fruit juice as a replacement for eating fruit. (As long as the juice is 100 percent fruit juice and only half your fruit intake is replaced with juice, this is an acceptable exchange.) For snacks, eat fruits, vegetables, or unsalted nuts.

Fill a quarter of your plate with whole grains such as 100 percent whole-grain cereals, breads, crackers, rice, and pasta. Half of your daily grain intake should be whole grains. Read the ingredients list on food labels carefully to determine if a food is comprised of whole grains.

Select a variety of protein foods to improve nutrient intake and promote health benefits. Each week, be sure to include a nice array of protein sources in your diet, such as nuts, seeds, beans, legumes, poultry, soy, and seafood. The recommended consumption amount for seafood for adults is two 4-ounce servings per week. When choosing meat, select lean cuts. Be conscious to prepare meats using little or no added saturated fat, such as butter.

If you enjoy drinking milk or eating milk products, such as cheese and yogurt, choose low-fat or nonfat products. Low-fat and nonfat products contain the same amount of calcium and other essential nutrients as whole-milk products, but with much less fat and calories. Calcium, an important mineral for your body, is also available in lactose-free and fortified soy beverage and rice beverage products. You can also get calcium in vegetables and other fortified foods and beverages.

Oils are essential for your diet as they contain valuable essential fatty acids, but the type you choose and the amount you consume is important. Be sure the oil is plant-based rather than based on animal fat. You can also get oils from many types of fish, as well as avocados, and unsalted nuts and seeds. Although oils are essential for health they do contain about 120 calories per tablespoon. It is vital to balance oil consumption with total caloric intake. The

Nutrition Facts label provides the information to help you make healthful decisions.

In short, substituting vegetables and fruits in place of foods high in added sugars, saturated fats, and sodium is a good way to make a nutrient-poor diet healthy again. Vegetables are full of nutrients and antioxidants that help promote good health and reduce the risk for developing chronic diseases such as stroke, heart disease, high blood pressure, Type 2 diabetes, and certain types of cancer. Starting with these small shifts in your diet as mentioned above will boost your overall health profile.

Discretionary Calories

When following a balanced, healthful diet with many nutrient-dense foods, you may consume enough of your daily nutrients before you reach your daily calorie limit. The remaining calories are discretionary (to be used according to your best judgment). To find out your discretionary calorie allowance, add up all the calories you consumed to achieve the recommended nutrient intakes and then subtract this number from your recommended daily caloric allowance. For example, someone who has a recommended 2,000-calorie per day diet may eat enough nutrient-dense foods to meet requirements after consuming only 1,814 calories. The remaining 186 calories are discretionary. See Table 12.5 "Sample Menu Plan Containing 2,000 Calories". These calories may be obtained from eating an additional piece of fruit, adding another teaspoon of olive oil on a salad or butter on a piece of bread, adding sugar or honey to cereal, or consuming an alcoholic beverage[1].

1. US Department of Agriculture. MyPyramid Education Framework. Accessed July 22, 2012.

The amount of discretionary calories increases with physical activity level and decreases with age. For most physically active adults, the discretionary calorie allowance is, at most, 15 percent of the recommended caloric intake. By consuming nutrient-dense foods, you afford yourself a discretionary calorie allowance.

Table 12.5 Sample Menu Plan Containing 2,000 Calories

Meal	Calories	Total Meal/Snack Calories
Breakfast		
1 scrambled egg	92	
with sliced mushrooms and spinach	7	
½ whole-wheat muffin	67	
1 tsp. margarine-like spread	15	
1 orange	65	
8 oz. low-sodium tomato juice	53	299
Snack		
6 oz. fat-free flavored yogurt	100	
with ½ c. raspberries	32	132
Lunch		
1 sandwich on pumpernickel bread	160	
with smoked turkey deli meat,	30	
4 slices tomato	14	
2 lettuce leaves	3	
1 tsp. mustard	3	
1 oz. baked potato chips	110	
½ c. blueberries, with 1 tsp. sugar	57	
8 oz. fat-free milk	90	467
Snack		
1 banana	105	
7 reduced-fat high-fiber crackers	120	225
Dinner		
1 c. Greek salad (tomatoes, cucumbers, feta)	150	
with 5 Greek olives,	45	
with 1.5 tsp. olive oil	60	
3 oz. grilled chicken breast	150	
½ c. steamed asparagus	20	

with 1 tsp. olive oil,	40	
with 1 tsp. sesame seeds	18	
½ c. cooked wild rice	83	
with ½ c. chopped kale	18	
1 whole-wheat dinner roll	4	
with 1 tsp. almond butter	33	691
(Total calories from all meals and snacks = 1,814)		
Discretionary calorie allowance: 186		

(Total calories from all meals and snacks = 1,814)
Discretionary calorie allowance: 186

Healthy Eating Index

To assess whether the American diet is conforming to the Dietary Guidelines, the Center for Nutrition Policy and Promotion (CNPP), a division of the USDA, uses a standardized tool called the Healthy Eating Index (HEI)[2].

The first HEI was developed in 1995 and revised in 2006. This tool is a simple scoring system of dietary components. The data for scoring diets is taken from national surveys of particular population subgroups, such as children from low-income families or Americans over the age of sixty-five. Diets are broken down into several food categories including milk, whole fruits, dark green and orange vegetables, whole grains, and saturated fat, and then a score is

2. Healthy Eating Index. US Department of Agriculture. http://www.cnpp.usda.gov/healthyeatingindex.htm. Updated March 14, 2012. Accessed November 22, 2017.

given based on the amount consumed. For example, a score of ten is given if a 2,000-kilocalorie diet includes greater than 2.6 cups of milk per day. If less than 10 percent of total calories in a diet are from saturated fat, a score of eight is given. All of the scores are added up from the different food categories and the diets are given a HEI score. Using this standardized diet-assessment tool at different times, every ten years for instance, the CNPP can determine if the eating habits of certain groups of the American population are getting better or worse. The HEI tool provides the federal government with information to make policy changes to better the diets of American people. For more information on the HEI, visit this website: http://www.cnpp.usda.gov/healthyeatingindex.htm.

The Whole Nutrient Package versus Disease

A healthy diet incorporating seven or more servings of fruits and vegetables has been shown in many scientific studies to reduce cardiovascular disease and overall deaths attributable to cancer. The WHO states that insufficient fruit and vegetable intake is linked to approximately 14 percent of gastrointestinal cancer deaths, about 11 percent of heart attack deaths, and 9 percent of stroke deaths globally[3].

The WHO estimates that, overall, 2.7 million deaths could be avoided annually by increasing fruit and vegetable intake. These preventable deaths place an economic, social, and mental burden on

3. Global Strategies on Diet, Physical Activity, and Health. World Health Organization. http://www.who.int/dietphysicalactivity/fruit/en/index.html. Accessed September 30, 2011.

society. This is why, in 2003, the WHO and the Food and Agricultural Organization of the United Nations launched a campaign to promote fruit and vegetable intake worldwide.

Antioxidant Variety in Food Provides Health Benefits

Not only has the several-billion-dollar supplement industry inundated us with FDA-unapproved health claims, but science is continuously advancing and providing us with a multitude of promising health benefits from particular fruits, vegetables, teas, herbs, and spices. For instance, blueberries protect against cardiovascular disease, an apple or pear a day reduces stroke risk by over 52 percent, eating more carrots significantly reduces the risk of bladder cancer, drinking tea reduces cholesterol and helps glucose homeostasis, and cinnamon blocks infection and reduces the risk of some cancers. However, recall that science also tells us that no one nutrient alone is shown to provide these effects.

What micronutrient and phytochemical sources are best at protecting against chronic disease? All of them, together. Just as there is no wonder supplement or drug, there is no superior fruit, vegetable, spice, herb, or tea that protects against all diseases. A review in the July–August 2010 issue of Oxidative Medicine and Cellular Longevity concludes that the plant-food benefits to health are attributed to two main factors—that nutrients and phytochemicals are present at low concentrations in general, and that the complex mixtures of nutrients and phytochemicals provides additive and synergistic effects[4]. In short, don't overdo it

4. Bouayed, J. and T. Bohn. (2010). Exogenous Antioxidants—Double-Edged Swords in Cellular Redox

with supplements and make sure you incorporate a wide variety of nutrients in your diet.

Eating a variety of fruits and vegetables rich in antioxidants and phytochemicals promotes health. Consider these diets:
Mediterranean diet. Fresh fruit and vegetables are abundant in this diet, and the cultural identity of the diet involves multiple herbs and spices. Moreover, olive oil is the main source of fat. Fish and poultry are consumed in low amounts and red meat is consumed in very low amounts. An analysis of twelve studies involving over one million subjects published in the September 2008 issue of the British Medical Journal reports that people who followed the Mediterranean diet had a 9 percent decrease in overall deaths, a 9 percent decrease in cardiovascular death, a 6 percent decrease in cancer deaths, and a 13 percent reduced incidence of Parkinson's disease and Alzheimer's disease[5]. The authors of this study concluded that the Mediterranean diet is useful as a primary prevention against some major chronic diseases.

Dietary Approaches to Stop Hypertension (DASH diet). Recall from Chapter 7 "Nutrients Important to Fluid and Electrolyte Balance" that the DASH diet is an eating plan that is low in saturated fat, cholesterol, and total fat. Fruits, vegetables, low-fat dairy foods,

State: Health Beneficial Effects at Physiologic Doses versus Deleterious Effects at High Doses. *Oxidative Medicine and Cellular Longevity*, 3(4), 228–37. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2952083/?tool=pubmed. Accessed November 22, 2017.

5. Sofi F, et al. (2008). Adherence to Mediterranean Diet and Health Status: Meta-Analysis. *British Medical Journal*, 337, a1344. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2533524/. Accessed November 22, 2017.

whole-grain foods, fish, poultry, and nuts are emphasized while red meats, sweets, and sugar-containing beverages are mostly avoided. Results from a follow-up study published in the December 2009 issue of the Journal of Human Hypertension suggest the low-sodium DASH diet reduces oxidative stress, which may have contributed to the improved blood vessel function observed in salt-sensitive people (between 10 to 20 percent of the population)[6].

Diets high in fruits and vegetables. An analysis of The Nurses' Health Study and the Health Professionals' Follow-up Study reported that for every increased serving of fruits or vegetables per day, especially green leafy vegetables and vitamin C-rich fruits, there was a 4 percent lower risk for heart disease[7].

6. Al-Solaiman Y, et al. (2008). Low-Sodium DASH Reduces Oxidative Stress and Improves Vascular Function in Salt-Sensitive Humans. *Journal of Human Hypertension*, 12, 826–35. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2783838/?tool=pubmed. Accessed November 22, 2017.
7. Joshipura KJ, et al. (2001). The Effect of Fruit and Vegetable Intake on Risk for Coronary Heart Disease. *Annuals of Internal Medicine*, 134(12), 1106–14. http://www.ncbi.nlm.nih.gov/pubmed/11412050. Accessed November 12, 2017.

Americans Typically Eat Fewer than the Recommended Servings of High Quality Food-Group Foods

An article in the January 2009 issue of the Medscape Journal of Medicine reports that fewer than one in ten Americans consumes the recommended amount of fruits and vegetables, which is between five and thirteen servings per day[8]. According to this study, the largest single contributor to fruit intake was orange juice, and potatoes were the dominant vegetable.

The USDA recommends that you fill half your plate with fruits and vegetables. The number of servings of fruits and vegetables that a person should consume every day is dependent on age, sex, and level of physical activity. For example, a forty-year-old male who exercises for sixty minutes per day should consume 2 cups of fruit and 3½ cups of vegetables, while a fifteen-year-old female who exercises for thirty minutes per day should consume 1½ cups of fruit and 2½ cups of vegetables. (One cup of a fruit or vegetable is equal to one banana, one small apple, twelve baby carrots, one orange, or one large sweet potato.) To find out the amount of fruits and vegetables the Centers for Disease Control and Prevention (CDC) recommends, see Note 8.25 "Interactive 8.4".

8. Kimmons J, et al. (2009). Fruit and Vegetable Intake among Adolescents and Adults in the United States: Percentage Meeting Individualized Recommendations. *Medscape Journal of Medicine*, 11(1), 26. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2654704/?tool=pubmed. Accessed November 22, 2017.

Improving Fruit and Vegetable Intake at Home and in Your Community

Eating more fruits and vegetables can make you think better, too. According to a study published in 2009 in the Journal of Alzheimer's Disease, no matter your age, eating more fruits and vegetables improves your brain function[9]. Check out Note 8.26 "Interactive 8.5" for thirteen fun ways to increase your fruit and vegetable intake.

The CDC has developed seven strategies to increase American's intake of fruits and vegetables[10].

1. Support local and state governments in the implementation of a Food Policy Council, which develops policies and programs that increase the availability of affordable fruits and vegetables.
2. In the food system, increase the availability and affordability of high-quality fruits and vegetables in underserved populations.
3. Promote farm-to-where-you-are programs, which is the

9. Polidori MC, et al. (2009). High Fruit and Vegetable Intake Is Positively Correlated with Antioxidant Status and Cognitive Performance in Healthy Subjects. *Journal of Alzheimer's Disease*, *17*(4), 921–7. http://www.ncbi.nlm.nih.gov/pubmed/19542607. Accessed November 22, 2017.
10. The CDC Guide to Fruit and Vegetable Strategies to Increase Access, Availability, and Consumption. Centers for Disease Control and Prevention. http://www.cdph.ca.gov/SiteCollectionDocuments/StratstoIncreaseFruitVegConsumption.pdf. Updated March 2010. Accessed November 22, 2017.

delivery of regionally grown farm produce to community institutions, farmers markets, and individuals.
4. Encourage worksites, medical centers, universities, and other community and business establishments to serve more fruits and vegetables in cafeterias and onsite eateries.
5. Support schools in developing healthy food messages to students by incorporating activities such as gardening into curricula.
6. Encourage the development and support of community and home gardens.
7. Have emergency food programs, including food banks and food rescue programs, increase their supply of fruits and vegetables.

The seven strategies developed by the CDC are based on the idea that improving access to and availability of fruits and vegetables will lead to an increase in their consumption.

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

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http://pressbooks.oer.hawaii.edu/humannutrition2/?p=426

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Pacific Based Dietary Guidelines

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

To reflect the unique food environment and practices of the Pacific, the Secretariat of the Pacific Community (SPC) Public Health division developed Dietary Guidelines for healthy eating to promote and protect the health and future of Pacific Island peoples[1]. With such a diverse food supply, it can be difficult to place some pacific foods into the USDA 5 food group system. For example, ʻulu, otherwise known as breadfruit, is a fruit but also has many similar properties and functions like whole grains as well due to its high carbohydrate and fiber content.

Therefore, guidelines for healthy eating include a series of leaflets and fact sheets that focus on traditional Pacific foods, food security, and health issues in the Pacific region. Healthy eating guidelines for adults and children are divided into 3 main food groups[2].

1. Factsheet no. 16 – Healthy Eating. Secretariat of the Pacific Community. https://www.spc.int/hpl/index2.php?option=com_docman&task=doc_view&gid=58&Itemid=51. Published 2002. Accessed December 2, 2017.
2. Factsheet no. 9 – Feeding babies and young children. Secretariat of the Pacific Community. http://www.spc.int/hpl/index2.php?option=com_docman&task=doc_view&gid=

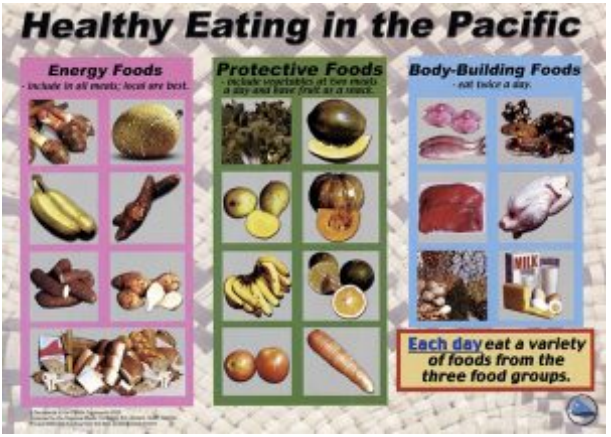
Table 12.6 The Different Categories from the Pacific

	Energy Nutrient-dense foods	Protective Foods	Body-building Foods
Types of Foods	Foods that are both high in calories and high in nutrients	Fruits and vegetables	Protein-rich foods
Description	The recommendation is that these foods should be included in all meals contributing to about half of the food you consume each day.	The foods in this group are high in vitamins and minerals. These foods are recommended to be included in all meals and snacks contributing about one third of the food consumed each day.	The foods in this group are high in protein and is recommended to be eaten twice a day in small amounts.

The recommendation is that these foods should be included in all meals contributing to about half of the food you consume each day. The foods in this group are high in vitamins and minerals. These foods are recommended to be included in all meals and snacks contributing about one third of the food consumed each day. The foods in this group are high in protein and is recommended to be eaten twice a day in small amounts. Examples of each of the foods from the Pacific that fit into these categories are shown in the image below.

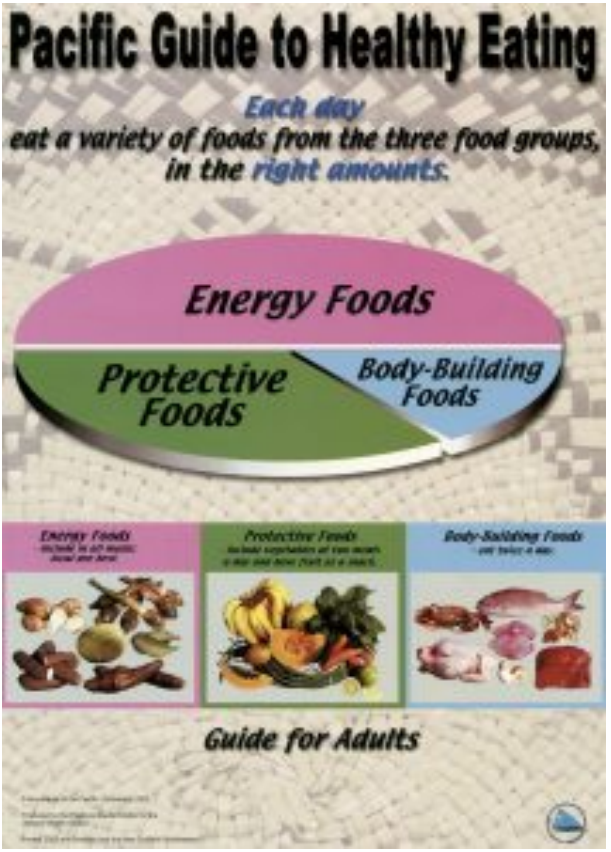
Figure 12.8 Healthy Eating in the Pacific

51&Itemid=51. Published 2002. Accessed December 2, 2017.



The overall key messages to the SPC Dietary Guidelines are to consume a variety of foods each day from the 3 food groups. However, food should be consumed in moderation as too much of any one food can be unhealthy. Foods should be consumed in recommended amounts. In addition, every effort should be made to consuming foods that are locally sourced. See the image below for a depiction of the key messages of the SPC Dietary Guidelines.

Figure 12.9 The Pacific Guide to Healthy Eating



To learn more about the SPC visit http://www.spc.int/about-us/

Bridging MyPlate with the Pacific

Although the diversity and expansiveness of the Pacific region makes this a monumental task, a food guide that reflects the traditional foods of the Pacific in relation to the US Dietary

Guidelines, more specifically MyPlate, was needed. The Pacific Food Guide was developed by the Children's Healthy Living Program (CHL) for Remote and Underserved Minorities of the Pacific Region. CHL is a partnership among the remote Pacific jurisdictions of Alaska, American Samoa, CNMI, RMI, the Republic of Palau, FSM, Guam, and Hawai'i to study child obesity among Pacific children, ages 2-8 years. The program is sponsored by the United States Department of Agriculture (USDA), Agriculture and Food Research Initiative Grant no 2011-68001-30335. To learn more about CHL visit http://www.chl-pacific.org/. The Pacific Food Guide is freely available at
http://manoa.hawaii.edu/ctahr/pacificfoodguide/index./about-the-guide/

Developed to assist with teaching introductory nutrition at the University of Hawai'i at Mānoa, the Pacific Food Guide allows readers to explore the traditional foods of the Pacific in relation to both dietary guideline systems (USDA and SPC). Since foods of the Pacific cross over multiple categories of both the MyPlate and SPC Dietary Guidelines foods are organized into 3 neutral categories:

- Walks along the Ground (animals)
- Chosen from the Sea (seafood)
- Grown from the Ground (plants)

The Pacific Food Guide allows users to identify with the origin of specific Pacific foods and see how these foods fit into both dietary guidelines using a unique set of pins (see image below). By grouping foods into its origin it allows for readers who may not be familiar with either/neither dietary guidelines to use the Guide.

These pins label foods according to the USDA MyPlate guidelines and food groups.

These pins label foods according to the SPC food groups for healthy eating in the Pacific.

Note: There may be a few foods that do not fall in either of the 3 food groups, which the SPC regards as not essential or needed in significant amounts to achieve healthy eating. The recommendations for these miscellaneous food items are to "Eat Less" of, but not necessarily to avoid completely as they may have cultural and traditional value. Such food items will have this pin.

To learn more about how to use the Pacific Food Guide visit http://manoa.hawaii.edu/ctahr/pacificfoodguide/index.php/nutritional-guidelines/how-to-use-the-guide/

Learning Activities

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Understanding the Bigger Picture of Dietary Guidelines

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

The first US dietary recommendations were set by the National Academy of Sciences in 1941. The recommended dietary allowances (RDA) were first established out of concern that America's overseas World War II troops were not consuming enough daily nutrients to maintain good health. The first Food and Nutrition Board was created in 1941, and in the same year set recommendations for the adequate intakes of caloric energy and eight essential nutrients. These were disseminated to officials responsible for food relief for armed forces and civilians supporting the war effort. Since 1980, the dietary guidelines have been reevaluated and updated every five years by the advisory committees of the US Department of Agriculture (USDA) and the US Department of Health and Human Services (HHS). The guidelines are continually revised to keep up with new scientific evidence-based conclusions on the importance of nutritional adequacy and physical activity to overall health.

While dietary recommendations set prior to 1980 focused only on preventing nutrient inadequacy, the current dietary guidelines have the additional goals of promoting health, reducing chronic disease, and decreasing the prevalence of overweight and obesity.

Establishing Human Nutrient Requirements for Worldwide Application

The Department of Nutrition for Health and Development, in

collaboration with FAO, continually reviews new research and information from around the world on human nutrient requirements and recommended nutrient intakes. This is a vast and never-ending task, given the large number of essential human nutrients. These nutrients include protein, energy, carbohydrates, fats and lipids, a range of vitamins, and a host of minerals and trace elements.

Many countries rely on WHO and FAO to establish and disseminate this information, which they adopt as part of their national dietary allowances. Others use it as a base for their standards. The establishment of human nutrient requirements is the common foundation for all countries to develop food-based dietary guidelines for their populations.

Establishing requirements means that the public health and clinical significance of intake levels – both deficiency and excess – and associated disease patterns for each nutrient, need to be thoroughly reviewed for all age groups. Every ten to fifteen years, enough research is completed and new evidence accumulated to warrant WHO and FAO undertaking a revision of at least the major nutrient requirements and recommended intakes.
http://www.who.int/nutrition/topics/nutrecomm/en/

Why Are Guidelines Needed?

Instituting nation-wide standard policies provides consistency across organizations and allows health-care workers, nutrition educators, school boards, and eldercare facilities to improve nutrition and subsequently the health of their respective populations. At the same time, the goal of the Dietary Guidelines is to provide informative guidelines that will help any interested person in obtaining optimal nutritional balance and health. The seventh edition of the Dietary Guidelines was released in 2010 and focused mainly on combating the obesity epidemic. USDA secretary

Tom Vilsack says, "The bottom line is that most Americans need to trim their waistlines to reduce the risk of developing diet-related chronic disease. Improving our eating habits is not only good for every individual and family, but also for our country." The 2015 Dietary Guidelines focus on eating patterns, which may be predictive of overall health status and disease risk. The Dietary Guidelines were formulated by the Food and Nutrition Board of the Institute of Medicine (IOM), which has recently changed their name to the National Academy of Medicine (NAM). These guidelines are from the review of thousands of scientific journal articles by a consensus panel consisting of more than two thousand nutrition experts with the overall mission of improving the health of the nation[1].

Major Themes of the 2015 Dietary Guidelines

Consume a healthy eating pattern that accounts for all foods and

1. Johnson TD. (2011). New Dietary Guidelines Call for Less Salt, Fewer Calories, More Exercise. *Nation's Health*, 41(2), E6. http://thenationshealth.aphapublications.org/content/41/2/E6.full. Accessed November 22, 2017. Key Recommendations: Components of Healthy Living Patterns. Dietary Guidelines 2015-2020. https://health.gov/dietaryguidelines/2015/guidelines/chapter-1/key-recommendations/. Published 2015. Accessed November 22, 2017.

beverages within an appropriate calorie level. A healthy eating pattern includes[2]:

- A variety of vegetables from all of the subgroups—dark green, red and orange, legumes (beans and peas), starchy, and other
- Fruits, especially whole fruits
- Grains, at least half of which are whole grains
- Fat-free or low-fat dairy, including milk, yogurt, cheese, and/or fortified soy beverages
- A variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), and nuts, seeds, and soy products
  Oils

A healthy eating pattern limits:

- Saturated fats and trans fats, added sugars, and sodium
- Cholesterol, in order to limit saturated fats.

Previously, the recommendation for cholesterol was less than 300 mg/day of cholesterol for the general public, and less than 200 mg/day for those with cardiovascular disease risk. The 2015 Dietary Guidelines recommends consuming as little dietary cholesterol as possible rather than quantifying it because someone consuming a diet according to the recommendations would consume around 100-300 mg daily and because dietary cholesterol does not impact

2. Key Recommendations: Components of Healthy Living Patterns. Dietary Guidelines 2015-2020. https://health.gov/dietaryguidelines/2015/guidelines/chapter-1/key-recommendations/. Published 2015. Accessed November 22, 2017.

blood cholesterol levels as much as previously believed[3]. The reason for consuming as little cholesterol as possible is because many (but not all) foods that have cholesterol also have saturated fat.

Key Recommendations that are quantitative are provided for several components of the diet that should be limited. These components are of particular public health concern in the United States, and the specified limits can help individuals achieve healthy eating patterns within calorie limits:

- Consume less than 10 percent of calories per day from added sugars
- Consume less than 10 percent of calories per day from saturated fats
- Consume less than 2,300 milligrams (mg) per day of sodium

If alcohol is consumed, it should be consumed in moderation—up to one drink per day for women and up to two drinks per day for men—and only by adults of legal drinking age[4].

High consumptions of certain foods, such as those high in saturated or trans fat, sodium, added sugars, and refined grains may contribute to the increased incidence of chronic disease.

3. Key Recommendations: Components of Healthy Living Patterns. Dietary Guidelines 2015-2020. https://health.gov/dietaryguidelines/2015/guidelines/chapter-1/key-recommendations/. Published 2015. Accessed November 22, 2017.
4. Key Recommendations: Components of Healthy Living Patterns. Dietary Guidelines 2015-2020. https://health.gov/dietaryguidelines/2015/guidelines/chapter-1/key-recommendations/. Published 2015. Accessed November 22, 2017.

Additionally, excessive consumption of these foods replaces the intake of more nutrient-dense foods.

The average person consumes 3,400 milligrams of sodium per day, mostly in the form of table salt. The Dietary Guidelines recommend that Americans reduce their daily sodium intake to less than 2,300 milligrams. If you are over the age of fifty-one, are African American, or have cardiovascular risk factors, such as high blood pressure or diabetes, sodium intake should be reduced even further to 1,500 milligrams. The Dietary Guidelines also recommend that less than 10 percent of calories come from saturated fat, and that fat calories should be obtained by eating foods high in unsaturated fatty acids. The Dietary Guidelines stress the importance of limiting the consumption of foods with refined grains and added sugars, and introduce the new term, SoFAS, which is an acronym for solid fats and added sugars, both of which should be consumed in moderation in a healthy diet[5].

Foods and Nutrients to Increase

The typical American diet lacks sufficient amounts of vegetables, fruits, whole grains, and high-calcium foods, causing concern for deficiencies in certain nutrients important for maintaining health. The Dietary Guidelines provide the following suggestions on food choices to achieve a healthier diet:

5. Nelson, J. and K. Zeratsky. Dietary Guidelines Connect SoFAS and Weight Gain. Mayo Clinic, Nutrition-Wise (blog). http://www.mayoclinic.com/health/dietary-guidelines/MY01417. Published August 25, 2010. Accessed November 22, 2017.

Instead of…	Replace with…
Sweetened fruit yogurt	Plain fat-free yogurt with fresh fruit
Whole milk	Low-fat or fat-free milk
Cheese	Low-fat or reduced-fat cheese
Bacon or sausage	Canadian bacon or lean ham
Sweetened cereals	Minimally sweetened cereals with fresh fruit
Apple or berry pie	Fresh apple or berries
Deep-fried French fries	Oven-baked French fries or sweet potato baked fries
Fried vegetables	Steamed or roasted vegetables
Sugary sweetened soft drinks	Seltzer mixed with 100 percent fruit juice
Recipes that call for sugar	Experiment with reducing amount of sugar and adding spices (cinnamon, nutmeg, etc…)

Source: Food Groups. US Department of Agriculture. http://www.choosemyplate.gov/food-groups/. Updated April 19, 2017. Accessed November 22, 2017.

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the

downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

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http://pressbooks.oer.hawaii.edu/humannutrition2/?p=434

PART XIII

CHAPTER 13. LIFESPAN NUTRITION FROM PREGNANCY TO THE TODDLER YEARS

Introduction

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

I maikaʻi ke kalo i ka ʻohā

The goodness of the taro is judged by the young plant it produces

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Image by Pua O Eleili Pinto / CC BY 4.0

Learning Objectives

By the end of this chapter you will be able to:

- Describe the physiological basis for nutrient requirements from pregnancy through the toddler years.

The Human Life Cycle

Human bodies change significantly over time, and food is the fuel for those changes. For example, for Native Hawaiians, expecting mothers were encouraged to eat greens like the lu'au (young taro leaves) and palula (young sweet potato leaves) to encourage a healthy, strong baby. These beliefs and customs practiced in the early stages of life were done in hopes of building a firm foundation and setting up lifelong health.[1]

People of all ages need the same basic nutrients—essential amino acids, carbohydrates, essential fatty acids, and twenty-eight vitamins and minerals—to sustain life and health. However, the amounts of nutrients needed differ. Throughout the human life cycle, the body constantly changes and goes through different periods known as stages. This chapter will focus on pregnancy,

1. Pukai MK., Handy ESC. (1958). *The Polynesian Family System in Ka-'u.* Rutland, Vermont: Charles E. Tuttle Company

infancy and the toddler years. Chapter 14 will focus on childhood through adolescence and Chapter 15 will focus on the stages of adulthood. The major stages of the human life cycle are defined as follows:

- **Pregnancy.** The development of a zygote into an embryo and then into a fetus in preparation for childbirth.
- **Infancy.** The earliest part of childhood. It is the period from birth through the first birthday.
- **Toddler years.** Occur during ages one to three and are the end of early childhood.
- **Childhood.** The period from birth to eighteen.
- **Onset of Puberty.** Can occur from ages nine to fourteen, which is the beginning of adolescence.
- **Older adolescence.** The stage that takes place between ages fourteen and eighteen.
- **Adulthood.** The period from the end of adolescence to the end of life and begins at age eighteen in the US and nineteen in some other countries.
- **Middle age.** The period of adulthood that stretches from age forty-five to sixty-four.
- **Senior years, or old age.** Extend from age sixty-five until the end of life.

Figure 13.1 Ultrasound image of a four-month-old fetus.

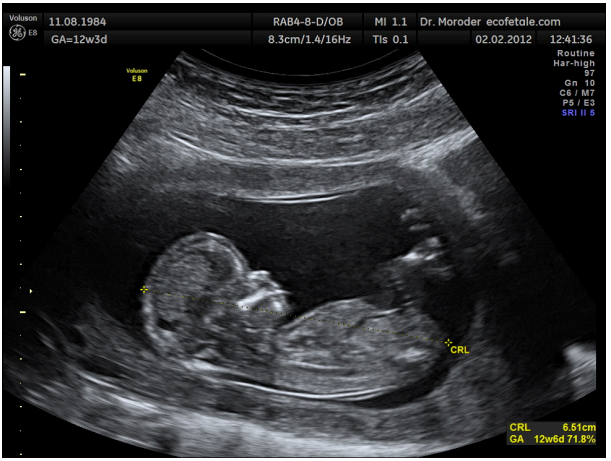

Image by [Wolfgang Moroder](#) / [CC BY-SA 3.0](#)

We begin with pregnancy, a developmental marathon that lasts about forty weeks. It begins with the first trimester (weeks one to week twelve), extends into the second trimester (weeks thirteen to week twenty-seven), and ends with the third trimester (week twenty-eight to birth). At conception, a sperm cell fertilizes an egg cell, creating a zygote. The zygote rapidly divides into multiple cells to become an embryo and implants itself in the uterine wall, where, by the end of the 8th week after conception, it develops into a fetus. Some of the major changes that occur include the branching of nerve cells to form primitive neural pathways at eight weeks. At the twenty-week mark, physicians typically perform an ultrasound to acquire information about the fetus and check for abnormalities. By this time, it is possible to know the sex of the baby. At twenty-eight weeks, the unborn baby begins to add body fat in preparation for life outside of the womb.[2] *Journey Across the LifeSpan: Human Development and Health Promotion*. Philadelphia: F.A. Davis Company, 81–82. The ability to coordinate sucking and swallowing,

2. Polan EU, Taylor DR. (2003),

necessary for feeding at birth, is not present until 32-34 weeks, and matures around 36-38 weeks gestation.[3]

Throughout this entire process, a pregnant woman's nutritional choices affect not only fetal development, but also her own health and the future health of her newborn.

Learning Activities

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Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

3. *Stanford Children's Health.* (n.d.). Retrieved June 9, 2020, from https://www.stanfordchildrens.org/en/topic/default?id=newborn-reflexes-90-P02630

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Pregnancy

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

Image by Marie Kainoa Fialkowski Revilla / CC BY 4.0

It is crucial to consume healthy foods at every phase of life, beginning in the womb. Good nutrition is vital for any pregnancy and not only helps an expectant mother remain healthy, but also impacts the development of the fetus and ensures that the baby thrives in infancy and beyond. During pregnancy, a woman's needs

increase for certain nutrients more than for others. If these nutritional needs are not met, infants could suffer from low birth weight (a birth weight less than 5.5 pounds, which is 2,500 grams), among other developmental problems. Therefore, it is crucial to make careful dietary choices.

The Early Days of Pregnancy

For medical purposes, pregnancy is measured from the first day of a woman's last menstrual period until childbirth, and typically lasts about forty weeks. Major changes begin to occur in the earliest days, often weeks before a woman even knows that she is pregnant. During this period, adequate nutrition supports cell division, tissue differentiation, and organ development. As each week passes, new milestones are reached. Therefore, women who are trying to conceive should make proper dietary choices to ensure the delivery of a healthy baby. Fathers-to-be should also consider their eating habits. A sedentary lifestyle and a diet low in fresh fruits and vegetables may affect male fertility. Men who drink too much alcohol may also damage the quantity and quality of their sperm.[1].

For both men and women, adopting healthy habits also boosts general well-being and makes it possible to meet the demands of parenting.

1. Healthy Sperm: Improving Your Fertility. Mayo Clinic. 1998–2012 Mayo Foundation for Medical Education and Research. http://www.mayoclinic.com/health/fertility/MC00023. Accessed February 21, 2012.

Tools for Change

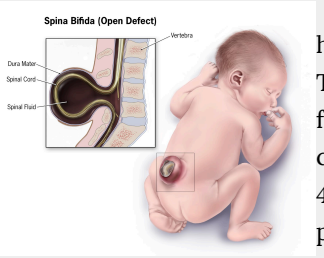


Image by Centers for Disease Control and Prevention (CDC) / Public Domain

A pregnancy may happen unexpectedly. Therefore, it is important for all women of childbearing age to get 400 micrograms of folate per day prior to pregnancy and 600 micrograms per day during pregnancy. Folate, which is also known as folic acid, is crucial for the production of DNA and RNA and the formation of cells. A deficiency can cause megaloblastic anemia, or the development of abnormal red blood cells, in pregnant women. It can also have a profound effect on the unborn baby. Typically, folate intake has the greatest impact during the first eight weeks of pregnancy, when the neural tube closes. The neural tube develops into the fetus's brain and spinal cord, and adequate folate reduces the risk of brain abnormalities and neural tube defects, which occur in one in a thousand pregnancies in North America each year. This vital nutrient also supports the spinal cord and its protective coverings. Inadequate folic acid can result in birth defects, such as spina bifida, which is the failure of the spinal column to close. The name "folate" is derived from the Latin word folium for leaf, and leafy green vegetables such as spinach and kale are excellent sources of it. Folate is also found in legumes, liver, and

oranges. Additionally, since 1998, food manufacturers have been required to add folate to cereals and other grain products.[2]

Weight Gain during Pregnancy

During pregnancy, a mother's body changes in many ways. One of the most notable and significant changes is weight gain. If a pregnant woman does not gain enough weight, her unborn baby will be at risk. Poor weight gain, especially in the second and third trimesters, could result not only in low birth weight, but also infant mortality and intellectual disabilities. Therefore, it is vital for a pregnant woman to maintain a healthy amount of weight gain. Her weight prior to pregnancy also has a major effect. Infant birth weight is one of the best indicators of a baby's future health. Pregnant women of normal prepregnancy weight should gain between 25 and 35 pounds in total through the entire pregnancy. The precise amount that a mother should gain usually depends on her beginning weight or body mass index (BMI). See Table 13.1 "Body Mass Index and Pregnancy" for The Institute of Medicine (IOM) recommendations.

2. Folic Acid. MedlinePlus, a service of the National Institutes of Health. 1995–2012 http://www.nlm.nih.gov/medlineplus/druginfo/natural/1017.html. Updated August 7, 2011. Accessed November 22, 2017.

Table 13.1 Body Mass Index and Pregnancy[3]

Prepregnancy BMI	Weight Category	Recommended Weight Gain
Below 18.5	Underweight	28–40 lbs.
18.5–24.9	Normal	25–35 lbs.
25.0–29.9	Overweight	15–25 lbs.
Above 30.0	Obese (all classes)	11–20 lbs.

Starting weight below or above the normal range can lead to different complications. Pregnant women with a prepregnancy BMI below twenty are at a higher risk of a preterm delivery and an underweight infant. Pregnant women with a prepregnancy BMI above thirty have an increased risk for a cesarean section during delivery. Therefore, it is optimal to have a BMI in the normal range prior to pregnancy.

Generally, women gain 2 to 5 pounds in the first trimester. After that, it is best not to gain more than one pound per week. Some of the new weight is due to the growth of the fetus, while some is due to changes in the mother's body that support the pregnancy. Weight gain often breaks down in the following manner as shown in Figure 13.2 6 to 8 pounds of fetus, 1 to 2 pounds for the placenta (which supplies nutrients to the fetus and removes waste products), 2 to 3 pounds for the amniotic sac (which contains fluids that surround and cushion the fetus), 1 to 2 pounds in the breasts, 1 to 2 pounds in the uterus, 3 to 4 pounds of maternal blood, 3 to 4 pounds maternal fluids, and 8 to 10 pounds of extra maternal fat stores that will be needed for breastfeeding and delivery. Women who are pregnant

3. Weight Gain during Pregnancy: Reexamining the Guidelines. Institute of Medicine. https://www.nap.edu/resource/12584/Report-Brief---Weight-Gain-During-Pregnancy.pdf

with more than one fetus are advised to gain even more weight to ensure the health of their unborn babies.

Figure 13.2 Areas of weight gain for pregnant women

The weight an expectant mother gains during pregnancy is two-thirds to three quarters lean tissue, including the placenta and fetus. Weight gain is not the only major change. A pregnant woman also will find that her breasts enlarge and that she has a tendency to retain water[4].

4. Weight Gain during Pregnancy. Utah Department of Health, Baby Your Baby. http://www.babyyourbaby.org/

The pace of weight gain is also important. If a woman puts on weight too slowly, her physician may recommend nutritional counseling. If she gains weight too quickly, especially in the third trimester, it may be the result of edema, or swelling due to excess fluid accumulation. Rapid weight gain may also result from increased calorie consumption or a lack of exercise.

Weight Loss after Pregnancy

During labor, new mothers lose some of the weight they gained during pregnancy with the delivery of their child. In the following weeks, they continue to shed weight as they lose accumulated fluids and their blood volume returns to normal. Some studies have hypothesized that breastfeeding also helps a new mother lose some of the extra weight, although research is ongoing.[5].

New mothers who gain a healthy amount of weight and participate in regular physical activity during their pregnancies also have an easier time shedding weight post-pregnancy. However, women who gain more weight than needed for a pregnancy typically retain that excess weight as body fat. If those few pounds increase a new mother's BMI by a unit or more, that could lead to complications such as hypertension or Type 2 diabetes in future pregnancies or later in life.

pregnancy/during. Published 2012. Accessed November 22, 2017.

5. Stuebe AM, Rich-Edwards JW. (2009). The Reset Hypothesis: Lactation and Maternal Metabolism. , *American Journal of Perinatology*, 26(1), 81–88.

Nutritional Requirements

As a mother's body changes, so do her nutritional needs. Pregnant women must consume more calories and nutrients in the second and third trimesters than other adult women. However, the average recommended daily caloric intake can vary depending on activity level and the mother's normal weight. Also, pregnant women should choose a high-quality, diverse diet, consume fresh foods, and prepare nutrient-rich meals. Steaming is one of the best ways to cook vegetables. Vitamins are destroyed by overcooking, whereas uncooked vegetables and fruits have the highest vitamin content. It is also recommended for pregnant women to take prenatal supplements to ensure adequate intake of the needed micronutrients.

Energy and Macronutrients

During the first trimester, a pregnant woman has the same energy requirements as normal and should consume the same number of calories as usual. However, as the pregnancy progresses, a woman must increase her caloric intake. According to the IOM, she should consume an additional 340 calories per day during the second trimester, and an additional 450 calories per day during the third trimester. This is partly due to an increase in metabolism, which occurs during pregnancy and contributes to increased energy needs. A woman can easily meet these increased needs by consuming more nutrient-dense foods.

The recommended daily allowance, or RDA, of carbohydrates during pregnancy is about 175 to 265 grams per day to fuel fetal brain development. The best food sources for pregnant women include whole-grain breads and cereals, brown rice, root vegetables, legumes, and fruits. These and other unrefined carbohydrates

provide nutrients, phytochemicals, antioxidants, and the extra 3 mg/day of fiber that is recommended during pregnancy. These foods also help to build the placenta and supply energy for the growth of the unborn baby.

During pregnancy, extra protein is needed for the synthesis of new maternal and fetal tissues. Protein builds muscle and other tissues, enzymes, antibodies, and hormones in both the mother and the unborn baby. Additional protein also supports increased blood volume and the production of amniotic fluid. The RDA of protein during pregnancy is 71 grams per day, which is 25 grams above the normal recommendation. Protein should be derived from healthy sources, such as lean red meat, poultry, legumes, nuts, seeds, eggs, and fish. Low-fat milk and other dairy products also provide protein, along with calcium and other nutrients.

There are no specific recommendations for fats in pregnancy, apart from following normal dietary guidelines. Although this is the case, it is recommended to increase the amount of essential fatty acids linoleic acid and ∝-linolenic acid because they are incorporated into the placenta and fetal tissues. Fats should make up 25 to 35 percent of daily calories, and those calories should come from healthy fats, such as avocados and salmon. It is not recommended for pregnant women to be on a very low-fat diet, since it would be hard to meet the needs of essential fatty acids and fat-soluble vitamins. Fatty acids are important during pregnancy because they support the baby's brain and eye development.

Fluids

Fluid intake must also be monitored. According to the IOM, pregnant women should drink 2.3 liters (about 10 cups) of liquids per day to provide enough fluid for blood production. It is also important to drink liquids during and after physical activity or when it is hot and humid outside, to replace fluids lost to perspiration.

The combination of a high-fiber diet and lots of liquids also helps to prevent constipation, a common complaint during pregnancy.

Pregnancy: Body Changes and Discomforts. US Department of Health and Human Services, Office on Women's Health. http://www.womenshealth.gov/pregnancy/you-are-pregnant/body-changes -discomforts.cfm. Updated September 27, 2010. Accessed December 2, 2017.

Vitamins and Minerals

The daily requirements for nonpregnant women change with the onset of a pregnancy. Taking a daily prenatal supplement or multivitamin helps to meet many nutritional needs. However, most of these requirements should be fulfilled with a healthy diet. The following table compares the normal levels of required vitamins and minerals to the levels needed during pregnancy. For pregnant women, the RDA of nearly all vitamins and minerals increases.

Table 13.2 Recommended Nutrient Intakes during Pregnancy

Nutrient	Nonpregnant Women	Pregnant Women
Vitamin A (mcg)	700.0	770.0
Vitamin B6 (mg)	1.5	1.9
Vitamin B12 (mcg)	2.4	2.6
Vitamin C (mg)	75	85
Vitamin D (mcg)	15	15
Vitamin E (mg)	15	15
Calcium (mg)	1,000.0	1,000.0
Folate (mcg)	400	600
Iron (mg)	18	27
Magnesium (mg)	320	360
Niacin(B3) (mg)	14	18
Phosphorus	700	700
Riboflavin (B2) (mg)	1.1	1.4
Thiamine (B1) (mg)	1.1	1.4
Zinc (mg)	8	11

Source: Nutrition during Pregnancy: Part I: Weight Gain, Part II: Nutrient Supplements. Institute of Medicine. http://iom.edu/Reports/1990/Nutrition-During-Pregnancy-Part-I-Weight-Gain-Part-II-Nutrient-Supplements.aspx. Published January 1, 1990. Accessed November 22, 2017.

Vitamins:

https://www.ncbi.nlm.nih.gov/books/NBK56068/table/summarytables.t2/?report=objectonly. Published by the National Academies Press; 2011. Accessed April 25, 2020.

Minerals:

https://www.ncbi.nlm.nih.gov/books/NBK545442/table/appJ_tab3/?report=objectonly. Published March 5, 2019. Accessed April 25, 2020.

The micronutrients involved with building the skeleton—vitamin D, calcium, phosphorus, and magnesium—are crucial during pregnancy to support fetal bone development. Although the levels

are the same as those for nonpregnant women, many women do not typically consume adequate amounts and should make an extra effort to meet those needs. Many of these nutrient requirements are higher yet for pregnant mothers who are in their teen years due to higher needs for their own growth in addition to the growth of the fetus.

There is an increased need for all B vitamins during pregnancy. Adequate vitamin B6 supports the metabolism of amino acids, while more vitamin B12 is needed for the synthesis of red blood cells and DNA. Also remember that folate needs increase during pregnancy to 600 micrograms per day to prevent neural tube defects. This micronutrient is crucial for fetal development because it also helps produce the extra blood a woman's body requires during pregnancy.

Additional zinc is crucial for cell development and protein synthesis. The need for vitamin A also increases, and extra iron intake is important because of the increase in blood supply during pregnancy and to support the fetus and placenta. Iron is the one micronutrient that is almost impossible to obtain in adequate amounts from food sources only. Therefore, even if a pregnant woman consumes a healthy diet, there still is a need to take an iron supplement, in the form of ferrous salts.

For most other minerals, recommended intakes are similar to those for nonpregnant women, although it is crucial for pregnant women to make sure to meet the RDAs to reduce the risk of birth defects. In addition, pregnant mothers should avoid exceeding the Upper Limit recommendations. Taking megadose supplements can lead to excessive amounts of certain micronutrients, such as vitamin A and zinc, which may produce toxic effects that can also result in birth defects.

Guide to Eating during Pregnancy

While pregnant women have an increased need for energy, vitamins,

and minerals, energy increases are proportionally less than other macronutrient and micronutrient increases. So, nutrient-dense foods, which are higher in proportion of macronutrients and micronutrients relative to calories, are essential to a healthy diet. Examples of nutrient-dense foods include fruits, vegetables, whole grains, peas, beans, eggs, reduced-fat dairy, and lean meats. Pregnant women should be able to meet almost all of their increased needs via a healthy diet. However, expectant mothers should take a prenatal supplement to ensure an adequate intake of iron and folate. Here are some additional dietary guidelines for pregnant women.[6]:

- Eat iron-rich or iron-fortified foods, including meat or meat alternatives, breads, and cereals, to help satisfy increased need for iron and prevent iron-deficiency anemia.
- Include vitamin C-rich foods, such as orange juice, broccoli, or strawberries, to enhance iron absorption.
- Eat a well-balanced diet, including fruits, vegetables, whole grains, calcium-rich foods, lean meats, and a variety of cooked seafood (excluding fish that are high in mercury, such as swordfish and shark).
- Drink additional fluids, water especially.

6. Staying Healthy and Safe. US Department of Health and Human Services, Office on Women's Health. Last updated March 5, 2009. https://www.womenshealth.gov/pregnancy/youre-pregnant-now-what/staying-healthy-and-safe. Updated February 1, 2017. Accessed November 30, 2017.

Foods to Avoid

A number of substances can harm a growing fetus. Therefore, it is vital for women to avoid them throughout a pregnancy. Some are so detrimental that a woman should avoid them even if she suspects that she might be pregnant. For example, consumption of alcoholic beverages results in a range of abnormalities that fall under the umbrella of fetal alcohol spectrum disorders. They include learning and attention deficits, heart defects, and abnormal facial features (See Figure 13.3). Alcohol enters the unborn baby via the umbilical cord and can slow fetal growth, damage the brain, or even result in miscarriage. The effects of alcohol are most severe in the first trimester, when the organs are developing. There is no safe amount of alcohol that a pregnant woman can consume. Although pregnant women in the past may have participated in behavior that was not known to be risky at the time, such as drinking alcohol or smoking cigarettes, today we know that it is best to avoid those substances completely to protect the health of the unborn baby.

Figure 13.3 Craniofacial features associated with fetal alcohol syndrome

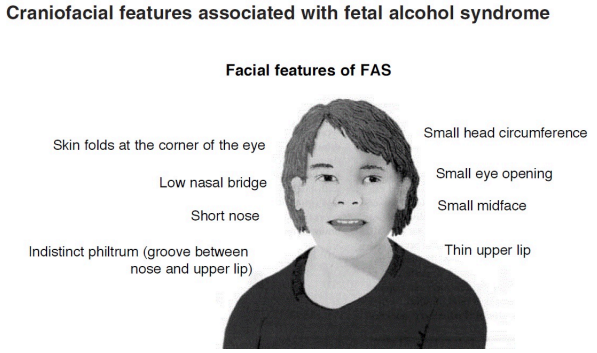


Figure by NIH/ National Institute on Alcohol Abuse and Alcoholism / Public Domain

Pregnant women should also limit caffeine intake, which is found not only in coffee, but also tea, colas, cocoa, chocolate, and some

over-the-counter painkillers. Some studies suggest that very high amounts of caffeine have been linked to babies born with low birth weights. The American Journal of Obstetrics and Gynecology released a report, which found that women who consume 200 milligrams or more of caffeine a day (which is the amount in 10 ounces of coffee or 25 ounces of tea) increase the risk of miscarriage[7].

Consuming large quantities of caffeine affects the pregnant mother as well, leading to irritability, anxiety, and insomnia. Most experts agree that small amounts of caffeine each day are safe (about one 8-ounce cup of coffee a day or less)[8]. However, that amount should not be exceeded.

Foodborne Illness

For both mother and child, foodborne illness can cause major health problems. For example, the foodborne illness caused by the bacteria Listeria monocytogenes can cause spontaneous abortion and fetal or newborn meningitis. According to the CDC, pregnant women are twenty times more likely to become infected with this disease, which is known as listeriosis, than nonpregnant, healthy adults. Symptoms include headaches, muscle aches, nausea, vomiting, and

7. Weng X, Odouli R, Li DK. (2008). Maternal caffeine consumption during pregnancy and the risk of miscarriage: a prospective cohort study. *American Journal of Obstetrics & Gynecology*, 198, 279.e1-279.e8.
8. American Medical Association. (2008). *Complete Guide to Prevention and Wellness*. Hoboken, NJ: John Wiley & Sons, Inc., 495.

fever. If the infection spreads to the nervous system, it can result in a stiff neck, convulsions, or a feeling of disorientation[9].

Foods more likely to contain the bacteria that should be avoided are unpasteurized dairy products, especially soft cheeses, and also smoked seafood, hot dogs, paté, cold cuts, and uncooked meats. To avoid consuming contaminated foods, women who are pregnant or breastfeeding should take the following measures:

- Thoroughly rinse fruits and vegetables before eating them
- Keep cooked and ready-to-eat food separate from raw meat, poultry, and seafood
- Store food at 40° F (4° C) or below in the refrigerator and at 0° F (–18° C) in the freezer
- Refrigerate perishables, prepared food, or leftovers within two hours of preparation or eating
- Clean the refrigerator regularly and wipe up any spills right away
- Check the expiration dates of stored food once per week
- Cook hot dogs, cold cuts (e.g., deli meats/luncheon meat), and smoked seafood to 160° F before consuming

It is always important to avoid consuming contaminated food to prevent food poisoning. This is especially true during pregnancy. Heavy metal contaminants, particularly mercury, lead, and cadmium, pose risks to pregnant mothers. As a result, vegetables should be washed thoroughly or have their skins removed to avoid consuming heavy metals. Maintaining good iron status helps women

9. Listeria and Pregnancy. American Pregnancy Association. http://www.americanpregnancy.org/pregnancycomplications/listeria.html. Updated March 10, 2017. Accessed November 29, 2017.

not to absorb these heavy metals, so it provides an additional level of protection.

Pregnant women can eat fish, ideally 8 to 12 ounces of different types each week. Expectant mothers are able to eat cooked shellfish such as shrimp, farm-raised fish such as salmon, and a maximum of 6 ounces of albacore (white) tuna. Canned light tuna is preferred over canned white albacore tuna because it has lower mercury levels. It is very important for pregnant women to avoid fish with very high methylmercury levels, such as shark, swordfish, tilefish, and king mackerel. Pregnant women should also avoid consuming raw fish and shellfish to avoid foodborne illness. The Environmental Defense Fund eco-rates fish to provide guidelines to consumers about the safest and most environmentally friendly choices. You can find ratings for fish and seafood at http://www.edf.org. A Local Guide to Eating Fish Safely from the Hawai'i Department of Health provides excellent guidance about eating local fish for pregnant women, nursing mothers, and young children. See: https://health.hawaii.gov/wic/files/2019/05/A-Local-Guide-to-Eating-Fish-Safely_2019-update.pdf. Updated April 2019. Accessed April 25, 2020.

Physical Activity during Pregnancy

For most pregnant women, physical activity is a must and is recommended in the 2015-2020 Dietary Guidelines for Americans and the 2018 Physical Activity Guidelines for Americans [10]. Regular exercise of moderate intensity, about thirty minutes per day most

10. -U.S. Department of Health and Human Services. (2018) *Physical Activity Guidelines for Americans, 2nd edition.* U.S. Department of Health and Human Services

days of the week, keeps the heart and lungs healthy. It also helps to improve sleep and boosts mood and energy levels. In addition, women who exercise during pregnancy report fewer discomforts and may have an easier time losing excess weight after childbirth. Brisk walking, swimming, or an aerobics class geared toward expectant mothers are all great ways to get exercise during a pregnancy. Healthy women who already participate in vigorous activities before pregnancy, such as running, can continue doing so during pregnancy provided they discuss an exercise plan with their physicians.

However, pregnant women should avoid pastimes that could cause injury, such as soccer, football, and other contact sports, or activities that could lead to falls, such as horseback riding and downhill skiing. It may be best for pregnant women not to participate in certain sports, such as tennis, that require you to jump or change direction quickly. Scuba diving should also be avoided because it might result in the fetus developing decompression sickness. This potentially fatal condition results from a rapid decrease in pressure when a diver ascends too quickly[11].

Food Cravings and Aversions

Food aversions and cravings do not have a major impact unless food choices are extremely limited. The most common food aversions are milk, meats, pork, and liver. For most women, it is not harmful

11. Reid, R. L., & Lorenzo, M. (2018). SCUBA Diving in Pregnancy. *Journal of Obstetrics and Gynaecology Canada*, 40(11), 1490–1496. https://doi.org/10.1016/j.jogc.2017.11.024)

to indulge in the occasional craving, such as the desire for pickles and ice cream. However, a medical disorder known as pica occurs during pregnancy more often than in nonpregnant women. Pica is willingly consuming foods with little or no nutritive value, such as dirt, clay, laundry starch, and large quantities of ice or freezer frost. In some places this is a culturally accepted practice. However, it can be harmful if these substances take the place of nutritious foods or contain toxins. Pica is associated with iron deficiency, sometimes even in the absence of anemia, and iron tends to cure the pica behavior.

Complications during Pregnancy

Expectant mothers may face different complications during the course of their pregnancy. They include certain medical conditions that could greatly impact a pregnancy if left untreated, such as gestational hypertension and gestational diabetes, which have diet and nutrition implications.

Gestational hypertension is a condition of high blood pressure during the second half of pregnancy.

First-time mothers are at a greater risk, along with women who have mothers or sisters who had gestational hypertension, women carrying multiple fetuses, women with a prior history of high blood pressure or kidney disease, and women who are overweight or who have obesity when they become pregnant. Hypertension can prevent the placenta from getting enough blood, which would result in the baby getting less oxygen and nutrients. This can result in low birth weight, although most women with gestational hypertension can still deliver a healthy baby if the condition is detected and treated early.

Some risk factors can be controlled, such as diet, while others cannot, such as family history. If left untreated, gestational hypertension can lead to a serious complication called preeclampsia

and eclampsia, which is sometimes referred to as toxemia of pregnancy. This disorder is marked by elevated blood pressure and protein in the urine and is associated with swelling. To prevent preeclampsia, the WHO recommends increasing calcium intake for women consuming diets low in that micronutrient, administering a low dosage of aspirin (75 milligrams), and increasing prenatal checkups. The WHO does not recommend the restriction of dietary salt intake during pregnancy with the aim of preventing the development of pre-eclampsia and its complications[12].

About 4 percent of pregnant women suffer from a condition known as gestational diabetes, which is abnormal glucose tolerance during pregnancy. The body becomes resistant to the hormone insulin, which enables cells to transport glucose from the blood. Gestational diabetes is usually diagnosed around twenty-four to twenty-six weeks, although it is possible for the condition to develop later into a pregnancy. Signs and symptoms of this disease include extreme hunger, thirst, or fatigue. If blood sugar levels are not properly monitored and treated, the baby might gain too much weight and require a cesarean delivery. Diet and regular physical activity can help to manage this condition. Most patients who suffer from gestational diabetes also require daily insulin injections to boost the absorption of glucose from the bloodstream and promote the storage of glucose in the form of glycogen in liver and muscle cells. Gestational diabetes usually resolves after childbirth, although women who experience this condition are more likely to develop Type 2 diabetes later in life, particularly if they are overweight.[13].

12. WHO Recommendations for Prevention and Treatment of Pre-eclampsia and Eclampsia.World Health Organization. http://whqlibdoc.who.int/publications/2011/9789241548335_eng.pdf. Published 2011. Accessed June 9, 2020.
13. Noctor, E., & Dunne, F. P. (2015). Type 2 diabetes after

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

An interactive or media element has been excluded from this version of the text. You can view it online here:
http://pressbooks.oer.hawaii.edu/humannutrition2/?p=446

gestational diabetes: The influence of changing diagnostic criteria. World Journal of Diabetes, 6(2), 234–244. https://doi.org/10.4239/wjd.v6.i2.234.

Infancy

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

Image by Marie Kainoa Fialkowski Revilla / CC BY 4.0

Diet and nutrition have a major impact on a child's development from infancy into the adolescent years. A healthy diet not only affects growth, but also immunity, intellectual capabilities, and emotional well-being. One of the most important jobs of parenting

is making sure that children receive an adequate amount of needed nutrients to provide a strong foundation for the rest of their lives.

Most expectant mothers begin thinking about how they will feed their baby early in their pregnancy. Therefore, it is important to offer breastfeeding education and support starting with the first prenatal appointment. Support from family members, especially the baby's father and grandmother, plus friends, employers, and others can greatly help with both the decision-making process during pregnancy and the beginning and maintenance of breastfeeding after the baby's birth. In the United States, about 83.2 percent of babies start out being breastfed.[1] Yet by the age of six months, when solid foods should begin to be introduced into a child's diet along with breast milk, only about 25 percent of infants in the United States were still breastfed exclusively, according to the Centers for Disease Control and Prevention (CDC).[2]

The approval and assistance of family members, friends, employers, health-care providers, and policymakers can make an enormous difference and provide the needed promotion and support for mothers who wish to breastfeed their children. Education about breastfeeding typically begins with health-care providers. During prenatal care and often soon after a woman has given birth, doctors, nurses, and other clinicians can explain the benefits of breastfeeding and describe the proper technique. Nearly all births in the United States and Canada occur in hospital settings, and hospital practices in labor, delivery, postpartum care, and discharge planning can inform and support women who want to

1. U.S. Centers for Disease Control. (2018). *Breastfeeding report card United States*, 2018. https://www.cdc.gov/breastfeeding/pdf/2018breastfeedingreportcard.pdf
2. U.S. Centers for Disease Control. (2018). *Breastfeeding report card United States*, 2018. https://www.cdc.gov/breastfeeding/pdf/2018breastfeedingreportcard.pdf

breastfeed. Once a new mother has left the hospital for home, she needs access to a trained individual who can provide consistent information. International Board Certified Lactation Consultants (IBCLCs) are health-care professionals (often a registered nurse or registered dietitian) certified in breastfeeding management that work with new mothers to solve problems and educate families about the benefits of this practice. Research shows that breastfeeding rates are higher among women who had infants in hospitals that make IBCLCs available to new mothers, rather than those who gave birth in institutions without these professionals on staff.[3]

Other important practices for maternity hospitals to support breastfeeding are summarized in the Ten Steps to Successful Breastfeeding, launched jointly by the WHO and UNICEF.[4] These recommended practices include: helping mothers initiate breastfeeding within one hour of birth; keeping mothers and babies together (rooming in); encouraging breastfeeding on demand, and giving breastfed infants no food or drink other than breastmilk, unless medically indicated.

In addition, spouses, partners, and other family members can play critical roles in helping a pregnant woman make the decision to breastfeed and assisting with feeding after the baby is born.

3. US Department of Health and Human Services. (2011, January 20). *Executive summary: The Surgeon General's call to action to support breastfeeding.* http://www.surgeongeneral.gov/topics/breastfeeding/executivesummary.pdf
4. Baby-Friendly USA. (2020). *The ten steps to successful breastfeeding*. https://www.babyfriendlyusa.org/for-facilities/practice-guidelines/10-steps-and-international-code/

Employment can also factor into a woman's decision to breastfeed or her ability to maintain the practice. Employed mothers have been less likely to initiate breastfeeding and tend to breastfeed for a shorter period of time than new mothers who are not employed or who have lengthy maternity leaves. In 2010 in the United States, the passage of the Affordable Care Act (ACA) required most employers to provide accommodations within the workplace for new mothers to pump breast milk. This law requires a private and clean space within the workplace, other than a restroom, along with adequate break time for a woman to express milk.[5]It also requires health insurance to cover certain breastfeeding services and supplies such as a breast pump.

Additionally, the Hawai'i State Legislature has passed several bills to support breastfeeding. These bills provide a number of rights to breastfeeding women in Hawai'i. These include: the right to breastfeed in public, the right to pump breastmilk at work (extending beyond the ACA worksite protections), protection from an employer from firing or penalizing a lactating employee because the employee breastfeeds or expresses milk at the workplace,[6] and the right for breastfeeding mothers to decline jury duty until the

5. US Department of Health and Human Services. (2011, January 20). *Executive summary: The Surgeon General's call to action to support breastfeeding.* http://www.surgeongeneral.gov/topics/breastfeeding/executivesummary.pdf
6. US Legal, Inc. (2019). *Hawaii.* https://breastfeedinglaws.uslegal.com/state-laws/hawaii-breast-feeding-laws/

child is 1 year old.[7] See: https://wicworks.fns.usda.gov/resources/50-state-summary-breastfeeding-laws

Everyday Connection

In the Pacific, the state of Hawai'i and and the territory of Guam are mandated to provide several accommodations within the workplace for new mothers. All employers are to required to allow breastfeeding mothers adequate break time to pump or nurse in location other than a bathroom. To learn more about Hawai'i's laws visit http://health.hawaii.gov/wic/files/2013/04/WorkplaceBreastfeeding_02_2014.pdf and for Guam's laws visit http://www.guamcourts.org/CompilerofLaws/GCA/10gca/10gc092A.pdf.

Members of a community can also promote and support breastfeeding. New mothers can join peer counseling groups or turn to other women within their community who have previous experience with breastfeeding. In addition, community-based programs can provide education and support. The US Department of Agriculture's Women, Infants, and Children program provides information on breastfeeding and both professional and peer support for women and their babies from low-income families. Launched in 2004, the Loving Support program combines peer counseling with breastfeeding promotion efforts to increase

7. Hawai'i State Judiciary. (2020). *Jury service frequently asked questions*. https://www.courts.state.hi.us/general_information/jury/jury_service_faqs#Q9

duration rates across the United States. La Leche League is an international program that provides mother-to-mother support, encouragement, and education about breastfeeding for women around the world. For more information on La Leche League, visit http://www.llli.org. The state coalition, Breastfeeding Hawai'i, provides a list of local and national resources: https://bfhawaii.org/index.php/lactation-support/.

Although breastfeeding should be recommended and encouraged for almost all new mothers, it is important to remember that the decision to breastfeed is a personal choice and women should not be made to feel guilty if they cannot, or choose not, to breastfeed their infants. In some rare cases, a woman is unable to breastfeed or it is not in the baby's best interest, for example if the baby has galactosemia, an inborn error of metabolism.

Nutritional choices that parents make, such as the decision to breastfeed or bottle-feed, not only affect early childhood development, but also a child's health and wellness later in life. Therefore, it is imperative to promote and support the best practices for the well-being of infants and mothers alike.

Infancy (Birth to Age One)

Image by Marie Kainoa Fialkowski Revilla / CC BY 4.0

A number of major physiological changes occur during infancy. The trunk of the body grows faster than the arms and legs, while the head becomes less prominent in comparison to the limbs. Organs and organ systems grow at a rapid rate. Also during this period, countless synapse pathways to link brain neurons are reinforced while others are trimmed back in the brain. Two soft spots on the baby's skull, known as fontanels, allow the skull to accommodate rapid brain growth. The posterior fontanel closes first, by the age

of eight weeks. The anterior fontanel closes about a year later, at eighteen months on average. Developmental milestones include sitting up without support, learning to walk, teething, and vocalizing among many, many others. All of these changes require adequate nutrition to ensure development at the appropriate rate.[8]

Healthy infants grow steadily, but not always at an even pace. For example, during the first year of life, height increases by 50 percent, while weight triples. Physicians and other health professionals use growth charts to track a baby's development process. Because infants cannot stand, length is used instead of height to determine the rate of a child's growth. Other important developmental measurements include head circumference and weight. All of these must be tracked and compared against standard measurements for an infant's age.

In the US, for infants and toddlers from birth to 24 months of age, the WHO growth charts are used to monitor growth. These standards represent optimal growth for children at this age and allow for tracking growth trends over time through percentile rankings. Growth charts may provide warnings that a child has a medical problem or is malnourished. Growth that is too rapid can increase the risk for overweight and obesity in childhood and later in life. Insufficient weight or height gain during infancy may indicate a condition known as failure-to-thrive (FTT), which is characterized by poor growth. FTT can happen at any age, but in infancy, it typically occurs after six months. Some causes include poverty, lack of enough food, feeding inappropriate foods, and excessive intake of fruit juice.

Figure 13.4 WHO Growth Chart For Boys From Birth To 24 Months

8. McMillan B. (2008). *Illustrated atlas of the human body*. Weldon Owen.

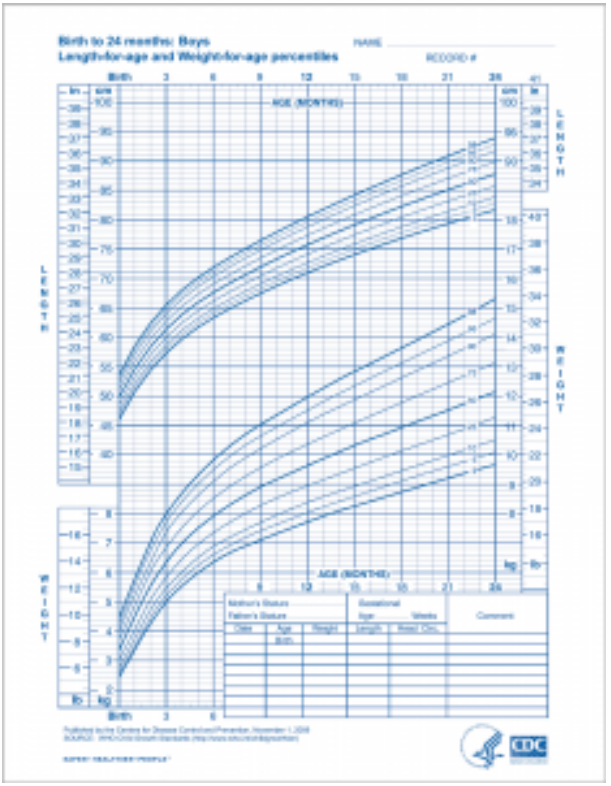


Image by Centers for Disease Control and Prevention / Public Domain

Nutritional Requirements

Requirements for macronutrients and micronutrients on a per-kilogram basis are higher during infancy than at any other stage in the human life cycle. These needs are affected by the rapid cell division that occurs during growth, which requires energy and protein, along with the nutrients that are involved in synthesis of DNA and other cellular components. During this period, children are entirely dependent on their parents or other caregivers to meet these needs. For almost all infants six months or younger, breast

milk is the best source to fulfill nutritional requirements. An exclusively breastfed infant does not even need extra water, including in hot climates.

A newborn infant (birth to 28 days) requires feedings eight to twelve times a day or more. Between 1 and 3 months of age, the breastfed infant becomes more efficient, and the number of feedings per day often become fewer even though the amount of milk consumed stays the same. After about six months, infants can gradually begin to consume solid foods to help meet nutrient needs. Foods that are added in addition to breastmilk are called complementary foods. Complementary foods should be nutrient dense to provide optimal nutrition. Complementary foods include baby meats, vegetables, fruits, infant cereal, and dairy products such as yogurt, but not infant formula. Infant formula is a substitute, not a complement to breastmilk. In addition to complementary foods, the World Health Organization recommends that breastfeeding continue up to 2 years of age or beyond, and the American Academy of Pediatrics recommends at least one year of breastfeeding, or longer. [9]

Energy and Macronutrients

Energy needs relative to size are much greater in an infant than an adult. A baby's resting metabolic rate is two times that of an adult. The RDA to meet energy needs changes as an infant matures and puts on more weight. The IOM uses a set of equations to calculate

9. World Health Organization. (2019). *Promoting proper feeding for infants and young children.* https://www.who.int/nutrition/topics/infantfeeding/en/

the total energy expenditure and resulting energy needs. For example, the equation for the first three months of life is (89 x weight [kg] –100) + 175 kcal.

Based on these equations, the estimated energy requirement for infants from zero to six months of age is 472 to 645 kilocalories per day for boys and 438 to 593 kilocalories per day for girls. For infants ages six to twelve months, the estimated requirement is 645 to 844 kilocalories per day for boys and 593 to 768 kilocalories per day for girls. From the age one to age two, the estimated requirement rises to 844–1,050 kilocalories per day for boys and 768–997 kilocalories per day for girls.[10] How often an infant wants to eat will also change over time due to growth spurts, which typically occur at about two weeks and six weeks of age, and again at about three months and six months of age.

The dietary recommendations for infants are based on the nutritional content of human breast milk. Carbohydrates make up about 40 to 55percent of the caloric content in breast milk, which amounts to a RDA (AI) of about 60 grams for infants 0-6 months old, and 95 grams for infants 7-12 months old. Almost all of the carbohydrate in human milk is lactose, which infants digest and tolerate well. In fact, lactose intolerance is practically nonexistent in infants. Protein makes up about 5 to 9 percent of the caloric content of breast milk, which amounts to a RDA (AI) of 9.1 grams per day for infants 0-6 months, and a RDA of 11 grams per day for infants 7-12 months. Infants have a high need for protein to support growth and development, although excess protein (which is only a concern with bottle-feeding) can cause dehydration, diarrhea, fever, and acidosis in premature infants. About 30 to 50 percent of the

10. Food and Nutrition Board, Institute of Medicine. (2005). *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids*. The National Academies Press.

caloric content in breast milk is made up of fat. A high-fat diet that includes cholesterol is necessary to support the development of neural pathways in the brain and throughout the body. However, saturated fats and trans fatty acids inhibit this growth. Infants who are over the age of six months, which means they are receiving complementary foods, should not consume foods that are high in these types of fats. The RDA (AI) for total fat is 30 grams per day for infants 0-6 months old and 31 grams per day for infants 7-12 months old.

Micronutrients

Almost all of the nutrients that infants require during the first 6 months can be met if they consume an adequate amount of breast milk. There are a few exceptions, though. Unless the mother is taking a large dose of Vitamin D, human milk will be low in vitamin D, which is needed for calcium absorption and building bone, among other things. Therefore, breastfed children often need to take a vitamin D supplement in the form of drops. Infants at the highest risk for vitamin D deficiency are those with darker skin and little to no exposure to sunlight, and infants born prematurely. Breast milk is also low in vitamin K[11] *Pediatric clinics of North America*, 60(1), 49–74., which is required for blood clotting, and deficits could lead to bleeding or hemorrhagic disease. Babies are born with limited vitamin K, so supplementation may be needed initially and some states require a vitamin K injection after birth. Also, breast milk is not high in iron, but the iron in breast milk is well absorbed by infants. After five to eight months, however, an infant needs an additional source of iron other than breast milk. For exclusively

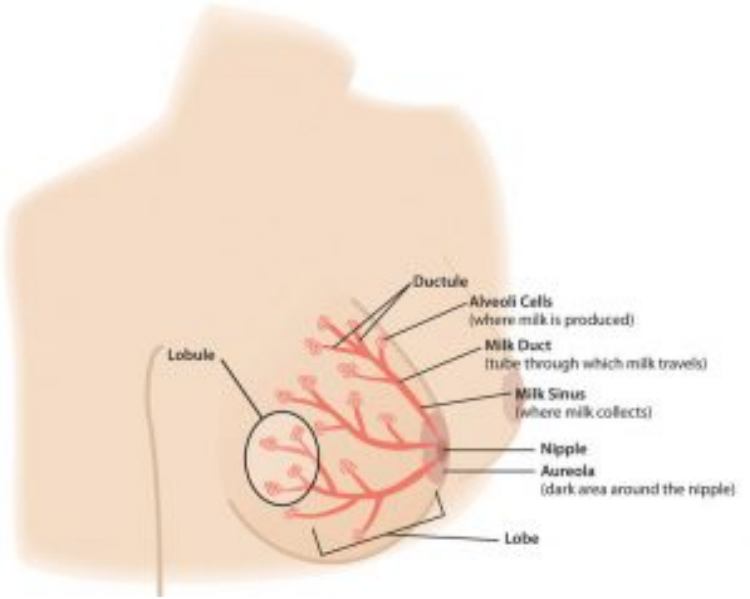
11. Ballard, O., & Morrow, A. L. (2013). Human milk composition: nutrients and bioactive factors.

breastfed infants, 6 months of age is a good time to introduce sources of highly bioavailable iron and zinc such as baby meats. Iron-fortified cereals and beans can boost the iron intake as well.

Fluids

Infants have a high need for fluids, 1.5 milliliters per kilocalorie consumed compared to 1.0 milliliters per kilocalorie consumed for adults. This is because children have larger body surface area per unit of body weight and a higher metabolic rate. Therefore, they are at greater risk of dehydration. However, parents or other caregivers can meet an infant's fluid needs with breast milk or formula. As solids are introduced, parents must make sure that young children continue to drink fluids throughout the day.

Breastfeeding



Although few aspects of human nutrition are surrounded by as much public controversy as is the choice to breastfeed or formula feed an infant, a little knowledge about the science of breastfeeding can go a long way to settling this debate. This section will cover the science of lactation and practical ways to improve both the breastfeeding experience and the nutritional status of mothers and infants. Learning about the different parts of the breast and their function is a first step to becoming better able to support mothers who want to breastfeed.

The structure of the breast includes the alveoli which are grape-like clusters where milk is made. A network of ducts branch out and carry the milk from the alveoli to the nipple. A tiny muscle surrounds each of the alveoli; when a baby nurses at the breast, a hormone is released from the mother's brain that makes these muscles contract and push the milk out into the ducts and towards

the nipple. Groups of alveoli connected by ducts are organized into lobes, or sections, of the breast. The breast contains 15 to 25 lobes, and each lobe contains 10 to 100 alveoli.

The areola is the darker skin around the nipple and is a visual target that helps the baby find the breast. The bumps on the areola are glands that provide lubrication and protection to the tissue. These glands also produce a scent to help the baby find the nipple. The nipple and areola contain erectile smooth muscles that contract to make the nipple protrude more during breastfeeding. Nipples come in many sizes and shapes and contain from 4 to 18 openings for the milk to flow out. Mothers do not need to do anything to get their nipples ready to breastfeed.

Breast size is mainly determined by the amount of fat in the breast; the milk-making structures don't vary as much as the amount of fat tissue. Most mothers can make enough milk for their babies whether they have small or large breasts. It is normal for a woman to have one breast that is different than the other in size or shape. During pregnancy, the breasts will normally increase in size. If a woman does not notice any changes to her breast during pregnancy, she should discuss this with her healthcare provider or a lactation consultant.

After the birth of the baby, nutritional needs must be met to ensure that an infant not only survives, but thrives from infancy into childhood. Breastfeeding provides the fuel a newborn needs for rapid growth and development. As a result, the WHO recommends that breastfeeding is exclusive (no other food or drink) for the first six months of an infant's life. Exclusive breastfeeding is one of the best ways a mother can support the growth and protect the health of her infant child. Breast milk contains nearly all of the nutrients that a newborn requires and gives a child the best start to a healthy life. Most women want to breastfeed their babies; in the US, over 80% of women start to breastfeed their infants. Unfortunately, a mother's intention alone may not be enough to make this practice

successful. Around the world, approximately 40 percent of infants are breastfed exclusively for the recommended 6 months.[12][13][14]

New mothers must also pay careful consideration to their own nutritional requirements to help their bodies recover in the wake of the pregnancy. This is particularly true for women who breastfeed their babies, which increases the need in certain nutrients.

Lactation

Preparation for making breast milk, although begun in puberty, is not completed until a woman's first pregnancy. Early in the first trimester, the cells that will secrete milk divide and multiply. Hormones play a major role in preparing the woman's body to breastfeed, particularly during the second and third trimesters. At that point, levels of the hormone prolactin increase to stimulate the growth of the milk duct system, which initiates and maintains milk production. Also during pregnancy, progesterone stimulates growth of the alveoli, the clusters of cells where the milk is made. During this process ducts that will carry the milk grow larger and branch out, and new capillaries are also formed to circulate the increased blood supply. However, levels of the hormone progesterone need to decrease for successful milk production, because progesterone

12. UNICEF Data. (2019, October). *Infant and young child feeding*. https://data.unicef.org/topic/nutrition/infant-and-young-child-feeding/
13. UNICEF. *For every child, breastfeeding*. https://www.unicef.org/breastfeeding/
14. FAO, IFAD, UNICEF, WFP and WHO. (2019). *The state of food security and nutrition in the world* 2019. http://www.fao.org/3/ca5162en/ca5162en.pdf

inhibits milk secretion. Shortly after birth, the expulsion of the placenta triggers progesterone levels to fall, which activates lactation.[15] When the infant suckles at the breast, levels of the hormone oxytocin rise to promote the release of breast milk from the breast when the infant suckles, which is known as the milk-ejection reflex.

New mothers usually find that their appetite and thirst is greater than before pregnancy; it is recommended that they still focus on nutrient-dense foods to nourish their body and replace their body's nutrient stores. A conservative rate of weight loss (1-2 pounds per week) during lactation does not usually impact the quantity or quality of breast milk, but maternal deficiencies in some nutrients have been described during lactation. The nutrient content of breastmilk does not change much based upon maternal diet for most nutrients. The RDA for energy is 330 additional Calories during the first six months of lactation and 400 additional Calories during the second six months of lactation. The energy needed to support breastfeeding comes from both increased intake and from stored fat. For example, during the first six months after her baby is born, the daily caloric cost for a lactating mother is 500 Calories, with 330 calories derived from increased intake and 170 Calories derived from maternal fat stores. This helps explain why breastfeeding may promote weight loss in new mothers. Lactating women should also drink 3.1 liters of liquids per day (about 13 cups) to avoid dehydration, according to the IOM. As is the case during pregnancy, the RDA of most vitamins and minerals increases for women who are breastfeeding their babies. Most doctors and nutritionists recommend that lactating women continue taking their prenatal vitamin/mineral supplement during lactation. The following table

15. King J. (2007). Contraception and lactation: Physiology of lactation. *Journal of Midwifery and Women's Health*, 52(6), 614–20.

compares the recommended vitamins and minerals for lactating women to the levels for nonpregnant and pregnant women.

Table 13.3 Recommended Nutrient Intakes during Lactation

Nutrient	Nonpregnant Women	Pregnant Women	Lactating Women
Vitamin A (mcg)	700.0	770.0	1,300.0
Vitamin B6 (mg)	1.3	1.9	2.0
Vitamin B12 (mcg)	2.4	2.6	2.8
Vitamin C (mg)	75.0	85.0	120.0
Vitamin D (mcg)	5.0	5.0	5.0
Vitamin E (mg)	15.0	15.0	19.0
Calcium (mg)	1,000.0	1,000.0	1,000.0
Folate (mcg)	400.0	600.0	500.0
Iron (mg)	18.0	27.0	9.0

Magnesium (mg)	310.0	350.0	310.0
Niacin (B3) (mg)	14.0	18.0	17.0
Phosphorus	700.0	700.0	700.0
Riboflavin (B2) (mg)	1.1	1.4	1.6
Thiamine (B1) (mg)	1.1	1.4	1.4
Zinc (mg)	8.0	11.0	12.0

Source: Institute of Medicine (2006). *Dietary reference intakes: The essential guide to nutrient requirements*. The National Academies Press. https://www.nap.edu/catalog/11537/dietary-reference-intakes-the-essential-guide-to-nutrient-requirements

Calcium requirements do not change during breastfeeding because of more efficient absorption, which is the case during pregnancy, too. However, the reasons for this differ. During pregnancy, there is enhanced absorption within the gastrointestinal tract. During lactation, there is enhanced retention by the kidneys. The RDA for phosphorus and fluoride also remains the same.

Components of Breastmilk

Human breast milk not only provides adequate nutrition for infants, it also helps to protect newborns from disease. In addition, breast milk is rich in cholesterol, which is needed for brain development. It is helpful to know the different types and components of breastmilk, along with the nutrients they provide to enable an infant to survive and thrive.

Colostrum is the milk produced immediately after birth, prior to the start of mature milk production, and lasts for two to five days after the arrival of the baby. Cells in the breast can begin to secrete colostrum by mid-pregnancy. During the last trimester, the alveoli (grape-like clusters of cells that produce milk) can become swollen with colostrum. Colostrum is thicker than mature breast milk, and is yellowish or creamy in color. This protein-rich liquid fulfills an infant's nutrient needs during those early days. Although low in volume, colostrum is packed with concentrated nutrition for newborns. This special milk is high in fat-soluble vitamins, minerals, and immunoglobulins (antibodies) that pass from the mother to the baby. Immunoglobulins provide passive immunity for the newborn and protect the baby from bacterial and viral diseases.[16] Colostrum also helps the baby to eliminate waste (meconium).

Two to four days after birth, colostrum is replaced by transitional milk. Nursing the baby early (within the first hour of birth) and frequently (8 to 14 times per 24 hours) helps to bring in this increased volume of milk sooner. Transitional milk is a creamy, usually yellow liquid that lasts for approximately two weeks and includes high levels of fat, lactose, and water-soluble vitamins. It

16. American Pregnancy Association. (2019, October 14). *Breastfeeding: Overview*. http://www.americanpregnancy.org/firstyearoflife/breastfeedingoverview.htm.

also contains more calories than colostrum. As a new mother begins to produce transitional milk, she typically notices an increase in the weight and size of her breasts and a change in the volume and type of liquid secreted.[17]

Mature milk is the final milk that a new mother produces. Its composition varies from morning to night, from the beginning of the feeding to the end, and from early postpartum to later in infancy and toddlerhood. Breastmilk that is produced by mothers of premature infants is higher in protein and calcium to meet the needs of the preemie. Foremilk (the milk that comes at the beginning of a feeding) tends to be lower in fat. Hind-milk comes towards the end of a feeding containing higher levels of fat, which helps the baby to feel satisfied and full. Combined, these two types of milk ensure that a baby receives adequate nutrients to grow and develop properly.[18]

About 87.5 percent of mature milk is water, which helps an infant remain hydrated. The other 12.5 percent contains carbohydrates, proteins, fats, vitamins and minerals which support energy and growth. Similar to cow's milk, the main carbohydrate of mature breast milk is lactose. Breast milk contains the essential fatty acids, linoleic acid and alpha-linolenic acid, and other fats that are important for development such as docosahexaenoic acid (DHA). In terms of protein, breast milk contains more whey than casein

17. American Pregnancy Association. (2019, October 14). *Breastfeeding: Overview*. http://www.americanpregnancy.org/firstyearoflife/breastfeedingoverview.htm.
18. American Pregnancy Association. (2019, October 14). *Breastfeeding: Overview*. http://www.americanpregnancy.org/firstyearoflife/breastfeedingoverview.htm.

(which is the reverse of cow's milk). Whey is much easier for infants to digest than casein. Casein and whey make a complete protein with all of the essential amino acids. Another protein in breastmilk, lactoferrin is an iron-binding protein that helps keep iron away from pathogenic bacteria and facilitates the absorption of iron into an infant's bloodstream.

For most vitamins and minerals, breast milk provides adequate amounts for growth and maintenance of optimal health. Although the absolute amounts of some micronutrients are low, they are more efficiently absorbed by infants from breast milk. Other essential components include digestive enzymes that help a baby digest the breast milk. Human milk also provides the hormones and growth factors that help a newborn to develop.

Diet and Milk Quality

A mother's health habits can impact milk production and quality. As during pregnancy, lactating mothers should avoid illegal substances and cigarettes. Some legal drugs and herbal products can be harmful as well, so it is helpful to discuss them with a healthcare professional. In some rare cases, mothers may need to avoid certain things, such as dairy or spicy foods, that can produce gas in sensitive infants. Lactating women can drink alcohol, though they must avoid breastfeeding until the alcohol has completely cleared from their milk. Typically, this takes two to three hours for 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of liquor, depending on

a woman's body weight.[19] Precautions are necessary because exposure to alcohol can negatively affect infant growth.

Benefits of Breastfeeding

Breastfeeding has a number of benefits, both for the mother and for the child. Breast milk contains immunoglobulins, enzymes, immune factors, and white blood cells. As a result, breastfeeding boosts the baby's immune system and lowers the incidence of diarrhea, respiratory diseases, gastrointestinal infections, and ear infections. Breastfed babies also are less likely to develop asthma and allergies, and breastfeeding lowers the risk of sudden infant death syndrome. In addition, human milk encourages the growth of a healthy microbiome (the bacteria in an infant's intestinal tract). Most of these benefits remain after an infant has been weaned from breast milk. Some studies suggest other possible long-term effects. For example, breast milk may improve an infant's intelligence and protect against Type 1 diabetes and obesity, although research is ongoing in these areas.[20]

Breastfeeding has a number of other important benefits. It is

19. LaFleur, E. (2019, July 3). *Breast-feeding and alcohol: Is it okay to drink?*. Mayo Clinic. http://www.mayoclinic.com/health/breast-feeding-and-alcohol/AN02131.
20. American Academy of Pediatrics. (2016, August 8). *Breastfeeding benefits your baby's immune system*. http://www.healthychildren.org/English/ages-stages/baby/breastfeeding/pages/Breastfeeding-Benefits-Your-Baby%27s-Immune-System.aspx

easier for babies to digest breast milk than infant formula, which contains proteins made from cow's milk or soybeans that are harder to tolerate. Breastfed infants are sick less often than bottle-fed infants. Breastfeeding is more sustainable and results in less plastic waste and other trash. Breastfeeding can also save families money because it typically saves over $1,200 per year in the US over purchasing formula. Other benefits include that breast milk is always ready. It does not have to be mixed, heated, or prepared. Also, breast milk is sterile and is always at the right temperature.

In addition, the skin-to-skin contact of breastfeeding promotes a close bond between mother and baby, which is an important emotional and psychological benefit. The practice also provides health benefits for the mother. Breastfeeding reduces the risk of Type 2 Diabetes in the mother and infant. Studies have also shown that breastfeeding reduces the risk of breast and ovarian cancers.[21]

The Baby-Friendly Hospital Initiative

In 1991, the WHO and UNICEF launched the Baby-Friendly Hospital Initiative (BFHI), which works to ensure that all maternity care facilities, including hospitals and free-standing facilities, become centers of breastfeeding support. A maternity care facility can be denoted as "baby-friendly" when it does not accept free infant formula and has implemented The Ten Steps to Successful

21. National Cancer Institute. (2016, November 9). *Reproductive history and breast cancer risk*. http://www.cancer.gov/cancertopics/factsheet/Risk/reproductive-history.

Breastfeeding. These steps include having a written policy on breastfeeding communicated to health-care staff on a routine basis, informing all new mothers about the benefits and management of breastfeeding, showing new mothers how to breastfeed their infants, and how to maintain lactation, and giving newborns no food or drink other than breast milk, unless medically indicated. Since the BFHI began, more than fifteen thousand facilities in 134 countries, from Benin to Bangladesh, have been deemed "baby friendly." As a result, more mothers are breastfeeding their newborns and infant health has improved, in both the developed world and in developing nations.[22] For information on the Baby-Friendly Initiative in the US, see: https://www.babyfriendlyusa.org.

Barriers to Breastfeeding

Although breast milk is ideal for almost all infants, there are some challenges that nursing mothers may face when starting and continuing to breastfeed their infants. These obstacles include painful engorgement or fullness in the breasts, often around day 3 to 5 postpartum, sore and tender nipples, lack of comfort or confidence in public, and lack of accommodation to breastfeed or express milk in the workplace.

One of the first challenges nursing mothers face is learning how

22. UNICEF. *The baby-friendly hospital initiative*. http://www.unicef.org/programme/breastfeeding/baby.htm

to comfortably position the baby at her breast. Improper position and latching usually results in pain for the mother and inadequate intake for the infant, which could slow growth and development. However, all International Board Certified Lactation Consultants (IBCLCs) and most Obstetric nurses are trained to help new mothers learn the proper technique. Some registered dietitians are trained in lactation support as well. A very helpful position for new mothers is called the "Laid-Back Nursing" position, and it usually helps mother and baby to feel more comfortable, and helps baby to latch on without causing any nipple pain. Resources on the laid back position can be found here: https://lllusa.org/lie-back-and-relax-a-look-at-laid-back-breastfeeding/

Education, the length of maternity leave, and laws to protect public breastfeeding, among other measures, can all help to facilitate breastfeeding for many lactating women and their newborns. The laws specific to Hawai'i and the other states can be found at: https://wicworks.fns.usda.gov/resources/50-state-summary-breastfeeding-laws.

Contraindications to Breastfeeding

Although there are numerous benefits to breastfeeding, in some cases there are also risks that must be considered. In the developed world, a new mother with HIV should not breastfeed, because the infection can be transmitted through breast milk. These women typically have access to infant formula and water that is safe, and can be used as a replacement for breast milk. However, in developing nations where HIV infection rates are high and acceptable infant formula can be difficult to find, many newborns would be deprived of the nutrients they need to develop and grow. Also, inappropriate or contaminated infant formulas cause 1.5 million infant deaths each year. As a result, the WHO recommends that women infected with HIV in the developing world should nurse

their infants while taking antiretroviral medications to lower the risk of transmission.[23] In any case, combination feeding (formula and breastmilk together) is not recommended for mothers who are HIV positive because the risk of transmitting HIV to the infant is higher than either breastfeeding or formula feeding alone.

Breastfeeding also is not recommended for women undergoing radiation or chemotherapy treatment for cancer. Additionally, if an infant is diagnosed with galactosemia, meaning an inability to process the simple sugar galactose, the child must be on a galactose-free diet, which excludes breast milk. This genetic disorder is a very rare condition, however, and only affects 1 in thirty- to sixty-thousand newborns.[24] When breastfeeding is contraindicated for any reason, feeding a baby formula enables parents and caregivers to meet their newborn's nutritional needs.

Bottle-Feeding

Most women can breastfeed when given sufficient education and support. However, as discussed, a small percentage of women are unable to breastfeed their infants, while others choose not to. For parents who choose to bottle-feed, infant formula provides a balance of nutrients. However, not all formulas are the same and there are important considerations that parents and caregivers must weigh. Standard formulas use cow's milk as a base. They have

23. World Health Organization. (2020, April 1). *Infant and young child feeding*. http://www.who.int/mediacentre/factsheets/fs342/en/index.html
24. Genetics Home Reference. (2020, June 9) *Galactosemia.* http://ghr.nlm.nih.gov/condition/galactosemia

20 calories per fluid ounce, similar to breast milk, with vitamins and minerals added. Often parents start their babies on soy formula because they incorrectly assume that soy formula will reduce allergies and other health problems, but this is not the case. Soy-based formulas are sometimes given to infants who develop diarrhea, constipation, vomiting, colic, or abdominal pain, but more often these babies are put on hydrolysate formula to address these concerns. Hypoallergenic protein hydrolysate formulas are given to infants who are allergic to cow's milk and soy protein, or who have trouble tolerating them. This type of formula uses hydrolyzed protein, meaning that the protein is broken down into amino acids and small peptides, which makes it easier to digest, and makes it less likely to trigger gastrointestinal distress.

Preterm infant formulas are given to premature and low birth weight infants, if breast milk is unavailable. Preterm infant formulas have 24 calories per fluid ounce and are given until the infant reaches a desired weight. These formulas are also higher in protein, calcium, and phosphorus to meet the special needs of premature infants.

Infant formula comes in three basic types:

1. Powder that requires mixing with water. This is the least expensive type of formula.
2. Concentrates, which are liquids that must be diluted with water. This type is slightly more expensive.
3. Ready-to-use liquids that can be poured directly into bottles. This is the most expensive type of formula. However, it requires no preparation. Ready-to-use formulas are used when a safe and sanitary water supply is not available. Ready-to-use formulas are also convenient for traveling.

Most babies need about 2.5 ounces of formula per pound of body weight each day. Therefore, the average infant consumes about 24 fluid ounces of breastmilk or formula per day, or one ounce per hour. If an infant sleeps for 2 hours, they often consume 2 ounces

of breastmilk or formula at their next feeding. When preparing formula, parents and caregivers should carefully follow the mixing instructions and safety guidelines, since an infant has an immature immune system. All equipment used in formula preparation should be sterilized for newborns, and especially premature infants. Prepared, unused formula should be refrigerated to prevent bacterial growth. A partially finished bottle of infant formula should be discarded after 1 hour. Parents must make sure not to use contaminated water to mix formula in order to prevent foodborne or other illnesses. Follow the instructions for powdered and concentrated formula carefully—formula that is overly diluted will not provide adequate calories and protein, while overly concentrated formula provides too much protein and too little water which can challenge immature kidneys and lead to dehydration.

Around 6 months of age, infants can start sipping expressed breast milk, infant formula, or water from a cup. By 12 to 14 months of age, children should be using a cup for all liquids.

It is important to note again that both the American Academy of Pediatrics and the WHO state that breast milk is far superior to infant formula. This table compares the advantages of giving a child breast milk to the disadvantages of using bottle formula.

Table 13.4 Breast Milk versus Bottle Formula

Breast Milk	Bottle Formula
Antibodies and lactoferrin in breast milk protect infants.	Formula does not contain immunoprotective factors.
The iron in breast milk is absorbed more easily. Because the iron is bound to lactoferrin, it is not available for bacteria in the gut to use as a growth factor.	Formula contains more iron than breast milk, but it is not absorbed as easily, and the iron is a growth factor for pathogenic microbes.
The feces that babies produce do not smell because breastfed infants have different bacteria in the gut.	The feces that bottle-fed infants produce tends to have a foul-smelling odor.
Breast milk is always available and is always at the correct temperature.	Formula must be prepared, refrigerated for storage, and warmed before it is given to an infant.
Breastfed infants are less likely to have constipation.	Bottle-fed infants are more likely to have constipation.
Breastfeeding ostensibly is free, though purchasing optional supplies such as a pump and bottles to express milk does require some expense.	Formula must be purchased and is expensive, typically costing over $1,200 in the first year.
Breast milk contains the fatty acids DHA and EPA, which are vital for brain and vision development.	Some formulas contain DHA and EPA.

Source: American Pregnancy Association (2019, October 14). *Breastfeeding versus bottle feeding*. http://www.americanpregnancy.org/firstyearoflife/breastfeedingandbottle.html

Introducing Solid Foods

Infants should be breastfed or bottle-fed exclusively for the first six months of life according to the WHO. Foods that are added in addition to breastmilk are called complementary foods. Complementary foods should be nutrient dense to provide optimal nutrition. Complementary foods include baby meats, vegetables,

fruits, infant cereal, and dairy products such as yogurt, but not infant formula. Infant formula is a substitute, not a complement to breastmilk.

Infants should not consume solid foods prior to six months because most solids are less nutritious than breastmilk. Eating solids before 6 months of age usually means drinking less breast milk and is associated with more ear infections and respiratory infections. If parents try to feed an infant who is too young or is not ready, their tongue will push the food out; this is called an extrusion reflex. After six months, the suck-swallow reflexes are not as strong, and infants can hold up their heads and move them around, both of which make eating solid foods more feasible.

Solid baby foods can be bought commercially or prepared from regular food using a food processor, blender, food mill, or grinder at home. By nine months to a year, infants are able to chew soft foods and can eat solids that are well chopped or mashed. Infants who are fed solid foods before 4 months of age are susceptible to developing food allergies. Therefore, as parents and caregivers introduce solids, they should feed their child only one new food at a time, to help identify allergic responses or food intolerances. An iron supplement is also recommended at this time. Rice is no longer recommended for a first infant food because of its high arsenic content. When cereals are introduced, parents can try baby oats or baby wheat.

A guide to infant feeding can be found in the 2019 USDA Infant Nutrition and Feeding Guide at: https://wicworks.fns.usda.gov/resources/infant-nutrition-and-feeding-guide.

Everyday Connection

Different cultures have specific food customs. In ancient

Hawai'i, poi (pounded taro) was a staple food in the diet and is still popular today due to it's nutrient-dense structure.

Poi is high in easily digestible calories, a good source of potassium along with a number of other essential vitamins and minerals. Poi also has many gastrointestinal tract health benefits due to its fiber and probiotic content. With it's viscous texture, poi is an excellent first food for infants to consume.

Complementary Foods

Guidelines for feeding healthy infants from the USDA Infant Nutrition and Feeding Guidelines are adapted in the table below.

Table 13.5 Guidelines for Feeding Healthy Infants Birth to 12 Months Old

Age	Human Milk or infant formula	Grain products	Vegetables	Fruit	Protein-rich foods
Birth – 6 months	Newborns breastfeed 8-12 times/day. Formula fed infants should consume 2-3 ounces of formula every 3-4 hours and by 6 months consume 32 ounces/day.	None	None	None	None
6-8 months	Breastfed infants continue to breastfeed, on demand. Formula-fed infants take in about 24-32 ounces. Amounts vary based on individual assessment. Intake of human milk or formula may decrease as complementary foods increase.	About 1-2 ounces iron-fortified infant cereals, bread, small pieces of crackers	About 2-4 ounces of cooked, plain, strained/ pureed/ mash vegetables	About 2-4 ounces of plain strained/ pureed/ mashed fruits	About 1-2 ounces meat, poultry, fish, eggs, cheese, yogurt, or legumes; all are plain strained/ pureed/ mashed

8-12 months	Guide/ encourage breastfeeding mothers and continue to support mothers who choose to breastfeeding beyond 12 months. Formula-fed infants take in about 24 ounces. Amounts vary based on individual nutrition assessment.	About 2-4 ounces iron-fortified infant cereals; other grains: baby crackers, bread, noodles, corn, grits, soft tortilla pieces	About 4-6 ounces, ground/ finely chopped/ diced	About 4-6 ounces, ground/ finely chopped/ diced	About 2-4 ounces meat, poultry, fish, eggs, cheese, yogurt, or mashed legumes; all are ground/ finely chopped/ diced

Source:

Kleinman, R. E. G., Frank R. (Ed.). (2013). *Pediatric nutrition, 7th Edition*. American Academy of Pediatrics.

Holt, K., Woodridge, N. H., Story, M., & Sofka, D. (Eds.). (2011). *Bright futures nutrition, 3rd Edition*. American Academy of Pediatrics.

American Academy of Pediatrics. (2012). Breastfeeding and the use of human milk. *Pediatrics*, *129*(3), e827.

American Academy of Pediatrics. (2018. September 24). *Amount and schedule of formula feedings*. https://www.healthychildren.org/English/ages-stages/baby/formula-feeding/Pages/Amount-and-Schedule-of-Formula-Feedings.aspx

Leonberg, B. L. (2020). *Pocket guide to pediatric nutrition assessment, 2nd ed*. Academy of Nutrition and Dietetics.

NOTE: These are general guidelines for the healthy, full-term infant per day; serving sizes may vary with individual infants. Start complementary foods when developmentally ready, about 6 months; start with about 0.5-1 ounce.

Foods to Avoid

Many foods can cause harm to infants, including:

- Honey should never be given to a child under 12 months, including honey graham crackers and other foods with honey.
- Cow's Milk should never be given to a child under 12 months.
- Syrups, Sugars, Artificial Sweeteners, and Sugar-Sweetened Beverages
- Vegetables High in Nitrates – spinach, beets, carrots, collard greens, or turnips should not be fed to infants less than 6 months of age.
- Raw or Partially Cooked Meat, Fish, or Poultry

Certain foods should also be avoided as they are choking hazards. These foods are listed in the table from the USDA Infant Nutrition and Feeding Guidelines.

Table 13.6 Common Foods That Cause Choking in Children Under Age 4

Vegetables	Fruits	Protein-rich foods	Grain products	Other foods and snacks
Small pieces of raw vegetable (like raw carrot rounds, baby carrots, string beans, or celery), or other raw, partially cooked vegetables Raw green peas Cooked or uncooked whole corn kernels Large, hard pieces of uncooked dried vegetables	Apples or other hard pieces of raw fruit, especially those with hard pits or seeds Large, hard pieces of uncooked dried fruits Whole pieces of canned fruit Whole grapes, cherries, berries, melon balls, or cherry and grape tomatoes	Tough or large chunks of meat Hot dogs, meat sticks, or sausages (even when cut into round slices) Fish with bones Large chunks of cheese or string cheese Peanuts, nuts, or seeds (like sunflower or pumpkin seeds) Chunks or spoonfuls of peanut butter or other nut and seed butters Whole beans	Plain wheat germ Whole-grain kernels Crackers or breads with seeds Nut pieces Hard pretzels	Hard or round candy Jelly beans Caramels Gum drops, gummy candies, or other gooey or sticky candy Chewy fruit snacks Chewing gum Marshmallows Popcorn, potato or corn chips, or similar snack foods Ice cubes

Learning to Self-Feed

With the introduction of solid foods, young children begin to learn how to handle food and how to feed themselves. At six to seven months, infants can use their whole hand to pick up items (this is known as the palmer grasp). They can lift larger items, but picking up smaller pieces of food is difficult. At eight months, a child might be able to use a pincer grasp, which uses fingers to pick up objects. After the age of one, children slowly begin to use utensils to handle

their food. Unbreakable dishes and cups are essential, since very young children may play with them or throw them when they become bored with their food.

Food Allergies

Food allergies impact four to six percent of young children in America. Common food allergens include peanuts, eggs, shellfish, wheat, and cow's milk. However, lactating women should not make any changes to their diets. Research shows that nursing mothers who attempt to ward off allergies in their infants by eliminating certain foods may do more harm than good. According to the American Academy of Allergy, Asthma, and Immunology, mothers who avoided certain dairy products showed decreased levels in their breast milk of an immunoglobulin specific to cow's milk. This antibody is thought to protect against the development of allergies in children. Even when an infant is at higher risk for food allergies, there is no evidence that alterations in a mother's diet make a difference. And, it is possible that continuing breastfeeding when introducing solid foods in the infant diet may help prevent allergies. There is currently no scientific evidence indicating that delayed (after six months of age) or early (before four months of age) introduction of solid foods is preventative. However, there is evidence that introduction of solid foods after 17 weeks of age is

associated with decreased risk of developing food allergies.[2526] A landmark study done in 2015 showed that infants with increased risk for allergy to peanuts (severe eczema and/or egg allergy) had a much lower incidence of peanut allergy if very small amounts (2 grams) were consumed 3 times a week beginning between 4-6 months of age rather than avoided until 60 months of age.[27] Because of this study, doctors now advise parents of children with a significant family history of allergies to introduce peanut protein between 4-6 months of age after the infant has begun eating other solid foods.

Early Childhood Caries

Primary teeth are at risk for a disorder known as early childhood caries from breast milk, formula, juice, or other drinks fed through a bottle. Liquids can build up in a baby's mouth, and the natural or added sugars lead to decay. Early childhood caries are caused

25. Alvisi P, Brusa S, Alboresi S. (2015). Recommendations on complementary feeding for healthy, full-term infants. *Italian Journal of Pediatrics*, 41(36) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4464122/
26. Gever J. (2012, March 7). *Nursing mom's diet no guard against baby allergies*. Medpage Today. http://www.medpagetoday.com/MeetingCoverage/AAAAIMeeting/31527
27. Du Toit G, et al. (2015). Randomized trial of peanut consumption in infants at risk for peanut allergy. *New England Journal of Medicine*. 372(9), 803-813.

not only by the kinds of liquids given to an infant, but also by the frequency and length of time that fluids are given. Giving a child a bottle of juice or other sweet liquids several times each day, or letting a baby suck on a bottle longer than a mealtime, either when awake or asleep, can also cause early childhood caries. In addition, this practice affects the development and position of the teeth and the jaw. The risk of early childhood caries continues into the toddler years as children begin to consume more foods with a high sugar content. Therefore, parents should avoid putting their children to bed with a bottle, and giving their children sugary snacks and beverages. If a parent insists on giving their child a bottle in bed, then it should be filled with water only.

Newborn Jaundice

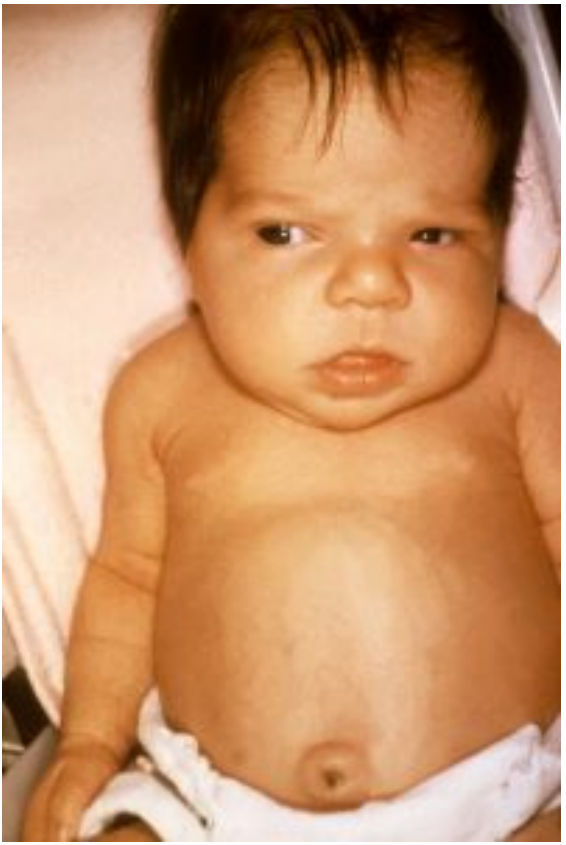


Image by Centers for Disease Control and Prevention / Public Domain

Newborn jaundice is a common occurrence in the first few weeks after birth. This condition can occur within a few days of birth and is characterized by yellowed skin or yellowing in the whites of the eyes, which can be harder to detect in dark-skinned babies. Jaundice typically appears on the face first, followed by the chest, abdomen, arms, and legs. This condition is caused by elevated levels of bilirubin in a baby's bloodstream. Bilirubin is a substance created

by the breakdown of red blood cells and is removed by the liver. Jaundice develops when a newborn's liver does not efficiently remove bilirubin from the blood. There are several types of jaundice associated with newborns:

- Physiologic jaundice. The most common type of newborn jaundice and can affect up to 60 percent of full-term babies in the first week of life.
- Breast-milk jaundice. The name for a condition that persists after physiologic jaundice subsides in otherwise healthy babies and can last for three to twelve weeks after birth. Breast-milk jaundice tends to be genetic and there is no known cause, although it may be linked to a substance in the breast milk that blocks the breakdown of bilirubin. However, that does not mean breastfeeding should be stopped. As long as bilirubin levels are monitored, the disorder rarely leads to serious complications.
- "Inadequate breastfeeding jaundice". Occurs when an infant does not get enough milk. This may happen because a newborn does not get a good start breastfeeding, does not latch on to the mother's breast properly, or is given other substances that interfere with breastfeeding (such as juice). Treatment includes increased feedings, with help from a lactation consultant to ensure that the baby takes in adequate amounts.

Newborn jaundice is more common in a breastfed baby and tends to last a bit longer. If jaundice is suspected, a pediatrician will run blood tests to measure the amount of bilirubin in an infant's blood. Treatment often involves increasing the number of feedings to increase bowel movements, which helps to excrete bilirubin. Within

a few weeks, as the baby begins to mature and red blood cell levels diminish, jaundice typically subsides with no lingering effects.[28]

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

An interactive or media element has been excluded from this version of the text. You can

28. American Pregnancy Association. *Breastfeeding and jaundice*. http://www.americanpregnancy.org/firstyearoflife/breastfeedingandjaundice.htm

view it online here:
http://pressbooks.oer.hawaii.edu/humannutrition2/?p=455

Toddler Years

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

Image by kazuend on unsplash.com / CC0

Major physiological changes continue into the toddler years. Unlike in infancy, the limbs grow much faster than the trunk, which gives the body a more proportionate appearance. By the end of the third year, a toddler is taller and more slender than an infant, with a more erect posture. As the child grows, bone density increases and bone tissue gradually replaces cartilage. This process known as ossification is not completed until puberty.[1] *Journey across the life span: Human development and health promotion*. F.A. Davis Co.

Developmental milestones include running, drawing, toilet training, and self-feeding. How a toddler acts, speaks, learns, and eats offers important clues about their development. By the age of two, children have advanced from infancy and are on their way to

1. Polan, E., & Taylor, D. (2003).

becoming school-aged children. Their physical growth and motor development slows compared to the progress they made as infants. However, toddlers experience enormous intellectual, emotional, and social changes. Of course, food and nutrition continue to play an important role in a child's development. During this stage, the diet completely shifts from breastfeeding or bottle-feeding to solid foods along with healthy juices and other liquids. Parents of toddlers also need to be mindful of certain nutrition-related issues that may crop up during this stage of the human life cycle. For example, fluid requirements relative to body size are higher in toddlers than in adults because children are at greater risk of dehydration.

The toddler years pose interesting challenges for parents or other caregivers, as children learn how to eat on their own and begin to develop personal preferences. However, with the proper diet and guidance, toddlers can continue to grow and develop at a healthy rate.

Nutritional Requirements

MyPlate may be used as a guide for the toddler's diet (http://www.choosemyplate.gov/preschoolers.html). A toddler's serving sizes should be approximately one-quarter that of an adult's. One way to estimate serving sizes for young children is one tablespoon for each year of life. For example, a two-year-old child would be served 2 tablespoons of fruits or vegetables at a meal, while a four-year-old would be given 4 tablespoons, or a quarter cup. Here is an example of a toddler-sized meal:

- 1 ounce of meat or chicken, or 2 to 3 tablespoons of beans
- One-quarter slice of whole-grain bread
- 1 to 2 tablespoons of cooked vegetable
- 1 to 2 tablespoons of fruit

Energy

The energy requirements for ages two to three are about 1,000 to 1,400 calories a day. In general, a toddler needs to consume about 40 calories for every inch of height. For example, a young child who measures 32 inches should take in an average of 1,300 calories a day. However, the recommended caloric intake varies with each child's level of activity. Toddlers require small, frequent, nutritious snacks and meals to satisfy energy requirements. The amount of food a toddler needs from each food group depends on daily calorie needs. See Table 13.6 "Serving Sizes for Toddlers" for some examples.

Table 13.6 Serving Sizes for Toddlers

Food Group	Daily Serving	Examples
Grains	About 3-5 ounces of grains per day, ideally whole grains	• 3 slices of br • 1 slice of bre rice or pasta
Proteins	2-4 ounces of meat, poultry, fish, eggs, or legumes	• 1 ounce of le • 1 ounce of fis
Fruits	1-1.5 cups of fresh, frozen, canned, and/or dried fruits, or 100 percent fruit juice	• 1 small apple • 1 cup of slice • 1 large banan
Vegetables	1-1.5 cups of raw and/or cooked vegetables	• 1 cup of pure potato, chop
Dairy Products	2-2.5 cups per day	• 2 cups of fat • 1 cup of fat-f • 1 cup of fat-f

Source: Hayes, D. (2018, February 20). *It's about eating right: Size-wise nutrition for toddlers*. Academy of Nutrition and Dietetics. https://www.eatright.org/food/nutrition/dietary-guidelines-and-myplate/what-and-how-much-should-my-preschooler-be-eating

Macronutrients

For carbohydrate intake, the Acceptable Macronutrient Distribution Range (AMDR) is 45 to 65 percent of daily calories (113 to 163 grams for 1,000 daily calories). Toddlers' needs increase to support their body and brain development. The RDA of protein is 5 to 20 percent of daily calories (13 to 50 grams for 1,000 daily calories). The AMDR for fat for toddlers is 30 to 40 percent of daily calories (33 to 44 grams for 1,000 daily calories). Essential fatty acids are vital for the development of the eyes, along with nerve and other types of tissue. However, toddlers should not consume foods with high amounts of trans fats and saturated fats. Instead, young children require the equivalent of 3 teaspoons of healthy oils, such as canola oil, each day.

Micronutrients

As a child grows bigger, the demands for micronutrients increase. These needs for vitamins and minerals can be met with a balanced diet, with a few exceptions. According to the American Academy of Pediatrics, toddlers and children of all ages need 600 international units of vitamin D per day. Vitamin D-fortified milk and cereals can help to meet this need. However, toddlers who do not get enough of this micronutrient should receive a supplement. Pediatricians may also prescribe a fluoride supplement for toddlers who live in areas

with fluoride-poor water. Iron deficiency is also a major concern for children between the ages of two and three. You will learn about iron-deficiency anemia later in this section.

Learning How to Handle Food

As children grow older, they enjoy taking care of themselves, which includes self-feeding. During this phase, it is important to offer children foods that they can handle on their own and that help them avoid choking and other hazards. Examples include fresh fruits that have been sliced into pieces, orange or grapefruit sections, peas or potatoes that have been mashed for safety, a cup of yogurt, and whole-grain bread or bagels cut into pieces. Even with careful preparation and training, the learning process can be messy. As a result, parents and other caregivers can help children learn how to feed themselves by providing the following:

- small utensils that fit a young child's hand
- small cups that will not tip over easily
- plates with edges to prevent food from falling off
- small servings on a plate
- high chairs, booster seats, or cushions to reach a table

Feeding Problems in the Toddler Years

During the toddler years, parents may face a number of problems related to food and nutrition. Possible obstacles include difficulty helping a young child overcome a fear of new foods, or fights over messy habits at the dinner table. Even in the face of problems and confrontations, parents and other caregivers must make sure their preschooler has nutritious choices at every meal. For example,

even if a child stubbornly resists eating vegetables, parents should continue to provide them. Before long, the child may change their mind, and develop a taste for foods once abhorred. It is important to remember this is the time to establish or reinforce healthy habits.

Nutritionist Ellyn Satter states that feeding is a responsibility that is split between parent and child. According to Satter, parents are responsible for what their infants eat, while infants are responsible for how much they eat. In the toddler years and beyond, parents are responsible for what they offer their children to eat, when they eat, and where they eat, while children are responsible for how much food they eat and whether they eat. Satter states that the role of a parent or a caregiver in feeding includes the following:

- selecting and preparing food
- providing regular meals and snacks
- making mealtimes pleasant
- showing children what they must learn about mealtime behavior
- avoiding letting children eat in between meal- or snack-times[2]

Picky Eaters

The parents of toddlers are likely to notice a sharp drop in their child's appetite. Children at this stage are often picky about what they want to eat because they just aren't as hungry. They may turn

2. Satter, E. (2016). Ellyn Satter's division of responsibility in feeding. https://www.ellynsatterinstitute.org/wp-content/uploads/2016/11/handout-dor-tasks-cap-2016.pdf

their heads away after eating just a few bites. Or, they may resist coming to the table at mealtimes. They also can be unpredictable about what they want to consume for specific meals or at particular times of the day. Although it may seem as if toddlers should increase their food intake to match their level of activity, there is a good reason for picky eating. A child's growth rate slows after infancy, and toddlers ages two and three do not require as much food.

One way to encourage a picky eater to try healthy foods is to get them involved in age-appropriate tasks in meal preparation. Even small toddlers can tear up lettuce leaves for a salad, or arrange fruit and cheese slices on a plate. Keiki Can Cook! is an online Hawai'i cookbook with healthy recipes for children that highlights tasks for young children. It can be found at: https://health.hawaii.gov/wic/files/2019/03/Cookbook-Keiki-Can-Cook.pdf.

Toddler Obesity

Another potential problem during the early childhood years is toddler obesity. According to the US Department of Health and Human Services, in the past thirty years, obesity rates have more than doubled for all children, including infants and toddlers.[3] Almost 10 percent of infants and toddlers weigh more than they

3. Ogden, C., & Carroll, M. (2010, June). *Prevalence of obesity among children and adolescents: United States, trends 1963-1965 through 2007-2008.* Centers for Disease Control and Prevention. https://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm

should considering their length, and slightly more than 20 percent of children ages two to five are overweight or have obesity.[4]

Some minority group children, such as Filipinos, Native Hawaiians, and Other Pacific Islanders, in Hawai'i have higher rates of overweight and obesity. In 2012, 12.8% of Hawai'i WIC (low-income) participants ages two to four years were overweight and 10.2% had obesity.[567] One study that investigated 2000-2010 data for children ages two to eight years in 51 communities in 11 United States Affiliated Pacific (USAP) jurisdictions found that 14.4% of the study population was overweight and 14% had obesity.[8]

4. Institute of Medicine. (2011). *Early childhood obesity prevention policies*. The National Academies Press.
5. Oshiro C., Novotny R., Grove J., Hurwitz E. (2015). Race/ethnic differences in birth size, infant growth, and body mass index at age five years in children in Hawaii. *Childhood Obesity*, 11(6),683-690. https://www.ncbi.nlm.nih.gov/pubmed/26561722
6. Thorn B., Tadler C., Huret N., Ayo E., Trippe C. (2015, November). WIC participant and program characteristics final report. https://fns-prod.azureedge.net/sites/default/files/ops/WICPC2014.pdf
7. State of childhood obesity. *Obesity rates & trend data*. https://stateofchildhoodobesity.org/data/
8. Novotny R., Fenfang L., Fialkowski, M. (2016). Prevalence of obesity and acanthosis nigricans among young children in the Children's Healthy Living Program in the United States Affiliated Pacific. *Medicine*, 37, e4711. http://chl-pacific.org/wp-content/uploads/2011/08/Novotny-et-

Obesity during early childhood tends to linger as a child matures and cause health problems later in life. There are a number of reasons for this growing problem. One is a lack of time. Parents and other caregivers who are constantly on the go may find it difficult to fit home-cooked meals into a busy schedule and may turn to fast food and other conveniences that are quick and easy, but not nutritionally sound. Another contributing factor is a lack of access to fresh fruits and vegetables. This is a problem particularly in low-income neighborhoods where local stores and markets may not stock fresh produce or may have limited options. Physical inactivity is also a factor, as toddlers who live a sedentary lifestyle are more likely to be overweight or obese. Another contributor is a lack of breastfeeding support. Children who were breastfed as infants have lower rates of obesity than children who were bottle-fed.

To prevent or address toddler obesity parents and caregivers can do the following:

- Eat at the kitchen table instead of in front of a television to monitor what and how much a child eats.
- Offer a child healthy portions. The size of a toddler's fist is an appropriate serving size.
- Plan time for physical activity, about sixty minutes or more per day. Toddlers should have no more than sixty minutes of sedentary activity, such as watching television, per day.

Early Childhood Caries

Early childhood caries remain a potential problem during the toddler years. The risk of early childhood caries continues as

al-2016-Prevalence_of_obesity_and_acanthosis_nigricans.-Medicine.pdf

children begin to consume more foods with a high sugar content. According to the National Health and Nutrition Examination Survey, children between ages of two and five consume about 200 calories of added sugar per day.[9] Therefore, parents with toddlers should avoid processed foods, such as snacks from vending machines, and sugary beverages, such as soda. Parents also need to instruct a child on brushing their teeth at this time to help a toddler develop healthy habits and avoid tooth decay. Generally, children need help brushing their teeth until they are 5 years old.

Iron-Deficiency Anemia

An infant who switches to solid foods, but does not eat enough iron-rich foods, can develop iron-deficiency anemia. This condition occurs when an iron-deprived body cannot produce enough hemoglobin, a protein in red blood cells that transports oxygen throughout the body. The inadequate supply of hemoglobin for new blood cells results in anemia. Iron-deficiency anemia causes a number of problems including weakness, pale skin, shortness of breath, and irritability. It can also result in intellectual, behavioral, or motor problems. In infants and toddlers, iron-deficiency anemia can occur as young children are weaned from iron-rich foods, such as breast milk and iron-fortified formula. They begin to eat solid foods that may not provide enough of this nutrient. As a result, their iron stores become diminished at a time when this nutrient is critical for brain growth and development.

9. Ervin, R. B., Kit, B. K., Carroll, M. D., & Ogden, C. L. (2012). Consumption of added sugar among U.S. children and adolescents, 2005-2008. *NCHS data brief*, (87), 1–8.

There are steps that parents and caregivers can take to prevent iron-deficiency anemia, such as adding more iron-rich foods to a child's diet, including lean meats, fish, poultry, eggs, legumes, and iron-enriched whole-grain breads and cereals. A toddler's diet should provide 7 to 10 milligrams of iron daily. Although milk is critical for the bone-building calcium that it provides, intake should not exceed the RDA to avoid displacing foods rich with iron. Children may also be given a daily supplement, using infant vitamin drops with iron or ferrous sulfate drops. If iron-deficiency anemia does occur, treatment includes a dosage of 3 milligrams per kilogram once daily before breakfast, usually in the form of a ferrous sulfate syrup. Consuming vitamin C, such as orange juice, can also help to improve iron absorption.[10]

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the

10. Louis A., Kazal J.R. (2002). Prevention of Iron deficiency in infants and toddlers. *American Academy of Family Physicians*, 66(7), 1217–25. http://www.aafp.org/afp/2002/1001/p1217.html.

downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

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PART XIV

CHAPTER 14. LIFESPAN NUTRITION DURING CHILDHOOD AND ADOLESCENCE

Introduction

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E mālama ʻia nā pono o ka ʻāina e na ʻōpio

The traditions of the land are perpetuated by its youth

Image by Brytni K-aloha / CC BY 4.0

Learning Objectives

By the end of this chapter you will be able to:

- Describe the physiological basis for nutrient requirements during childhood and adolescence.

Early childhood encompasses infancy and the toddler years, from birth through age three. The remaining part of childhood is the period from ages four through eight and is the time when children enter school. A number of critical physiological and emotional changes take place during the life stage from childhood through adolescences. Children's attitudes and opinions about food deepen. They not only begin taking their cues about food preferences from family members, but also from peers and the larger culture. In Hawai'i, organizations such as the Kōkua Hawai'i Foundation have implemented school programs such as 'Āina In Schools to connect children to their local land, waters, and food. The program initiative is to address childhood health issues by fostering healthy eating habits by teaching and engaging youth about local and traditional foods.[1]

Parents also greatly impact their child's nutritional choices. This time in a child's life provides an opportunity for parents and other caregivers to reinforce good eating habits and to introduce new foods into the diet, while remaining mindful of a child's preferences. Parents should also serve as role models for their children, who will

1. About 'Āina In Schools. Kōkua Hawai'i Foundation. https://www.kokuahawaiifoundation.org/aina. Accessed February 16, 2018.

often mimic their behavior and eating habits. Parents must continue to help their school-aged children and adolescents establish healthy eating habits and attitudes toward food. Their primary role is to bring a wide variety of health-promoting foods into the home, so that their children can make good choices.

Learning Activities

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Childhood

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Image by Brytni K-aloha /

Nutritional needs change as children leave the toddler years. From ages four to eight, school-aged children grow consistently, but at a slower rate than infants and toddlers. They also experience the loss of deciduous, or "baby," teeth and the arrival of permanent teeth, which typically begins at age six or seven. As new teeth come

in, many children have some malocclusion, or malposition, of their teeth, which can affect their ability to chew food. Other changes that affect nutrition include the influence of peers on dietary choices and the kinds of foods offered by schools and afterschool programs, which can make up a sizable part of a child's diet. Food-related problems for young children can include tooth decay, food sensitivities, and malnourishment. Also, excessive weight gain early in life can lead to obesity into adolescence and adulthood.

At this life stage, a healthy diet facilitates physical and mental development and helps to maintain health and wellness. School-aged children experience steady, consistent growth, with an average growth rate of 2–3 inches (5–7 centimeters) in height and 4.5–6.5 pounds (2–3 kilograms) in weight per year. In addition, the rate of growth for the extremities is faster than for the trunk, which results in more adult-like proportions. Long-bone growth stretches muscles and ligaments, which results in many children experiencing "growing pains," at night, in particular.[1]

Energy

Children's energy needs vary, depending on their growth and level of physical activity. Energy requirements also vary according to gender. Girls ages four to eight require 1,200 to 1,800 calories a day, while boys need 1,200 to 2,000 calories daily, and, depending on their activity level, maybe more. Also, recommended intakes of macronutrients and most micronutrients are higher relative to body size, compared with nutrient needs during adulthood. Therefore,

1. Polan EU, Taylor DR. (2003). *Journey Across the LifeSpan: Human Development and Health Promotion*. Philadelphia: F. A. Davis Company, 150–51.

children should be provided nutrient-dense food at meal- and snack-time. However, it is important not to overfeed children, as this can lead to childhood obesity, which is discussed in the next section. Parents and other caregivers can turn to the MyPlate website for guidance: http://www.choosemyplate.gov/.

Macronutrients

For carbohydrates, the Acceptable Macronutrient Distribution Range (AMDR) is 45–65 percent of daily calories (which is a recommended daily allowance of 135–195 grams for 1,200 daily calories). Carbohydrates high in fiber should make up the bulk of intake. The AMDR for protein is 10–30 percent of daily calories (30–90 grams for 1,200 daily calories). Children have a high need for protein to support muscle growth and development. High levels of essential fatty acids are needed to support growth (although not as high as in infancy and the toddler years). As a result, the AMDR for fat is 25–35 percent of daily calories (33–47 grams for 1,200 daily calories). Children should get 17–25 grams of fiber per day.

Micronutrients

Micronutrient needs should be met with foods first. Parents and caregivers should select a variety of foods from each food group to ensure that nutritional requirements are met. Because children grow rapidly, they require foods that are high in iron, such as lean meats, legumes, fish, poultry, and iron-enriched cereals. Adequate fluoride is crucial to support strong teeth. One of the most important micronutrient requirements during childhood is adequate calcium and vitamin D intake. Both are needed to build dense bones and a strong skeleton. Children who do not consume

adequate vitamin D should be given a supplement of 10 micrograms (400 international units) per day. Table 14.1 “Micronutrient Levels during Childhood” shows the micronutrient recommendations for school-aged children. (Note that the recommendations are the same for boys and girls. As we progress through the different stages of the human life cycle, there will be some differences between males and females regarding micronutrient needs.)

Table 14.1 Micronutrient Levels during Childhood

Nutrient	Children, Ages 4–8
Vitamin A (mcg)	400.0
Vitamin B6 (mcg)	600.0
Vitamin B12 (mcg)	1.2
Vitamin C (mg)	25.0
Vitamin D (mcg)	5.0
Vitamin E (mg)	7.0
Vitamin K (mcg)	55.0
Calcium (mg)	800.0
Folate (mcg)	200.0
Iron (mg)	10.0

Magnesium (mg)	130.0
Niacin(B3) (mg)	8.0
Phosphorus (mg)	500.0
Riboflavin (B2) (mg)	600.0
Selenium (mcg)	30.0
Thiamine (B1) (mcg)	600.0
Zinc (mg)	5.0

Source:Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537. Accessed December 10, 2017.

Factors Influencing Intake

A number of factors can influence children's eating habits and attitudes toward food. Family environment, societal trends, taste preferences, and messages in the media all impact the emotions that children develop in relation to their diet. Television commercials can entice children to consume sugary products, fatty fast-foods, excess calories, refined ingredients, and sodium.

Therefore, it is critical that parents and caregivers direct children toward healthy choices.

One way to encourage children to eat healthy foods is to make meal- and snack-time fun and interesting. Parents should include children in food planning and preparation, for example selecting items while grocery shopping or helping to prepare part of a meal, such as making a salad. At this time, parents can also educate children about kitchen safety. It might be helpful to cut sandwiches, meats, or pancakes into small or interesting shapes. In addition, parents should offer nutritious desserts, such as fresh fruits, instead of calorie-laden cookies, cakes, salty snacks, and ice cream. Also, studies show that children who eat family meals on a frequent basis consume more nutritious foods.[2]

Children and Malnutrition

Malnutrition is a problem many children face, in both developing nations and the developed world. Even with the wealth of food in North America, many children grow up malnourished, or even hungry. The US Census Bureau characterizes households into the following groups:

- food secure
- food insecure without hunger
- food insecure with moderate hunger

2. Research on the Benefits of Family Meals. Dakota County, Minnesota. https://www.co.dakota.mn.us/HealthFamily/HealthyLiving/DietNutrition/Documents/ReturnFamilyMeals.doc. Updated April 30, 2012. Accessed December 4, 2017.

- food insecure with severe hunger

Millions of children grow up in food-insecure households with inadequate diets due to both the amount of available food and the quality of food. In the United States, about 20 percent of households with children are food insecure to some degree. In half of those, only adults experience food insecurity, while in the other half both adults and children are considered to be food insecure, which means that children did not have access to adequate, nutritious meals at times.[3]

Growing up in a food-insecure household can lead to a number of problems. Deficiencies in iron, zinc, protein, and vitamin A can result in stunted growth, illness, and limited development. Federal programs, such as the National School Lunch Program, the School Breakfast Program, and Summer Feeding Programs, work to address the risk of hunger and malnutrition in school-aged children. They help to fill the gaps and provide children living in food-insecure households with greater access to nutritious meals.

The National School Lunch Program

Beginning with preschool, children consume at least one of their meals in a school setting. Many children receive both breakfast and lunch outside of the home. Therefore, it is important for schools to provide meals that are nutritionally sound. In the United States, more than thirty-one million children from low-income families are given meals provided by the National School Lunch Program. This federally-funded program offers low-cost or free lunches to

3. Coleman-Jensen A, et al. (2011). Household Food Security in the United States in 2010. *US Department of Agriculture, Economic Research Report*, no. ERR-125.

schools, and also snacks to after-school facilities. School districts that take part receive subsidies from the US Department of Agriculture (USDA) for every meal they serve. School lunches must meet the 2015 Dietary Guidelines for Americans and need to provide one-third of the RDAs for protein, vitamin A, vitamin C, iron, and calcium. However, local authorities make the decisions about what foods to serve and how they are prepared.[4]

The Healthy School Lunch Campaign works to improve the food served to children in school and to promote children's short- and long-term health by educating government officials, school officials, food-service workers, and parents. Sponsored by the Physicians Committee for Responsible Medicine, this organization encourages schools to offer more low-fat, cholesterol-free options in school cafeterias and in vending machines.[5]

Food Allergies and Food Intolerance

As discussed previously, the development of food allergies is a concern during the toddler years. This remains an issue for school-

4. ENational School Lunch Program Fact Sheet. US Department of Agriculture. https://fns-prod.azureedge.net/sites/default/files/cn/NSLPFactSheet.pdf. Published 2011. Accessed December 4, 2017.nter your footnote content here.
5. Healthy School Lunches. Physicians Committee for Responsible Medicine. http://healthyschoollunches.org/. Accessed March 5, 2012.

aged children. Recent studies show that three million children under age eighteen are allergic to at least one type of food.[6]

Some of the most common allergenic foods include peanuts, milk, eggs, soy, wheat, and shellfish. An allergy occurs when a protein in food triggers an immune response, which results in the release of antibodies, histamine, and other defenders that attack foreign bodies. Possible symptoms include itchy skin, hives, abdominal pain, vomiting, diarrhea, and nausea. Symptoms usually develop within minutes to hours after consuming a food allergen. Children can outgrow a food allergy, especially allergies to wheat, milk, eggs, or soy.

Anaphylaxis is a life-threatening reaction that results in difficulty breathing, swelling in the mouth and throat, decreased blood pressure, shock, or even death. Milk, eggs, wheat, soybeans, fish, shellfish, peanuts, and tree nuts are the most likely to trigger this type of response. A dose of the drug epinephrine is often administered via a "pen" to treat a person who goes into anaphylactic shock.[7]

Some children experience a food intolerance, which does not involve an immune response. A food intolerance is marked by unpleasant symptoms that occur after consuming certain foods. Lactose intolerance, though rare in very young children, is one

6. Allergy Statistics. American Academy of Allergy, Asthma and Immunology. http://www.aaaai.org/about-the-aaaai/newsroom/allergy-statistics.aspx. Accessed on March 5, 2012.
7. Food Allergy Quick Facts. National Institutes of Health, US Department of Health and Human Services. http://www.niaid.nih.gov/topics/foodallergy/understanding/pages/quickfacts.aspx. Updated March 27, 2017. Accessed December 10, 2017.

example. Children who suffer from this condition experience an adverse reaction to the lactose in milk products. It is a result of the small intestine's inability to produce enough of the enzyme lactase, which is produced by the small intestine. Symptoms of lactose intolerance usually affect the GI tract and can include bloating, abdominal pain, gas, nausea, and diarrhea. An intolerance is best managed by making dietary changes and avoiding any foods that trigger the reaction.[8]

The Threat of Lead Toxicity

There is a danger of lead toxicity, or lead poisoning, among school-aged children. Lead is found in plumbing in old homes, in lead-based paint, and occasionally in the soil. Contaminated food and water can increase exposure and result in hazardous lead levels in the blood. Children under age six are especially vulnerable. They may consume items tainted with lead, such as chipped, lead-based paint. Another common exposure is lead dust in carpets, with the dust flaking off of paint on walls. When children play or roll around on carpets coated with lead, they are in jeopardy. Lead is indestructible, and once it has been ingested it is difficult for the human body to alter or remove it. It can quietly build up in the body for months, or even years, before the onset of symptoms. Lead toxicity can damage the brain and central nervous system, resulting in impaired thinking, reasoning, and perception.

8. Lactose Intolerance. National Institute of Diabetes and Digestive and Kidney Diseases. http://digestive.niddk.nih.gov/ddiseases/pubs/lactoseintolerance/. Updated June 2014. Accessed December 4, 2017.

Treatment for lead poisoning includes removing the child from the source of contamination and extracting lead from the body. Extraction may involve chelation therapy, which binds with lead so it can be excreted in urine. Another treatment protocol, EDTA therapy, involves administering a drug called ethylenediaminetetraacetic acid to remove lead from the bloodstream of patients with levels greater than 45 mcg/dL.[9] Fortunately, lead toxicity is highly preventable. It involves identifying potential hazards, such as lead paint and pipes, and removing them before children are exposed to them.

Learning Activities

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Learning activities may be used across various mobile devices, however, for the best user experience it is strongly

9. Lead Exposure: Tips to Protect Your Child. Mayo Foundation for Medical Education and Research. https://www.mayoclinic.org/diseases-conditions/lead-poisoning/in-depth/lead-exposure/art-20044627. Updated March 12, 2015. Accessed December 5, 2017.

recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

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Adolescence

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Image by Peter Hershey on unsplash.com / CC0

The onset of puberty is the beginning of adolescence and is the bridge between the childhood years and young adulthood. According to the DRI recommendations, adolescence is divided into two age groups: 9 through 13 years, and 14 through 18 years. Some of the important physiological changes that take place during this stage include the development of primary sex characteristics, or the reproductive organs, along with the onset of menstruation in females. This life stage is also characterized by the appearance of secondary sex characteristics, such as the growth of facial and body hair, the development of breasts in girls, and the deepening of the voice in boys. Other physical changes include rapid growth and alterations in body proportions.[1] All of these changes, as well as

1. Polan EU, Taylor DR. (2003). *Journey Across the LifeSpan:*

the accompanying mental and emotional adjustments, should be supported with sound nutrition.

The Onset of Puberty (Ages 9 through 13 years)

This period of physical development is divided into two phases. The first phase involves height increases from 20 to 25 percent. Puberty is second to the prenatal period in terms of rapid growth as the long bones stretch to their final, adult size. Girls grow 2–8 inches (5–20 centimeters) taller, while boys grow 4–12 inches (10–30 centimeters) taller. The second phase involves weight gain related to the development of bone, muscle, and fat tissue. Also in the midst of puberty, the sex hormones trigger the development of reproductive organs and secondary sexual characteristics, such as pubic hair. Girls also develop "curves," while boys become broader and more muscular.[2]

Energy and Macronutrients

The energy requirements for preteens differ according to gender, growth, and activity level. For ages nine to thirteen, girls should consume about 1,400 to 2,200 calories per day and boys should consume 1,600 to 2,600 calories per day. Physically active preteens

Human Development and Health Promotion. Philadelphia: F. A. Davis Company; 170–71.

2. McMillan B. (2008). *Illustrated Atlas of the Human Body*. Sydney, Australia: Weldon Owen, 258.

who regularly participate in sports or exercise need to eat a greater number of calories to account for increased energy expenditures.

For carbohydrates, the AMDR is 45 to 65 percent of daily calories (which is a recommended daily allowance of 158–228 grams for 1,400–1,600 daily calories). Carbohydrates that are high in fiber should make up the bulk of intake. The AMDR for protein is 10 to 30 percent of daily calories (35–105 grams for 1,400 daily calories for girls and 40–120 grams for 1,600 daily calories for boys). The AMDR for fat is 25 to 35 percent of daily calories (39–54 grams for 1,400 daily calories for girls and 44–62 grams for 1,600 daily calories for boys), depending on caloric intake and activity level.

Micronutrients

Key vitamins needed during puberty include vitamins D, K, and B12. Adequate calcium intake is essential for building bone and preventing osteoporosis later in life. Young females need more iron at the onset of menstruation, while young males need additional iron for the development of lean body mass. Almost all of these needs should be met with dietary choices, not supplements (iron is an exception). Table 14.2 "Micronutrient Levels during Puberty" shows the micronutrient recommendations for young adolescents.

Table 14.2 Micronutrient Levels during Puberty

Nutrient	Preteens, Ages 9–13
Vitamin A (mcg)	600.0
Vitamin B6 (mg)	1.0
Vitamin B12 (mcg)	1.8
Vitamin C (mg)	45.0
Vitamin D (mcg)	5.0
Vitamin E (mg)	11.0
Vitamin K (mcg)	60.0
Calcium (mg)	1,300.0
Folate (mcg)	300.0
Iron (mg)	8.0
Magnesium (mg)	240.0
Niacin (B3) (mg)	12.0
Phosphorus (mg)	1,250.0
Riboflavin (B2) (mcg)	900.0
Selenium (mcg)	40.0
Thiamine (B1) (mcg)	900.0
Zinc (mg)	8.0

Source: Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537. Accessed December 10, 2017.

Learning Activities

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Late Adolescence

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Image by Riley McCullough on unsplash.com / CC0

After puberty, the rate of physical growth slows down. Girls stop growing taller around age sixteen, while boys continue to grow taller until ages eighteen to twenty. One of the psychological and emotional changes that takes place during this life stage includes the desire for independence as adolescents develop individual identities apart from their families.[1] As teenagers make more and more of their dietary decisions, parents or other caregivers and authority figures should guide them toward appropriate, nutritious choices. One way that teenagers assert their independence is by choosing what to eat. They have their own money to purchase food

1. Polan EU, Taylor DR. (2003). *Journey Across the LifeSpan: Human Development and Health Promotion*. Philadelphia: F. A. Davis Company, 171–76.

and tend to eat more meals away from home. Older adolescents also can be curious and open to new ideas, which includes trying new kinds of food and experimenting with their diet. For example, teens will sometimes skip a main meal and snack instead. That is not necessarily problematic. Their choice of food is more important than the time or place.

However, too many poor choices can make young people nutritionally vulnerable. Teens should be discouraged from eating fast food, which has a high fat and sugar content, or frequenting convenience stores and using vending machines, which typically offer poor nutritional selections. Other challenges that teens may face include obesity and eating disorders. At this life stage, young people still need guidance from parents and other caregivers about nutrition-related matters. It can be helpful to explain to young people how healthy eating habits can support activities they enjoy, such as skateboarding or dancing, or connect to their desires or interests, such as a lean figure, athletic performance, or improved cognition.

As during puberty, growth and development during adolescence differs in males than in females. In teenage girls, fat assumes a larger percentage of body weight, while teenage boys experience greater muscle and bone increases. For both, primary and secondary sex characteristics have fully developed and the rate of growth slows with the end of puberty. Also, the motor functions of an older adolescent are comparable to those of an adult.[2] Again, adequate nutrition and healthy choices support this stage of growth and development.

2. Polan EU, Taylor DR. (2003). *Journey Across the Life Span: Human Development and Health Promotion*. Philadelphia: F. A. Davis Company, 171–173.

Energy and Macronutrients

Adolescents have increased appetites due to increased nutritional requirements. Nutrient needs are greater in adolescence than at any other time in the life cycle, except during pregnancy. The energy requirements for ages fourteen to eighteen are 1,800 to 2,400 calories for girls and 2,000 to 3,200 calories for boys, depending on activity level. The extra energy required for physical development during the teenaged years should be obtained from foods that provide nutrients instead of "empty calories." Also, teens who participate in sports must make sure to meet their increased energy needs.

Older adolescents are more responsible for their dietary choices than younger children, but parents and caregivers must make sure that teens continue to meet their nutrient needs. For carbohydrates, the AMDR is 45 to 65 percent of daily calories (203–293 grams for 1,800 daily calories). Adolescents require more servings of grain than younger children, and should eat whole grains, such as wheat, oats, barley, and brown rice. The Institute of Medicine recommends higher intakes of protein for growth in the adolescent population. The AMDR for protein is 10 to 30 percent of daily calories (45–135 grams for 1,800 daily calories), and lean proteins, such as meat, poultry, fish, beans, nuts, and seeds are excellent ways to meet those nutritional needs.

The AMDR for fat is 25 to 35 percent of daily calories (50–70 grams for 1,800 daily calories), and the AMDR for fiber is 25–34 grams per day, depending on daily calories and activity level. It is essential for young athletes and other physically active teens to intake enough fluids, because they are at a higher risk for becoming dehydrated.

Micronutrients

Micronutrient recommendations for adolescents are mostly the same as for adults, though children this age need more of certain minerals to promote bone growth (e.g., calcium and phosphorus, along with iron and zinc for girls). Again, vitamins and minerals should be obtained from food first, with supplementation for certain micronutrients only (such as iron).

The most important micronutrients for adolescents are calcium, vitamin D, vitamin A, and iron. Adequate calcium and vitamin D are essential for building bone mass. The recommendation for calcium is 1,300 milligrams for both boys and girls. Low-fat milk and cheeses are excellent sources of calcium and help young people avoid saturated fat and cholesterol. It can also be helpful for adolescents to consume products fortified with calcium, such as breakfast cereals and orange juice. Iron supports the growth of muscle and lean body mass. Adolescent girls also need to ensure sufficient iron intake as they start to menstruate. Girls ages twelve to eighteen require 15 milligrams of iron per day. Increased amounts of vitamin C from orange juice and other sources can aid in iron absorption. Also, adequate fruit and vegetable intake allows for meeting vitamin A needs. Table 14.3 “Micronutrient Levels during Older Adolescence” shows the micronutrient recommendations for older adolescents, which differ slightly for males and females, unlike the recommendations for puberty.

Table 14.3 Micronutrient Levels during Older Adolescence

Nutrient	Males, Ages 14–18	Females, Ages 14–18
Vitamin A (mcg)	900.0	700.0
Vitamin B6 (mg)	1.3	1.2
Vitamin B12 (mcg)	2.4	2.4
Vitamin C (mg)	75.0	65.0
Vitamin D (mcg)	5.0	5.0
Vitamin E (mg)	15.0	15.0
Vitamin K (mcg)	75.0	75.0
Calcium (mg)	1,300.0	1,300.0
Folate mcg)	400.0	400.0
Iron (mg)	11.0	15.0
Magnesium (mg)	410.0	360.0
Niacin (B3) (mg)	16.0	14.0
Phosphorus (mg)	1,250.0	1,250.0
Riboflavin (B2) (mg)	1.3	1.0
Selenium (mcg)	55.0	55.0
Thiamine (B1) (mg)	1.2	1.0
Zinc (mg)	11.0	9.0

Source: Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537. Accessed December 10, 2017.

Eating Disorders

Many teens struggle with an eating disorder, which can have a detrimental effect on diet and health. A study published by North Dakota State University estimates that these conditions impact twenty-four million people in the United States and seventy million

worldwide.[3] These disorders are more prevalent among adolescent girls, but have been increasing among adolescent boys in recent years. Because eating disorders often lead to malnourishment, adolescents with an eating disorder are deprived of the crucial nutrients their still-growing bodies need.

Eating disorders involve extreme behavior related to food and exercise. Sometimes referred to as "starving or stuffing," they encompass a group of conditions marked by under eating or overeating. Some of these conditions include:

- **Anorexia Nervosa.** Anorexia nervosa is a potentially fatal condition characterized by under eating and excessive weight loss. People with this disorder are preoccupied with dieting, calories, and food intake to an unhealthy degree. Anorexics have a poor body image, which leads to anxiety, avoidance of food, a rigid exercise regimen, fasting, and a denial of hunger. The condition predominantly affects females. Between 0.5 and 1 percent of American women and girls suffer from this eating disorder.
- **Binge-Eating Disorder.** People who suffer from binge-eating disorder experience regular episodes of eating an extremely large amount of food in a short period of time. Binge eating is a compulsive behavior, and people who suffer from it typically feel it is beyond their control. This behavior often causes feelings of shame and embarrassment, and leads to obesity, high blood pressure, high cholesterol levels, Type 2 diabetes, and other health problems. Both males and females suffer from binge-eating disorder. It affects 1 to 5 percent of the

3. Eating Disorder Statistics. North Dakota State University. http://www.ndsu.edu/fileadmin/counseling/Eating_Disorder_Statistics.pdf. Accessed March 5, 2012.

population.

- **Bulimia Nervosa.** Bulimia nervosa is characterized by alternating cycles of overeating and undereating. People who suffer from it partake in binge eating, followed by compensatory behavior, such as self-induced vomiting, laxative use, and compulsive exercise. As with anorexia, most people with this condition are female. Approximately 1 to 2 percent of American women and girls have this eating disorder.[4]

Eating disorders stem from stress, low self-esteem, and other psychological and emotional issues. It is important for parents to watch for signs and symptoms of these disorders, including sudden weight loss, lethargy, vomiting after meals, and the use of appetite suppressants. Eating disorders can lead to serious complications or even be fatal if left untreated. Treatment includes cognitive, behavioral, and nutritional therapy.

Childhood and Adolescent Obesity

Children need adequate caloric intake for growth, and it is important not to impose very restrictive diets. However, exceeding caloric requirements on a regular basis can lead to childhood obesity, which has become a major problem in North America. Nearly one of three US children and adolescents are overweight or obese.[5]

4. Learn By Eating Disorder. National Eating Disorders Association.https://www.nationaleatingdisorders.org/learn/by-eating-disorder . Accessed December 4, 2017.
5. Learn the Facts. Let's Move. https://letsmove.obamawhitehouse.archives.gov/learn-

There are a number of reasons behind this problem, including:

- larger portion sizes
- limited access to nutrient-rich foods
- increased access to fast foods and vending machines
- lack of breastfeeding support
- declining physical education programs in schools
- insufficient physical activity and a sedentary lifestyle
- media messages encouraging the consumption of unhealthy foods

Children who suffer from obesity are more likely to become overweight or obese adults. Obesity has a profound effect on self-esteem, energy, and activity level. Even more importantly, it is a major risk factor for a number of diseases later in life, including cardiovascular disease, Type 2 diabetes, stroke, hypertension, and certain cancers.[6]

A percentile for body mass index (BMI) specific to age and sex is used to determine if a child is overweight or obese. This is more appropriate than the BMI categories used for adults because the body composition of children varies as they develop, and differs between boys and girls. If a child gains weight inappropriate to growth, parents and caregivers should limit energy-dense, nutrient-poor snack foods. In addition, it is extremely beneficial to increase a child's physical activity and limit sedentary activities,

facts/epidemic-childhood-obesity. Accessed December 5, 2017.

6. Obesity and Overweight Fact Sheet. World Health Organization. http://www.who.int/mediacentre/factsheets/fs311/en/. Updated October 2017. Accessed November 29, 2017.

such as watching television, playing video games, or surfing the Internet.

Programs to address childhood obesity can include behavior modification, exercise counseling, psychological support or therapy, family counseling, and family meal-planning advice. For most, the goal is not weight loss, but rather allowing height to catch up with weight as the child continues to grow. Rapid weight loss is not recommended for preteens or younger children due to the risk of deficiencies and stunted growth.

Avoiding Added Sugars

One major contributing factor to childhood obesity is the consumption of added sugars. Added sugars include not only sugar added to food at the table, but also are ingredients in items such as bread, cookies, cakes, pies, jams, and soft drinks. The added sugar in store-bought items may be listed as white sugar, brown sugar, high-fructose corn syrup, honey, malt syrup, maple syrup, molasses, anhydrous dextrose, crystal dextrose, and concentrated fruit juice. (Not included are sugars that occur naturally in foods, such as the lactose in milk or the fructose in fruits.) In addition, sugars are often "hidden" in items added to foods after they're prepared, such as ketchup, salad dressing, and other condiments. According to the National Center for Health Statistics, young children and adolescents consume an average of 322 calories per day from added sugars, or about 16 percent of daily calories.[7]

7. Ervin RB, Kit BK, Carroll MD. (2012). Consumption of Added Sugar among US Children and Adolescents, 2005–2008. *National Center for Health Statistics.* NCHS

The primary offenders are processed and packaged foods, along with soda and other beverages. These foods are not only high in sugar, they are also light in terms of nutrients and often take the place of healthier options. Intake of added sugar should be limited to 100–150 calories per day to discourage poor eating habits.

Tools for Change

The 2008 Physical Activity Guidelines for Americans call for sixty minutes of moderate to vigorous physical activity daily for preteens and teens. This includes aerobic activity, along with bone- and muscle-strengthening exercises.[8] However, many young people fall far short of this goal. Preteens must be encouraged to lead more active lifestyles to prevent or treat childhood obesity. In the United States, the Let's Move! campaign inspires kids to start exercising. This program, launched in 2010 by First Lady Michelle Obama, works to solve the problem of rising obesity rates among children, preteens, and teens. It offers information to parents and educators, works to provide healthier food choices in schools and afterschool programs, and helps children become more active. One way the program promotes physical activity is by encouraging preteens and teens to find something they love to do. When kids find an activity they enjoy, whether riding a bike, playing football, joining a soccer team, or participating in a dance crew, they are more likely to get

Data Brief, 87. http://www.cdc.gov/nchs/data/databriefs/db87.pdf. Accessed December 5, 2017.

8. 2008 Physical Activity Guidelines for Americans. US Department of Health and Human Services. http://www.health.gov/paguidelines/pdf/paguide.pdf. Accessed March 5, 2012.

moving and stay healthy. You can learn more about Let's Move! and efforts to encourage physical activity among adolescents at this website: http://www.letsmove.gov/.

Learning Activities

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PART XV

CHAPTER 15. LIFESPAN NUTRITION IN ADULTHOOD

Introduction

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E ola koa.

Live like a koa tree.

Image by nic.co on unsplash.com / CCO

Learning Objectives

By the end of this chapter you will be able to:

- Describe the physiological basis for nutrient

requirements during adulthood.

Adulthood begins at the end of adolescents and continues until the end of one's life. During adulthood, the human body will reach maximum cardiac output specifically between ages twenty and thirty. Bone and muscle mass also reach optimal levels, and physical activity helps to improve muscle strength, endurance, and tone.[1] In order to maintain health and fitness throughout the lifespan, it is important to remain active. The CDC has implemented science based physical activity guidelines for all Americans to follow in hopes of creating a healthy lifestyle. In Hawai'i, nearly 60% of all adults meet the recommended aerobic physical activity guidelines. However, only 32% of adults meet the guidelines for muscle strengthening and less than a quarter (23%) of Hawai'i residents meet the recommended guidelines for both.[2] To learn more about the current physical activity guidelines visit https://www.cdc.gov/cancer/dcpc/prevention/policies_practices/physical_activity/guidelines.htm.

Along with physical activity, nutrition also plays an essential role in maintaining health through adulthood. As you've already learned, a healthful diet includes a variety of nutrient dense foods. The USDA

1. Polan EU, Taylor DR. (2003). *Journey Across the LifeSpan: Human Development and Health Promotion.* Philadelphia: F. A. Davis Company, 192–93.
2. Hawaii Physical Activity and Nutrition Plan, 2013-2020. https://health.hawaii.gov/physical-activity-nutrition/files/2013/08/Hawaii-PAN-Plan-2013-2020.pdf. Accessed February 16, 2018.

Dietary Guidelines recommend eating a balanced diet from the five food groups: fruits, vegetables, protein, grains and dairy.[3] In Hawai'i, only about 19% of adults eat the recommended amount of servings of fruits and vegetables per day. Inadequacy of any food group can lead to several health issues.[4] Consuming diets high in fruits and vegetables may have health benefits such as a reduced risk for heart disease, and protection against certain cancers.[5]

Learning Activities

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3. All About the Fruit Group. USDA ChooseMyPlate.gov. https://www.choosemyplate.gov/fruit Accessed February 16, 2018.
4. Hawai'i Physical Activity and Nutrition Plan, 2013-2020. https://health.hawaii.gov/physical-activity-nutrition/files/2013/08/Hawaii-PAN-Plan-2013-2020.pdf. Accessed February 16, 2018.
5. Nutrients and Health Benefits. USDA ChooseMyPlate.gov. https://www.choosemyplate.gov/fruits-nutrients-health. Accessed February 16, 2018.

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Young Adulthood

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Image by David Marcu on unsplash.com / CC0

Young adulthood is the period from ages nineteen to thirty years. It is a stable time compared to childhood and adolescence. Physical growth has been completed and all of the organs and body systems are fully developed. Typically, a young adult who is active has reached his or her physical peak and is in prime health. For example, vital capacity, or the maximum amount of air that the lungs can inhale and exhale, is at its peak between the ages of twenty and forty.[1] During this life stage, it important to continue to practice good nutrition. Healthy eating habits promote metabolic functioning, assist repair and regeneration, and prevent the

1. Polan EU, Taylor DR. (2003). *Journey Across the Life Span: Human Development and Health Promotion*. Philadelphia: F. A. Davis Company, 192–93.

development of chronic conditions. In addition, the goals of a young adult, such as beginning a career or seeking out romantic relationships, can be supported with good habits. Proper nutrition and adequate physical activity at this stage not only promote wellness in the present, but also provide a solid foundation for the future.

With the onset of adulthood, good nutrition can help young adults enjoy an active lifestyle. The body of an adult does not need to devote its energy and resources to support the rapid growth and development that characterizes youth. However, the choices made during those formative years can have a lasting impact. Eating habits and preferences developed during childhood and adolescence influence health and fitness into adulthood. Some adults have gotten a healthy start and have established a sound diet and regular activity program, which helps them remain in good condition from young adulthood into the later years. Others carry childhood obesity into adulthood, which adversely affects their health. However, it is not too late to change course and develop healthier habits and lifestyle choices. Therefore, adults must monitor their dietary decisions and make sure their caloric intake provides the energy that they require, without going into excess.

Energy and Macronutrients

Young men typically have higher nutrient needs than young women. For ages nineteen to thirty, the energy requirements for women are 1,800 to 2,400 calories, and 2,400 to 3,000 calories for men, depending on activity level. These estimates do not include women who are pregnant or breastfeeding, who require a higher energy intake. For carbohydrates, the AMDR is 45 to 65 percent of daily calories. All adults, young and old, should eat fewer energy-dense carbohydrates, especially refined, sugar-dense sources, particularly for those who lead a more sedentary lifestyle. The AMDR for protein

is 10 to 35 percent of total daily calories, and should include a variety of lean meat and poultry, eggs, beans, peas, nuts, and seeds. The guidelines also recommend that adults eat two 4-ounce servings (or one 8-ounce serving) of seafood per week.

It is also important to replace proteins that are high in trans fats and saturated fat with ones that are lower in solid fats and calories. All adults should limit total fat to 20 to 35 percent of their daily calories and keep saturated fatty acids to less than 10 percent of total calories by replacing them with monounsaturated and polyunsaturated fatty acids. Avoid trans fats by limiting foods that contain synthetic sources, such as partially hydrogenated oils. The AMDR for fiber is 22 to 28 grams per day for women and 28 to 34 grams per day for men. Soluble fiber may help improve cholesterol and blood sugar levels, while insoluble fiber can help prevent constipation.

Micronutrients

Micronutrient needs in adults differ slightly according to sex. Young men and women who are very athletic and perspire a great deal also require extra sodium, potassium, and magnesium. Males require more of vitamins C and K, along with thiamine, riboflavin, and niacin. Females require extra iron due to menstruation. Therefore, it can be beneficial for some young adults to follow a daily multivitamin regimen to help meet nutrient needs. But as always, it is important to remember "food first, supplements second." Table 15.1 "Micronutrient Levels during Adulthood" shows the micronutrient recommendations for adult men and women.

Table 15.1 Micronutrient Levels during Adulthood

Nutrient	Adult Males	Adult Females
Vitamin A (mcg)	900.0	700.0
Vitamin B_6 (mg)	1.3	1.3
Vitamin B_{12} (mcg)	2.4	2.4
Vitamin C (mg)	90.0	75.0
Vitamin D (mcg)	5.0	5.0
Vitamin E (mg)	15.0	15.0
Vitamin K(mcg)	120.0	90.0
Calcium (mg)	1,000.0	1,000.0
Folate (mcg)	400.0	400.0
Iron (mg)	8.0	18.0
Magnesium (mg)	400.0	310.0
Niacin (mg)	16.0	14.0
Phosphorus (mg)	700.0	700.0
Riboflavin (mg)	1.3	1.1
Selenium	55.0	55.0
Thiamin (mg)	1.2	1.1
Zinc (mg)	11.0	8.0

Source: Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537. Accessed December 10, 2017.

Nutritional Concerns in Young Adulthood

There are a number of intake recommendations for young adults. According to the IOM, an adequate intake (AI) of fluids for men is 3.7 liters per day, from both food and liquids. The AI for women

is 2.7 liters per day, from food and liquids.[2] It is best when fluid intake is from water, instead of sugary beverages, such as soda. Fresh fruits and vegetables, including watermelon and cucumbers, are excellent food sources of fluid. In addition, young adults should avoid consuming excessive amounts of sodium. The health consequences of high sodium intake include high blood pressure and its complications. Therefore, it is best to limit sodium to less than 2,300 milligrams per day.

Obesity during Adulthood

Obesity remains a major concern into young adulthood. For adults, a BMI above 25 is considered overweight, and a BMI of 30 or higher is obese. By that measurement, about two-thirds of all adults in the United States are overweight or obese, with 35.7 percent considered to be obese. [3] As during childhood and adolescence, physical inactivity and poor dietary choices are major contributors to obesity in adulthood. Solid fats, alcohol, and added sugars (SoFAAS) make up 35 percent of total calories for most people, leading to high

2. Institute of Medicine. 2005. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: The National Academies Press. https://doi.org/10.17226/10925. Accessed December 10, 2017.
3. Prevalence of Obesity in the United States, 2009–2010. Centers for Disease Control, National Center for Health Statistics.NCHS Data Brief, No. 82. http://www.cdc.gov/nchs/data/databriefs/db82.pdf. Published January 2012. Accessed December 8, 2017.

levels of saturated fat and cholesterol and insufficient dietary fiber. Therefore, it is important to limit unrefined carbohydrates and processed foods.

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Middle Age

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Middle age is defined as the period from age thirty-one to fifty. The early period of this stage is very different from the end. For example, during the early years of middle age, many women experience pregnancy, childbirth, and lactation. In the latter part of this life stage, women face perimenopause, which is a transition period that leads up to menopause, or the end of menstruation. A number of physical changes take place in the middle-aged years, including the loss of bone mass in women due to dropping levels of estrogen during menopause. In both men and women, visual acuity declines, and by age forty there can be a decreased ability to see objects at a close distance, a condition known as presbyopia.[1] All of these are signs of aging, as the human body begins to change in subtle and not-so-subtle ways. However, a middle aged person can remain vital, healthy, and near his or her physical peak with proper diet and adequate exercise.

During this stage of the human life cycle, adults begin to experience the first outward signs of aging. Wrinkles begin to appear, joints ache after a highly active day, and body fat accumulates. There is also a loss of muscle tone and elasticity in the connective tissue.[2] Many people in their late thirties and in

1. Polan EU, Taylor DR. (2003). *Journey Across the Life Span: Human Development and Health Promotion.* Philadelphia: F. A. Davis Company, 192–93.
2. Polan EU, Taylor DR. (2003), *Journey Across the Life Span: Human Development and Health Promotion.* Philadelphia: F. A. Davis Company, 212–213.

their forties notice a decline in endurance, the onset of wear-and-tear injuries (such as osteoarthritis), and changes in the digestive system. Wounds and other injuries also take longer to heal. Body composition changes due to fat deposits in the trunk. To maintain health and wellness during the middle-aged years and beyond, it is important to:

- maintain a healthy body weight
- consume nutrient-dense foods
- drink alcohol moderately or not at all
- be a nonsmoker
- engage in moderate physical activity at least 150 minutes per week

Energy and Macronutrients

The energy requirements for ages thirty-one to fifty are 1,800 to 2,200 calories for women and 2,200 to 3,000 calories for men, depending on activity level. These estimates do not include women who are pregnant or breastfeeding. Middle-aged adults must rely on healthy food sources to meet these needs. In many parts of North America, typical dietary patterns do not match the recommended guidelines. For example, five foods—iceberg lettuce, frozen potatoes, fresh potatoes, potato chips, and canned tomatoes—account for over half of all vegetable intake.[3] Following

3. Drewnowski A, Darmon, N. (2005). Food Choices and Diet Cost: an Economic Analysis. *The Journal of Nutrition*, 135(4), 900-904. http://jn.nutrition.org/content/135/4/900.full. Accessed December 12, 2017.

the dietary guidelines in the middle-aged years provides adequate but not excessive energy, macronutrients, vitamins, and minerals.

The AMDRs for carbohydrates, protein, fat, fiber, and fluids remain the same from young adulthood into middle age. It is important to avoid putting on excess pounds and limiting an intake of SoFAAS to help avoid cardiovascular disease, diabetes, and other chronic conditions.

Micronutrients

There are some differences, however, regarding micronutrients. For men, the recommendation for magnesium increases to 420 milligrams daily, while middle-aged women should increase their intake of magnesium to 320 milligrams per day. Other key vitamins needed during the middle-aged years include folate and vitamins B6 and B12 to prevent elevation of homocysteine, a byproduct of metabolism that can damage arterial walls and lead to atherosclerosis, a cardiovascular condition. Again, it is important to meet nutrient needs with food first, then supplementation, such as a daily multivitamin, if you can't meet your needs through food.

Preventive/Defensive Nutrition

During the middle-aged years, preventive nutrition can promote wellness and help organ systems to function optimally throughout aging. Preventive nutrition is defined as dietary practices directed toward reducing disease and promoting health and well-being. Healthy eating in general—such as eating unrefined carbohydrates instead of refined carbohydrates and avoiding trans fats and saturated fats—helps to promote wellness. However, there are also some things that people can do to target specific concerns. One

example is consuming foods high in antioxidants, such as strawberries, blueberries, and other colorful fruits and vegetables, to reduce the risk of cancer.

Phytochemicals are also great nonessential nutrients that may promote body wellness.For example, carotenoids, which are found in carrots, cantaloupes, sweet potatoes, and butternut squash, may protect against cardiovascular disease by helping to prevent the oxidation of cholesterol in the arteries, although research is ongoing.[4] According to the American Cancer Society, some studies suggest that a phytochemical found in watermelons and tomatoes called lycopene may protect against stomach, lung, and prostate cancer, although more research is needed.[5]

Omega-3 fatty acids can help to prevent coronary artery disease. These crucial nutrients are found in oily fish, including salmon, mackerel, tuna, herring, cod, and halibut. Other beneficial fats that are vital for healthy functioning include monounsaturated fats, which are found in plant oils, avocados, peanuts, and pecans.

4. Voutilainen S, Nurmi T, Mursu J, Rissanen, TH. (2006). Carotenoids and Cardiovascular Health. *American Journals of Clinical Nutrition*, 83, 1265–71. http://www.ajcn.org/content/83/6/1265.full.pdf. Accessed December 9, 2017.
5. Lycopene. American Cancer Society. http://www.cancer.org/Treatment/TreatmentsandSideEffects/ComplementaryandAlternativeMedicine/DietandNutrition/lycopene. Updated May 13, 2010. Accessed November 29, 2017.

Menopause

In the middle-aged years, women undergo a specific change that has a major effect on their health. They begin the process of menopause, typically in their late forties or early fifties. The ovaries slowly cease to produce estrogen and progesterone, which results in the end of menstruation. Menopausal symptoms can vary, but often include hot flashes, night sweats, and mood changes. The hormonal changes that occur during menopause can lead to a number of physiological changes as well, including alterations in body composition, such as weight gain in the abdominal area. Bone loss is another common condition related to menopause due to the loss of female reproductive hormones. Bone thinning increases the risk of fractures, which can affect mobility and the ability to complete everyday tasks, such as cooking, bathing, and dressing.[6]

Recommendations for women experiencing menopause or perimenopause (the stage just prior to the end of the menstruation) include:

- consuming a variety of whole grains, and other nutrient-dense foods
- maintaining a diet high in fiber, low in fat, and low in sodium
- avoiding caffeine, spicy foods, and alcohol to help prevent hot flashes
- eating foods rich in calcium, or taking physician-prescribed calcium supplements and vitamin D
- doing stretching exercises to improve balance and flexibility

6. Eating Right During Menopause.Academy of Nutrition and Dietetics. http://www.eatright.org/Public/content.aspx?id=6809. Updated January 2015. Accessed December 4, 2017.

and reduce the risk of falls and fractures

Learning Activities

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Older Adulthood: The Golden Years

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"Man wearing blue shirt standing on white surfboard" by Alex Blajan / Unsplash License

The senior years are the period from age fifty-one until the end of life. A number of physiological and emotional changes take place during this life stage. For example, many older adults face serious health challenges, such as cancer, heart disease, diabetes, or dementia. Both men and women experience a loss of hormone production, muscle mass, and strength and undergo changes in body composition. Fat deposits build up in the abdominal area, which increases the risk for Type 2 diabetes and cardiovascular disease. The skin becomes thinner and may take longer to heal after an injury. Around age seventy, men begin to experience bone loss when estrogen and testosterone levels begin to decline.[1] Also in

1. American Medical Association. (2008). *Complete Guide to*

the later years, the heart has to work harder because each pump is not as efficient as it used to be. Kidneys are not as effective in excreting metabolic products such as sodium, acid, and potassium, which can alter water balance and increase the risk for over- or underhydration. In addition, immune function decreases and there is lower efficiency in the absorption of vitamins and minerals.

In addition, disorders of the nervous system can have profound effects. Dementia is the umbrella term for changes in the normal activity of the brain. Elderly adults who suffer from dementia may experience memory loss, agitation, and delusions. One in eight people over age sixty-four and almost half of all people over eighty-five suffer from the brain disorder Alzheimer's disease, which is the most common form of dementia.[2] Neurological disorder and psychological conditions, such as depression, can influence attitudes toward food, along with the ability to prepare or ingest food. They might lead some adults to overindulge to compensate for stress or emotions that are difficult to handle. Other adults might eat less or pay less attention to their diet and nutritional needs. Older adults may also need guidance from dietitians and health-care professionals to make the best dietary choices for this stage of life.

Beginning at age fifty-one, requirements change once again and relate to the nutritional issues and health challenges that older people face. After age sixty, blood pressure rises and the immune system may have more difficulty battling invaders and infections. The skin becomes more wrinkled and hair has turned gray or white or fallen out, resulting in hair thinning. Older adults may gradually

Prevention and Wellness. Hoboken, NJ: John Wiley & Sons, Inc., 512.

2. American Medical Association. (2008). *Complete Guide to Prevention and Wellness*. Hoboken, NJ: John Wiley & Sons, Inc.,421.

lose an inch or two in height. Also, short-term memory might not be as keen as it once was.[3]

Being either underweight or overweight is also a major concern for the elderly. However, many older adults remain in relatively good health and continue to be active into their golden years. Good nutrition is often the key to maintaining health later in life. In addition, the fitness and nutritional choices made earlier in life set the stage for continued health and happiness. Older adults should continue to consume nutrient-dense foods and remain physically active. However, deficiencies are more common after age sixty, primarily due to reduced intake or malabsorption. The loss of mobility among frail, homebound elderly adults also impacts their access to healthy, diverse foods.

Energy and Macronutrients

Due to reductions in lean body mass and metabolic rate, older adults require less energy than younger adults. The energy requirements for people ages fifty-one and over are 1,600 to 2,200 calories for women and 2,000 to 2,800 calories for men, depending on activity level. The decrease in physical activity that is typical of older adults also influences nutritional requirements. The AMDRs for carbohydrates, protein, and fat remain the same from middle age into old age. Older adults should substitute more unrefined carbohydrates for refined ones, such as whole grains and brown rice. Fiber is especially important in preventing constipation and diverticulitis, and may also reduce the risk of colon cancer. Protein

3. McMillan, B. (2008). *Illustrated Atlas of the Human Body*. Weldon Owen, 260.

should be lean, and healthy fats, such as omega-3 fatty acids, are part of any good diet.

Micronutrients

An increase in certain micronutrients can help maintain health during this life stage. The recommendations for calcium increase to 1,200 milligrams per day for both men and women to slow bone loss. Also to help protect bones, vitamin D recommendations increase to 10–15 micrograms per day for men and women. Vitamin B_6 recommendations rise to 1.7 milligrams per day for older men and 1.5 milligrams per day for older women to help lower levels of homocysteine and protect against cardiovascular disease. As adults age, the production of stomach acid can decrease and lead to an overgrowth of bacteria in the small intestine. This can affect the absorption of vitamin B_{12} and cause a deficiency. As a result, older adults need more B_{12} than younger adults, and require an intake of 2.4 micrograms per day, which helps promote healthy brain functioning. For elderly women, higher iron levels are no longer needed postmenopause and recommendations decrease to 8 milligrams per day. People over age fifty should eat foods rich with all of these micronutrients.

Nutritional Concerns for Older Adults

Dietary choices can help improve health during this life stage and address some of the nutritional concerns that many older adults face. In addition, there are specific concerns related to nutrition that affect adults in their later years. They include medical problems, such as disability and disease, which can impact diet and

activity level. For example, dental problems can lead to difficulties with chewing and swallowing, which in turn can make it hard to maintain a healthy diet. The use of dentures or the preparation of pureed or chopped foods can help solve this problem. There also is a decreased thirst response in the elderly, and the kidneys have a decreased ability to concentrate urine, both of which can lead to dehydration.

Sensory Issues

At about age sixty, taste buds begin to decrease in size and number. As a result, the taste threshold is higher in older adults, meaning that more of the same flavor must be present to detect the taste. Many elderly people lose the ability to distinguish between salty, sour, sweet, and bitter flavors. This can make food seem less appealing and decrease the appetite. An intake of foods high in sugar and sodium can increase due to an inability to discern those tastes. The sense of smell also decreases, which impacts attitudes toward food. Sensory issues may also affect the digestion because the taste and smell of food stimulates the secretion of digestive enzymes in the mouth, stomach, and pancreas.

Dysphagia

Some older adults have difficulty getting adequate nutrition because of the disorder dysphagia, which impairs the ability to swallow. Any damage to the parts of the brain that control swallowing can result in dysphagia, therefore stroke is a common cause. Dysphagia is also associated with advanced dementia because of overall brain function impairment. To assist older adults suffering from dysphagia, it can be helpful to alter food consistency.

For example, solid foods can be pureed, ground, or chopped to allow more successful and safe swallow. This decreases the risk of aspiration, which occurs when food flows into the respiratory tract and can result in pneumonia. Typically, speech therapists, physicians, and dietitians work together to determine the appropriate diet for dysphagia patients.

Obesity in Old Age

Similar to other life stages, obesity is a concern for the elderly. Adults over age sixty are more likely to be obese than young or middle-aged adults. As explained throughout this chapter, excess body weight has severe consequences. Being overweight or obese increases the risk for potentially fatal conditions that can afflict the elderly. They include cardiovascular disease, which is the leading cause of death in the United States, and Type 2 diabetes, which causes about seventy thousand deaths in the United States annually.[4] Obesity is also a contributing factor for a number of other conditions, including arthritis.

For older adults who are overweight or obese, dietary changes to promote weight loss should be combined with an exercise program to protect muscle mass. This is because dieting reduces muscle as well as fat, which can exacerbate the loss of muscle mass due to aging. Although weight loss among the elderly can be beneficial, it is best to be cautious and consult with a healthcare professional before beginning a weight-loss program.

4. Deaths and Mortality. Centers for Disease Control, National Center for Health Statistics. http://www.cdc.gov/nchs/fastats/deaths.htm. Updated May 3, 2017. Accessed December 9, 2017.

The Anorexia of Aging

In addition to concerns about obesity among senior citizens, being underweight can be a major problem. A condition known as the anorexia of aging is characterized by poor food intake, which results in dangerous weight loss. This major health problem among the elderly leads to a higher risk for immune deficiency, frequent falls, muscle loss, and cognitive deficits. Reduced muscle mass and physical activity mean that older adults need fewer calories per day to maintain a normal weight. It is important for health care providers to examine the causes for anorexia of aging among their patients, which can vary from one individual to another. Understanding why some elderly people eat less as they age can help healthcare professionals assess the risk factors associated with this condition. Decreased intake may be due to disability or the lack of a motivation to eat. Also, many older adults skip at least one meal each day. As a result, some elderly people are unable to meet even reduced energy needs.

Nutritional interventions should focus primarily on a healthy diet. Remedies can include increasing the frequency of meals and adding healthy, high-calorie foods (such as nuts, potatoes, whole-grain pasta, and avocados) to the diet. Liquid supplements between meals may help to improve caloric intake.[5] Health care professionals should consider a patient's habits and preferences when developing a nutritional treatment plan. After a plan is in place, patients should be weighed on a weekly basis until they show improvement.

5. Morley, JE. (1997). Anorexia of Aging: Physiologic and Pathologic. *American Journal of Clinical Nutrition*, 66, 760–73. http://www.ajcn.org/content/66/4/760.full.pdf. Accessed November 12, 2017.

Vision Problems

Many older people suffer from vision problems and a loss of vision. Age-related macular degeneration is the leading cause of blindness in Americans over age sixty.[6] This disorder can make food planning and preparation extremely difficult and people who suffer from it often must depend on caregivers for their meals. Self-feeding also may be difficult if an elderly person cannot see his or her food clearly. Friends and family members can help older adults with shopping and cooking. Food-assistance programs for older adults (such as Meals on Wheels) can also be helpful.

Diet may help to prevent macular degeneration. Consuming colorful fruits and vegetables increases the intake of lutein and zeaxanthin. Several studies have shown that these antioxidants provide protection for the eyes. Lutein and zeaxanthin are found in green, leafy vegetables such as spinach, kale, and collard greens, and also corn, peaches, squash, broccoli, Brussels sprouts, orange juice, and honeydew melon.[7]

Longevity and Nutrition

The foods you consume in your younger years influence your health as you age. Good nutrition and regular physical activity can help you

6. American Medical Association. (2008). *Complete Guide to Prevention and Wellness.* Hoboken, NJ: John Wiley & Sons, Inc., 413.
7. American Medical Association. (2008). *Complete Guide to Prevention and Wellness.* Hoboken, NJ: John Wiley & Sons, Inc., 415.

live longer and healthier. Conversely, poor nutrition and a lack of exercise can shorten your life and lead to medical problems. The right foods provide numerous benefits at every stage of life. They help an infant grow, an adolescent develop mentally and physically, a young adult achieve his or her physical peak, and an older adult cope with aging. Nutritious foods form the foundation of a healthy life at every age.

Developing Habits

Eating habits develop early in life. They are typically formed within the first few years and it is believed that they persist for years, if not for life. So it is important for parents and other caregivers to help children establish healthy habits and avoid problematic ones. Children begin expressing their preferences at an early age. Parents must find a balance between providing a child with an opportunity for self-expression, helping a child develop healthy habits, and making sure that a child meets all of their nutritional needs.

Bad habits and poor nutrition have an accrual effect. The foods you consume in your younger years will impact your health as you age, from childhood into the later stages of life. As a result, good nutrition today means optimal health tomorrow. Therefore, it is best to start making healthy choices from a young age and maintain them as you mature. However, a recent report published in the American Journal of Clinical Nutrition, suggests that adopting good nutritional choices later in life, during the forties, fifties, and even the sixties, may still help to reduce the risk of chronic disease as you grow older.[8]

8. Rivlin, RS. (2007). Keeping the Young-Elderly Healthy: Is

Even if past nutritional and lifestyle choices were not aligned with dietary guidelines, older adults can still do a great deal to reduce their risk of disability and chronic disease. As we age, we tend to lose lean body mass. This loss of muscle and bone can have critical health implications. For example, a decrease in body strength can result in an increased risk for fractures because older adults with weakened muscles are more likely to fall, and to sustain serious injuries when they do. However, improving your diet while increasing physical activity helps to control weight, reduce fat mass, and maintain muscle and bone mass.

There are a number of changes middle-aged adults can implement, even after years of unhealthy choices. Choices include eating more dark, green, leafy vegetables, substituting high-fat proteins with lean meats, poultry, fish, beans, and nuts, and engaging in moderate physical activity for thirty minutes per day, several days per week. The resulting improvements in body composition will go a long way toward providing greater protection against falls and fractures, and helping to ward off cardiovascular disease and hypertension, among other chronic conditions.[9]

It Too Late to Improve Our Health through Nutrition?. *American Journal of Clinical Nutrition*, *86*, 1572S–6S.

9. Rivlin, RS. (2007). Keeping the Young-Elderly Healthy: Is It Too Late to Improve Our Health through Nutrition?. *American Journal of Clinical Nutrition*, *86*, 1572S–6S.

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PART XVI

CHAPTER 16. PERFORMANCE NUTRITION

Introduction

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He poʻi na kai uli, kai koʻo, ʻaʻohe hina pūkoʻa

Though the sea be deep and rough, the coral rock remains standing.

Haydenraml erdesigns

Learning Objectives

By the end of this chapter you will be able to:

- Describe the physiological changes that occur in response to exercise
- Describe the effects of physical fitness on overall health
- Describe the purpose and applications of nutrition supplements

Becoming and staying physically fit is an important part of achieving optimal health. A well-rounded exercise program is crucial to becoming and remaining healthy. Physical activity improves your health in a number of ways. It promotes weight loss, strengthens muscles and bones, keeps the heart and lungs strong, and helps to protect against chronic disease. There are four essential elements of physical fitness: cardiorespiratory, muscular strength, flexibility, and maintaining a healthful body composition. Some enthusiasts might argue the relative importance of each, but optimal health requires some degree of balance between all four. For example, the Hawai'i Ironman is a vigorous race that consists of a 2.4 mile swim, 112 mile bike, and a 26 mile run. All four elements of physical fitness are vital in order to complete each leg of the race. To learn more about the Hawai'i Ironman, visit their website at http://www.ironman.com.

Some forms of exercise confer multiple benefits, which can help you to balance the different elements of physical fitness. For example, riding a bicycle for thirty minutes or more not only builds cardiorespiratory endurance, it also improves muscle strength and muscle endurance. Some forms of yoga can also build muscle strength and endurance, along with flexibility. However, addressing fitness standards in all four categories generally requires incorporating a range of activities into your regular routine. If you exercise regularly, your body will begin to change and you will notice that you are able to continue your activity longer. This is

due to the overload principle that our bodies will adapt to with continuous repetition. For example, if you run a mile everyday for a week, in a few weeks you would be able to run further and likely faster.

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The Essential Elements of Physical Fitness

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Cardiorespiratory Endurance

Cardiorespiratory endurance is enhanced by aerobic training which involves activities that increase your heart rate and breathing such as walking, jogging, or biking. Building cardiorespiratory endurance through aerobic exercise is an excellent way to maintain a healthy weight. Working on this element of physical fitness also improves your circulatory system. It boosts your ability to supply the body's cells with oxygen and nutrients, and to remove carbon dioxide and metabolic waste. Aerobic exercise is continuous exercise (lasting more than 2 minutes) that can range from low to high levels of intensity. In addition, aerobic exercise increases heart and breathing rates to meet increased demands for oxygen in working muscles. Regular, moderate aerobic activity, about thirty minutes at a time for five days per week, trains the body to deliver oxygen more efficiently, which strengthens the heart and lungs, and reduces the risk of cardiovascular disease.[1] Strengthening your heart muscle

1. The American Heart Association Recommendations for Physical Activity in Adults. American Heart Association. Heart.org. http://www.heart.org/HEARTORG/HealthyLiving/PhysicalActivity/FitnessBasics/American-Heart-Association-Recommendations-for-

and increasing the blood volume pumped each heartbeat will lead to a lower resting heart rate for healthy individuals. Aerobic exercise increases the ability of muscles to use oxygen for energy metabolism therefore creating ATP.

Aerobic capacity, or VO_2 is the most common standard for evaluating cardiorespiratory endurance. VO_2 max is your maximal oxygen uptake, and the VO_2 max test measures the amount of oxygen (in relation to body weight) that you can use per minute. A test subject usually walks or runs on a treadmill or rides a stationary bicycle while the volume and oxygen content of exhaled air is measured to determine oxygen consumption as exercise intensity increases. At some point, the amount of oxygen consumed no longer increases despite an increase in exercise intensity. This value of oxygen consumption is referred to as VO_2 max, 'V' meaning volume, and 'max' meaning the maximum amount of oxygen (O2) an individual is capable of utilizing. The higher the number, the more oxygen you can consume, and the faster or longer you can walk, run, bike, or swim, among other aerobic activities. VO_2 max can increase over time with training.[2]

Figure 16.1 VO_2 Max Test

Physical-Activity-Infographic_UCM_450754_SubHomePage.jsp. Accessed March 10, 2018.

2. Ed Eyestone. How to Improve Your VO_2 Max. RunnersWorld.com. http://www.runnersworld.com/article/0,7120,s6-238-244--12408-0,00.html. Published January 9, 2008.

Image by [Cosmed](#) / [CC BY-SA 3.0](#)

Muscle Strength

Muscle strength is developed and maintained by weight or resistance training that often is called anaerobic exercise. Anaerobic exercise consists of short duration, high intensity movements that rely on immediately available energy sources and require little or no oxygen during the activity. This type of high intensity training is used to build muscle strength by short, high intensity activities. Building muscle mass is not just crucial for athletes and bodybuilders—building muscle strength and endurance is important for children, seniors, and everyone in between. The support that your muscles provide allows you to work, play, and live more efficiently. Strength training involves the use of resistance machines, resistance bands, free weights, or other tools. However, you do not need to pay for a gym membership or expensive equipment to strengthen your muscles. Homemade weights, such as plastic bottles filled with sand, can work just as well. You can also use your own body weight and do push-ups, leg squats, abdominal

crunches, and other exercises to build your muscles. If strength training is performed at least twice a week, it can help to improve muscle strength and to increase bone strength. Strength training can also help you to maintain muscle mass during a weight-loss program.[3]

Flexibility

Flexibility is the range of motion available to your joints. Yoga, tai chi, Pilates, and stretching exercises work to improve this element of fitness. Stretching not only improves your range of motion, it also promotes better posture, and helps you perform activities that can require greater flexibility, such as chores around the house. In addition to working on flexibility, older adults should include balance exercises in their regular routine. Balance tends to deteriorate with age, which can result in falls and fractures.[4]

Body Composition

Body composition is the proportion of fat and fat-free mass (which

3. American College of Sports Medicine. Resistance Training for Health and Fitness. Acsm.org. https://www.acsm.org/docs/brochures/resistance-training.pdf. Accessed March 11, 2018.
4. Fitness Training: Elements of a Well-Rounded Routine. MayoClinic.com. http://www.mayoclinic.com/health/fitness-training/HQ01305. Updated August 10, 2017.

includes bones, muscles and organs) in your body. A healthy and physically fit individual has a greater proportion of muscle and smaller proportion of fat than an unfit individual of the same weight. Although habitual physical activity can promote a more healthful body composition, other factors like age, gender, genetics, and diet contribute to an individual's body composition. Women have a higher healthy fat percentage than men. For adult women, a healthy amount of body fat ranges from 20 to 32 percent. Adult males on the other hand range from 10 to 22 percent of body fat.[5]

Metabolic Fitness

Being fit also includes metabolic fitness. It relates to the number of calories you require to survive and the number of calories you burn during physical activity. Recall that metabolism is the sum of all chemical reactions that occur in the human body to conduct life's processes. Some are catabolic reactions that break down nutrients to supply the body with cellular energy. The rate at which a person burns calories depends on body composition, gender, age, nutritional status, physical activity, and genetics.

Increasing your daily activity and shedding excess body fat helps to improve metabolic fitness. Physical activity also makes weight management easier because it increases energy needs and lean body mass. During moderate to vigorous activity, energy expenditure raises well above the resting rate. With continuous

5. Measuring and Evaluating Body Composition. ACSM.org. http://www.acsm.org/public-information/articles/2016/10/07/measuring-and-evaluating-body-composition

exercise over time, regular exercise increases lean body mass as well. At rest, lean tissues use more energy than fat tissue therefore increasing basal metabolism. The combination of increased energy output, energy expenditure and basal needs over a long period of time can have a major impact on total energy expenditure (see Figure 16.2 "The Effect of Physical Activity on Energy Expenditure"). The more energy you expend, the more foods you are able to consume while maintaining a healthy weight. Any improvement to metabolic fitness is beneficial and means a decrease in the risk for developing diabetes, or other chronic conditions.

One measurement of metabolic fitness is basal metabolic rate, or BMR, which is a measurement of the amount of energy required for the body to maintain its basic functions while at rest, i.e. breathing, heart beats, liver and kidney function, and so on. On average, BMR accounts for between 50 and 70 percent of a person's total daily energy expenditure. Different factors can affect the BMR. For example, a slender person who is tall has more body surface area and therefore has a higher RMR relative to their body mass (weight). Also, muscle utilizes more energy at rest than fat, so a person with more muscle mass has a higher BMR.

A second measurement of metabolic fitness is the number of calories burned during physical activity. The amount of calories burned depends on how much oxygen is delivered to tissues, and how efficiently metabolic reactions consume oxygen and, therefore, expend calories. One of the best estimates of energy expenditure during exercise is how much oxygen a person consumes. Recall that VO2 max is a measure of the maximum cardiorespiratory capacity to deliver oxygen to the body, especially to working muscles during exercise.. Greater VO2 max is indicative of better cardiovascular fitness. In contrast to RMR, VO2 max increases significantly with exercise training due to training adaptations that increase the body's ability to deliver oxygen to working tissues and an increased capacity of muscles to take up and utilize oxygen.

Figure 16.2 The Effect of Physical Activity on Energy Expenditure

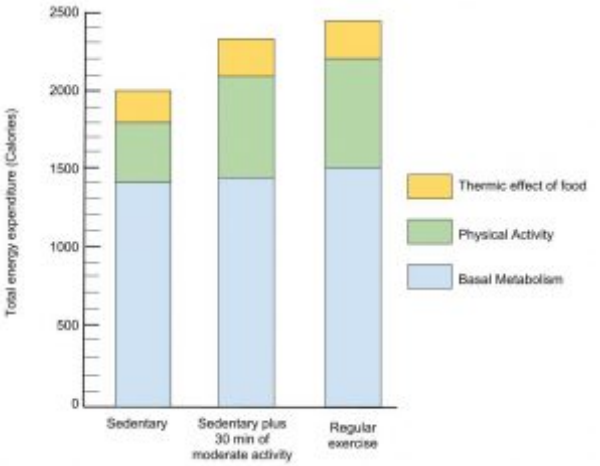

Image by Allison Calabrese / CC BY 4.0

Physical Activity Recommendations

The CDC along with the American College of Sports Medicine (ACSM) have evidence based recommendations and guidelines for individuals to follow in order to obtain or maintain a healthy lifestyle. Adults should get at least 150 minutes of moderate-intensity aerobic physical activity or 75 minutes of vigorous-intensity aerobic physical activity each week. In addition to aerobic physical activity, it is recommended that adults do muscle strengthening activities on each major muscle group two or three times each week. Adults also are recommended by the ACSM to do flexibility exercises at least two to three times a week to improve range of motion. To learn more about these guidelines visit the CDC website at https://health.gov/paguidelines/guidelines/adults.aspx and the ACSM website at http://www.acsm.org/about-acsm/media-room/news-releases/2011/08/01/acsm-issues-new-recommendations-on-quantity-and-quality-of-exercise.

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The Benefits of Physical Activity

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Regular physical activity is one of the best things you can do to achieve optimal health. Individuals who are physically active for about seven hours per week lower the risk of dying early by 40 percent compared to those who are active for less than thirty minutes per week.[1] Improving your overall fitness involves sticking with an exercise program on a regular basis. If you are nervous or unsure about becoming more active, the good news is that moderate-intensity activity, such as brisk walking, is safe for most people. Also, the health advantages of becoming active far outweigh the risks. Physical activity not only helps to maintain your weight, it also provides a wealth of benefits—physical, mental, and emotional.

Physical Benefits

Getting the recommended amount of physical activity each week, about 150 minutes of moderate, aerobic exercise, such as power walking or bicycling, does not require joining a gym, or taking expensive, complicated classes. If you can't commit to a formal

1. Physical Activity and Health: The Benefits of Physical Activity. CDC.org. http://www.cdc.gov/physicalactivity/everyone/health/index.html. Last updated February 16, 2011.

workout four to five days per week, you can become more active in simple ways—by taking the stairs instead of the elevator, by walking more instead of driving, by going out dancing with your friends, or by doing your household chores at a faster pace. It is not necessary to perform at the level of a professional dancer or athlete, or to work out for several hours every day, to see real gains from exercise. Even slightly increased activity can lead to physical benefits, such as:

- Longer life. A regular exercise program can reduce your risk of dying early from heart disease, certain cancers, and other leading causes of death.
- Healthier weight. Exercise, along with a healthy, balanced eating plan, can help you lose extra weight, maintain weight loss, or prevent excessive weight gain.
- Cardiovascular disease prevention. Being active boosts HDL cholesterol and decreases unhealthy triglycerides, which reduces the risk of cardiovascular diseases.
- Management of chronic conditions. A regular routine can help to prevent or manage a wide range of conditions and concerns, such as metabolic syndrome, type 2 diabetes, depression, arthritis, and certain types of cancer.
- Energy boosts. Regular physical activity can improve muscle tone and strength and provide a boost to your cardiovascular system. When the heart and lungs work more efficiently, you have more energy.
- Strong bones. Research shows that aerobic activity and strength training can slow the loss of bone density that typically accompanies aging.

Mental and Emotional Benefits

The benefits of an exercise program are not just physical, they are mental and emotional as well. Anyone who has gone for a walk to

clear their head knows the mental benefits of exercise firsthand. Also, you do not have to be a marathoner on a "runner's high" to enjoy the emotional benefits of becoming active. The mental and emotional benefits of physical activity include:

- Mood improvement. Aerobic activity, strength-training, and more contemplative activities such as yoga, all help break cycles of worry, absorption, and distraction, effectively draining tension from the body.
- Reduced risk of depression, or limited symptoms of it. Some people have called exercise "nature's antidepressant," and studies have shown that physical activity reduces the risk of and helps people cope with the symptoms of depression.
- Cognitive skills retention. Regular physical activity can help people maintain thinking, learning, and judgement as they age.
- Better sleep. A good night's sleep is essential for clear thinking, and regular exercise promotes healthy, sound sleep. It can also help you fall asleep faster and deepen your rest.

Changing to a More Active Lifestyle

A physically active lifestyle yields so many health benefits that it is recommended for everyone. Change is not always easy, but even small changes such as taking the stairs instead of the elevator, or parking farther away from a store to add a bit more walking into your day can lead to a more active lifestyle and set you on the road to optimal health. When people go one step further by walking or biking on a regular basis, or becoming active by growing and maintaining a garden, they do more than promote their own health—they safeguard the health of the planet, too.

As you change to a more active lifestyle, select an activity that you can integrate into your schedule smoothly, so you can maintain it. For example, instead of making time to get coffee with friends,

you might suggest a walk, rollerblading, or going for a swim in the campus pool. Also, find an activity that you will be motivated to do. Some people decide to participate in team sports, such as local soccer or softball leagues, because they enjoy being active with others or like knowing that a team relies on them. Others prefer to take a class, such as spinning or yoga, that is led by an instructor who will motivate them. Still others prefer more solitary pursuits, such as taking a jog alone in their neighborhood. No matter what your preference, you are more likely to stick to a workout program if you enjoy it.

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Fuel Sources

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The human body uses carbohydrate, fat and protein in food and from body stores as energy. These essential nutrients are needed regardless of the intensity of activity you are doing. If you are lying down reading a book or running the the Honolulu Marathon, these macronutrients are always needed in the body. However, in order for these nutrients to be used as fuel for the body, their energy must be transferred into the high energy molecule known as Adenosine Triphosphate (ATP). ATP is the body's immediate fuel source of energy that can be generated either with the presences of oxygen known as aerobic metabolism or without the presence of oxygen by anaerobic metabolism. The type of metabolism that is predominately used during physical activity is determined by the availability of oxygen and how much carbohydrate, fat, and protein are used.

Anaerobic and Aerobic Metabolism

Anaerobic metabolism occurs in the cytosol of the muscle cells. As seen in Figure 16.2 "Anaerobic versus Aerobic Metabolism", a small amount of ATP is produced in the cytosol without the presence of oxygen. Anaerobic metabolism uses glucose as its only source of fuel and produces pyruvate and lactic acid. Pyruvate can then be used as fuel for aerobic metabolism. Aerobic metabolism takes place in the mitochondria of the cell and is able to use carbohydrates, protein or fat as its fuel source. Aerobic metabolism is a much slower process than anaerobic metabolism but produces majority of the ATP.

Figure 16.3 Anaerobic versus Aerobic Metabolism

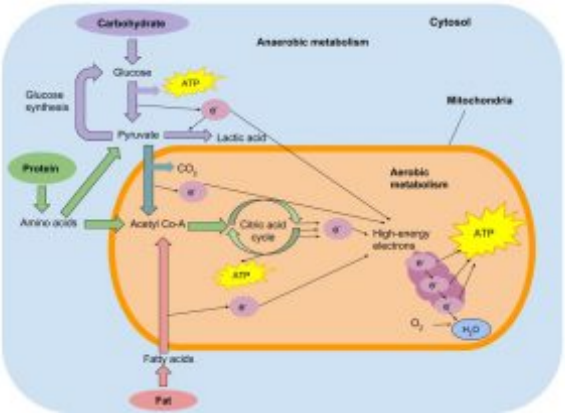

Image by Allison Calabrese / CC BY 4.0

Physical Activity Duration and Fuel Use

The respiratory system plays a vital role in the uptake and delivery of oxygen to muscle cells throughout the body. Oxygen is inhaled by the lungs and transferred from the lungs to the blood where the cardiovascular system circulates the oxygen-rich blood to the muscles. The oxygen is then taken up by the muscles and can be used to generate ATP. When the body is at rest, the heart and lungs are able to supply the muscles with adequate amounts of oxygen to meet the aerobic metabolism energy needs. However, during physical activity your muscles energy and oxygen needs are increased. In order to provide more oxygen to the muscle cells, your heart rate and breathing rate will increase. The amount of oxygen that is delivered to the tissues via the cardiovascular and respiratory systems during exercise depend on the duration, intensity and physical conditioning of the individual.

During the first few steps of exercise, your muscles are the first to respond to the change in activity level. Your lungs and heart however do not react as quickly and during those beginning steps they do not begin to increase the delivery of oxygen. In order for

our bodies to get the energy that is needed in these beginning steps, the muscles rely on a small amount of ATP that is stored in resting muscles. The stored ATP is able to provide energy for only a few seconds before it is depleted. Once the stored ATP is just about used up, the body resorts to another high-energy molecule known as creatine phosphate to convert ADP (adenosine diphosphate) to ATP. After about 10 seconds, the stored creatine phosphate in the muscle cells are also depleted as well.

About 15 seconds into exercise, the stored ATP and creatine phosphate are used up in the muscles. The heart and lungs have still not adapted to the increase need of oxygen so the muscles must begin to produce ATP by anaerobic metabolism (without oxygen). Anaerobic metabolism can produce ATP at a rapid pace but only uses glucose as its fuel source. The glucose is obtained from the blood of muscle glycogen. At around 30 seconds, anaerobic pathways are operating at their full capacity but because the availability of glucose is limited, it cannot continue for a long period of time.

As your exercise reaches two to three minutes, your heart rate and breathing rate have increased to supply more oxygen to your muscles. Aerobic metabolism is the most efficient way of producing ATP by producing 18 times more ATP for each molecule of glucose than anaerobic metabolism. Although the primary source of ATP in aerobic metabolism is carbohydrates, fatty acids and protein can also be used as fuel to generate ATP.

Figure 16.4 The Effect of Exercise Duration on Energy Systems

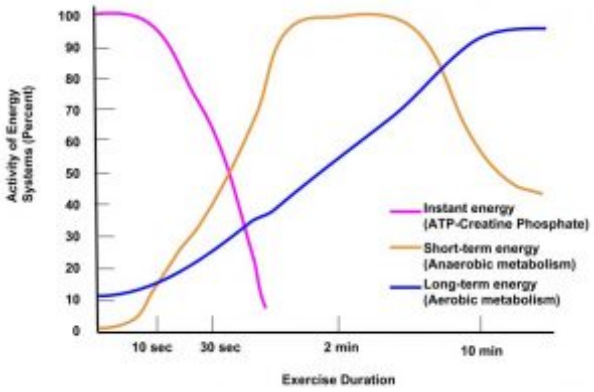

Image by Allison Calabrese / CC BY 4.0

The fuel sources for anaerobic and aerobic metabolism will change depending on the amount of nutrients available and the type of metabolism. Glucose may come from blood glucose (which is from dietary carbohydrates or liver glycogen and glucose synthesis) or muscle glycogen. Glucose is the primary energy source for both anaerobic and aerobic metabolism. Fatty acids are stored as triglycerides in muscles but about 90% of stored energy is found in adipose tissue. As low to moderate intensity exercise continues using aerobic metabolism, fatty acids become the predominant fuel source for the exercising muscles. Although protein is not considered a major energy source, small amounts of amino acids are used while resting or doing an activity. The amount of amino acids used for energy metabolism increase if the total energy intake from your diet does not meet the nutrient needs or if you are involved in long endurance exercises. When amino acids are broken down removing the nitrogen-containing amino acid, that remaining carbon molecule can be broken down into ATP via aerobic metabolism or used to make glucose. When exercise continues for many hours, amino acid use will increase as an energy source and for glucose synthesis.

Figure 16.5 Fuel Sources for Anaerobic and Aerobic Metabolism

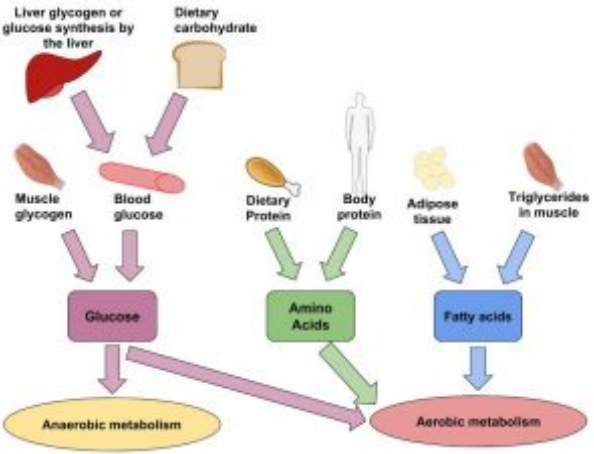

Image by Allison Calabrese / CC BY 4.0

Physical Activity Intensity and Fuel Use

The exercise intensity determines the contribution of the type of fuel source used for ATP production(see Figure 16.4 "The Effect of Exercise Intensity on Fuel Sources"). Both anaerobic and aerobic metabolism combine during exercise to ensure that the muscles are equipped with enough ATP to carry out the demands placed on them. The amount of contribution from each type of metabolism will depend on the intensity of an activity. When low-intensity activities are performed, aerobic metabolism is used to supply enough ATP to muscles. However, during high-intensity activities more ATP is needed so the muscles must rely on both anaerobic and aerobic metabolism to meet the body's demands.

During low-intensity activities, the body will use aerobic metabolism over anaerobic metabolism because it is more efficient by producing larger amounts of ATP. Fatty acids are the primary energy source during low-intensity activity. With fat reserves in the body being almost unlimited, low-intensity activities are able to continue for a long time. Along with fatty acids, a small amount

of glucose is used as well. Glucose differs from fatty acids where glycogen storages can be depleted. As glycogen stores are depleted, fatigue will eventually set in.

Figure 16.6 The Effect of Exercise Intensity on Fuel Sources

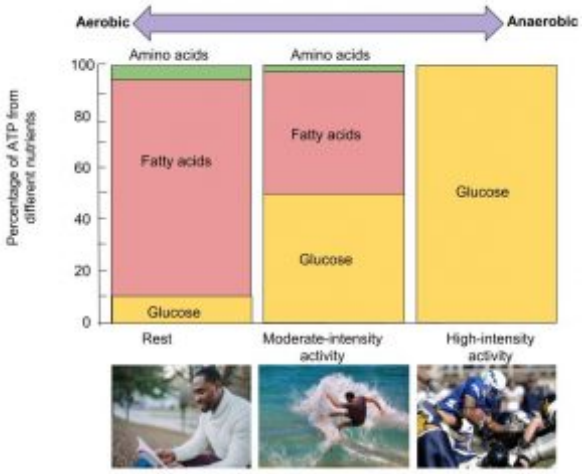

Image by Allison Calabrese / CC BY 4.0

The Fat-Burning Zone

The fat-burning zone is a low intensity aerobic activity that keeps your heart rate between 60 and 69% of your maximum heart rate. The cardio zone on the other hand is a high intensity aerobic activity that keeps the heart rate between about 70 to 85% of your maximum heart rate. So which zone do you burn the most fat in? Technically, your body burns a higher percentage of of calories from fat during a low intensity aerobic activity but there's more to it

than just that. When you begin a low intensity activity, about 50% of the calories burned comes from fat whereas in the cardio zone only 40% come froms fat. However, when looking at the actual numbers of calories burned, higher intensity activity burns just as much fat and a much greater total calories overall.

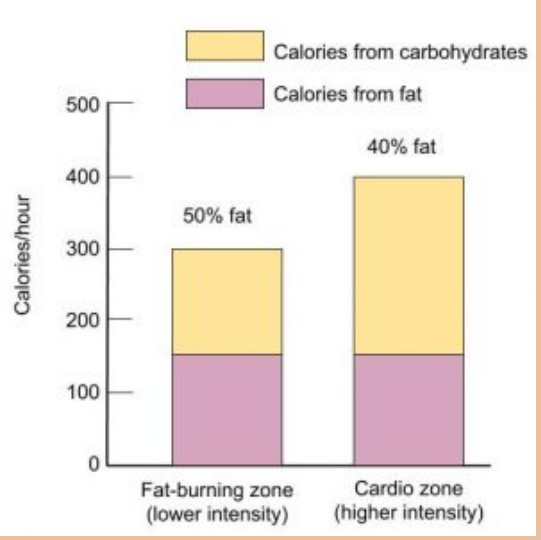

Image by Allison Calabrese / CC BY 4.0

"Hitting the Wall" or "Bonking"

If you are familiar with endurance sports, you may have heard of "hitting the wall" or "bonking." These colloquial terms refer to the extreme fatigue that sets in after about 120 minutes of performing an endurance sport, such as marathon running or long-distance

cycling. The physiology underlying "hitting the wall" means that muscles have used up all their stored glycogen and are therefore dependent on other nutrients to support their energy needs. Fatty acids are transported from fat-storing cells to the muscle to rectify the nutrient deficit. However, fatty acids take more time to convert to energy than glucose, thus decreasing performance levels. To avoid "hitting the wall" or "bonking," endurance athletes load up on carbohydrates for a few days before the event, known as carbohydrate loading. This will maximize an athlete's amount of glycogen stored in their liver and muscle tissues. It is important not to assume that carbohydrate loading works for everyone. Without accompanied endurance training you will not increase the amount of stored glucose. If you plan on running a five-mile race for fun with your friend and decide to eat a large amount of carbohydrates in the form of a big spaghetti dinner the night before, the excess carbohydrates will be stored as fat. Therefore, if you are not an endurance athlete exercising for more than 90 minutes, carbohydrate loading will provide no benefit, and can even have some disadvantages. Another way for athletes to avoid "hitting the wall" is to consume carbohydrate-containing drinks and foods during an endurance event. In fact, throughout the Tour de France—a twenty-two-day, twenty-four-hundred-mile race—the average cyclist consumes greater than 60 grams of carbohydrates per hour.

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook

features interactive learning activities. These activities are available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

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Sports Nutrition

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Nutrient Needs for Athletes

Nutrition is essential to your performance during all types of exercise. The foods consumed in your diet are used to provide the body with enough energy to fuel an activity regardless of the intensity of activity. Athletes have different nutritional needs to support the vigorous level they compete and practice at.

Energy Needs

To determine an athletes nutritional needs, it is important to revisit the concept of energy metabolism. Energy intake is the foundation of an athlete's diet because it supports optimal body functions, determines the amount of intake of macronutrients and micronutrients, and assists in the maintaining of body composition. Energy needs for athletes increase depending on their energy expenditure. The energy expended during physical activity are contingent on the intensity, duration, and frequency of the exercise. Competitive athletes may need 3,000 to over 5,000 calories daily compared to a typical inactive individual who needs about 2,000 calories per day. Energy needs are also affected by an individual's gender, age, and weight. Weight-bearing exercises, such as running, burn more calories per hour than non-weight bearing exercises, such as swimming. Weight-bearing exercises requires your body to move against gravity which requires more energy. Men

are also able to burn more calories than women for the same activity because they have more muscle mass which requires more energy to support and move around.[1]

Body weight and composition can have a tremendous impact on exercise performance. Body weight and composition are considered the focal points of physique for athletes because they are the able to be manipulated the most. Energy intake can play a role in manipulating the physiques for athletes. For individuals competing in sports such as football and weight lifting, having a large amount of muscle mass and increased body weight may be beneficial. This can be obtained through a combination of increased energy intake, and protein. Although certain physiques are more advantageous for specific sports, it is important to remember that a single and rigid "optimal" body composition is not recommended for any group of athletes.[2]

1. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.
2. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

Macronutrient Needs

The composition of macronutrients in the diet is a key factor in maximizing performance for athletes. Carbohydrates are an important fuel source for the brain and muscle during exercise. Carbohydrate storage in the liver and muscle cells are relatively limited and therefore it is important for athletes to consume enough carbohydrates from their diet. Carbohydrate needs should increase about 3-10 g/kg/day depending on the type of training or competition.[3] See Table 16.1 "Daily Needs for Carbohydrate Fuel" for carbohydrate needs for athletes depending on the intensity of the exercise.

Table 16.1 Daily Needs for Carbohydrate Fuel

Activity Level	Example of Exercise	Increase of Carbohydrate (g/kg of athlete's body weight/ day)
Light	Low intensity or skill based activities	3-5
Moderate	Moderate exercise program (about 1 hour per day)	5-7
High	Endurance program (about 1-3 hours per day of moderate to high intensity exercise)	6-10
Very High	Extreme commitment (4-5 hours per day of moderate to high intensity exercise)	8-12

3. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

Source: Nutrition and Athletic Performance. American College of Sports Medicine.Medicine & Science in Sports & Exercise. 2016; 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition__and__Athletic__Performance.25.aspx. Accessed March 17, 2018.

Fat is a necessary component of a healthy diet to provide energy, essential fatty acids and to facilitate the absorption of fat-soluble vitamins. Athletes are recommended to consume the same amount of fat in the diet as the general population, 20-35% of their energy intake. Although these recommendations are in accordance with public health guidelines, athletes should individualize their needs based on their training level and body composition goals. Athletes who choose to excessively restrict their fat intake in an effort to lose body weight or improve body composition should ensure they are still getting the minimum recommended amount of fat. Fat intakes below 20% of energy intake will reduce the intake of fat-soluble vitamins and essential fatty acids, especially omega 3's. [4]

Although protein accounts for only about 5% of energy expended, dietary protein is necessary to support metabolic reactions (that generate ATP), and to help muscles with maintenance, growth, and repair. During exercise, these metabolic reactions for generating ATP rely heavily on proteins such as enzymes and transport proteins. It is recommended that athletes consume 1.2 to 2.0 g/kg/day of proteins in order to support these functions. Higher intakes may also be needed for short periods of intense training

4. Nutrition and Athletic Performance. (2016), American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

or when reducing energy intake.[5] See Table 16.2 "Recommended Protein Intakes for Athletes" below for a better representation of protein needs depending on extent of training and dietary sources.

Table 16.2 The Recommended Protein Intakes for Individuals

Group	Protein Intake (g/kg body weight)
Most adults	0.8
Endurance athletes	1.2 to 1.4
Vegetarian endurance athletes	1.3 to 1.5
Strength athletes	1.6 to 1.7
Vegetarian strength athletes	1.7 to 1.8

Source: Dietary Reference Intakes, 2002 ACSM/ADA/Dietitians of Canada Position Statement: Nutrition & Athletic Performance, 2001. Accessed March 17, 2018.

It is important to consume adequate amounts of protein and to understand that the quality of the protein consumed affects the amount needed. High protein foods such as meats, dairy, and eggs contain all of the essential amino acids in relative amounts that most efficiently meet the body's needs for growth, maintenance and repair of muscles. Vegetarian diets contain protein that has lower digestibility and amino acid patterns that do not match human needs as closely as most animal proteins. To compensate for this as well as the fact that plant food protein sources also contain higher amounts of fiber, higher protein intakes are recommended

5. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

for vegetarian athletes. (See Table 16.2 “The Recommended Protein Intakes for Individuals”)

Micronutrient Needs

Vitamins and minerals are essential for energy metabolism, the delivery of oxygen, protection against oxidative damage, and the repair of body structures. When exercise increases, the amount of many vitamins and minerals needed are also increased due to the excess loss in nutrients. Currently, there is not special micronutrient recommendations made for athletes but most athletes will meet their needs by consuming a balanced diet that meets their energy needs. Because the energy needs of athletes increase, they often consume extra vitamins and minerals. The major micronutrients of concern for athletes include iron, calcium, vitamin D, and some antioxidants. [6]

6. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

Common Nutrient Deficiencies for Athletes

Energy deficiency

For athletes, consuming sufficient amounts of calories to support their energy expenditure is vital to maintain health and body functions. When the energy intake for athletes does not meet the high demands of exercise, a syndrome referred to as relative deficiency in sport (RED-S) occurs. RED-S has a negative effect on performance and health in both male and female athletes as shown in Table 16.7 "Relative Energy Deficiency in Sport Effects". Athletes in sports with weight classes, such as wrestling, may put their health at risk by rapid weight loss in order to hit a specific weight for a match. These athletes are vulnerable to eating disorders due to sporadic dieting (several of which will restrict energy intake). The long term effects of these practices can not only impair performance but also have serious repercussions such as heart and kidney function, temperature regulation and electrolyte balance problems.

Figure 16.7 Relative Energy Deficiency in Sport Effects

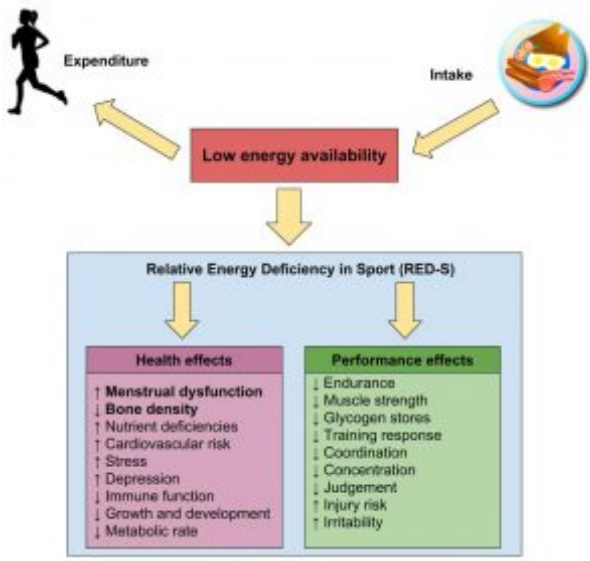

Image by Allison Calabrese / CC BY 4.0

Of the RED-S consequences that occur from an energy intake deficiency, the two health effects that are of the greatest concern to female athletes are menstrual dysfunction and decreased bone density. Menstrual dysfunction and low bone density symptoms of RED-S can create hormonal imbalances that are described in "Figure 16.8 The Female Athlete Triad". In today's society, there is increasing pressure to be extremely thin that some females take exercise too far. The low energy intakes will lead to the female athlete triad that causes bone loss, stoppage of menstrual periods, and eating disorders.[7]

7. The Female Athlete Triad. (2016). American College of Sports Medicine. http://www.acsm.org/public-information/articles/2016/10/07/the-female-athlete-

Figure 16.8 The Female Athlete Triad

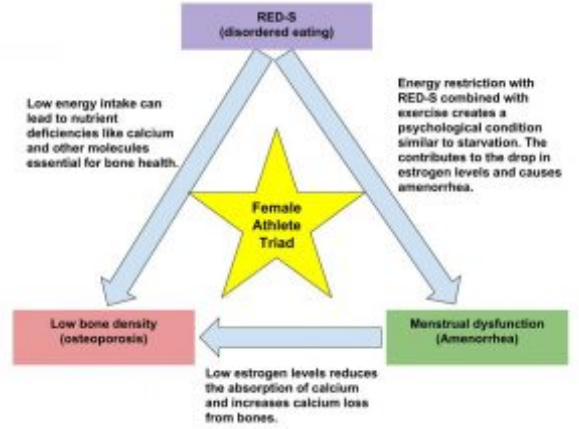

Image by Allison Calabrese / CC BY 4.0

Iron

Iron deficiency is very common in athletes. During exercise, iron-containing proteins like hemoglobin and myoglobin are needed in great amounts. An iron deficiency can impair muscle function to limit work capacity leading to compromised training performance. Some athletes in intense training may have an increase in iron losses through sweat, urine, and feces. Iron losses are greater in females than males due to the iron lost in blood every menstrual cycle. Female athletes, distance runners and vegetarians are at the greatest risk for developing iron deficiency.[8] See Table 16.3 "The

triad. Published October 7, 2016. Accessed March 16, 2018.

8. Beard J, Tobin B. (2000). Iron Status and Exercise. *The American Journal of Clinical Nutrition*, 72(2), 594S–597S.

Potential Iron Loss in Endurance Athletes" for the potential amounts of iron loss each day in male and female athletes. An increased recommendation for both genders are shown below. These recommendations are based on the assumption that iron has a 10% absorption efficiency. As noted above, women athletes have a greater iron loss due to menstruation and therefore must increase their dietary needs more than male athletes.

Table 16.3 The Potential Iron Loss in Endurance Athletes

Approximate Daily Iron Losses in Endurance Athletes (mg/day)and Increased Dietary Need		
	Male	Female
Sedentary	1	1.5
Athlete	1.8	2.5
*Increase dietary needs	8	10
*Assumes 10% absorption efficiency		

Source: Weaver CM, Rajaram S.Exercise and iron status. J Nutr. 1992 Mar;122(3 Suppl):782-7. https://www.ncbi.nlm.nih.gov/pubmed/1542048. Accessed March 23, 2018.

Sports anemia, which is different from iron deficiency anemia is an adaptation to training for athletes. Excessive training causes the blood volume to expand in order to increase the amount of oxygen delivered to the muscles. During sports anemia, the synthesis of red blood cells lags behind the increase in blood volume which results in a decreased percentage of blood volume that is red blood cells. The total amount of red blood cells remains the same or may increase slightly to continue the transport of oxygen. Eventually as training

https://academic.oup.com/ajcn/article/72/2/594S/4729672. Accessed March 16, 2018.

progresses, the amount of red blood cells will increase to catch up with the total blood volume.

Vitamin D and Calcium

Vitamin D regulates the calcium and phosphorus absorption and metabolism and plays a key role in maintaining optimal bone health. There is also growing evidence that vitamin D is important for other aspect of athletic performance such as injury prevention, rehabilitation, and muscle metabolism. Individuals who primarily practice indoors are at a larger risk for a vitamin D deficiency and should ensure they are consuming foods high in vitamin D to maintain sufficient vitamin D status.[9]

Calcium is especially important for the growth, maintenance, and repair of bone tissue. Low calcium intake occurs in athletes with RED-S, menstrual dysfunction, and those who avoid dairy products. A diet inadequate in calcium increases the risk for low bone mineral density which ultimately leads to stress fractures.

Antioxidant nutrients

Antioxidant nutrients play an important role in protecting cell

9. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

membranes from oxidative damage. During exercise, the amount of oxygen used by the muscles increases and can produce free radicals which causes an increase in antioxidant systems in the the body. These antioxidant systems rely on the dietary antioxidants such as beta-carotene, vitamin C, vitamin E, and selenium that can be obtained through a nutrient dense diet.

Learning Activities

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Water and Electrolyte Needs

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During exercise, being appropriately hydrated contributes to performance. Water is needed to cool the body, transport oxygen and nutrients, and remove waste products from the muscles. Water needs are increased during exercise due to the extra water losses through evaporation and sweat. Dehydration can occur when there is inadequate water levels in the body and can be very hazardous to the health of an individual. As the severity of dehydration increases, the exercise performance of an individual will begin to decline (see Figure 16.9 "Dehydration Effect on Exercise Performance"). It is important to continue to consume water before, during and after exercise to avoid dehydration as much as possible.

Figure 16.9 Dehydration Effect on Exercise Performance

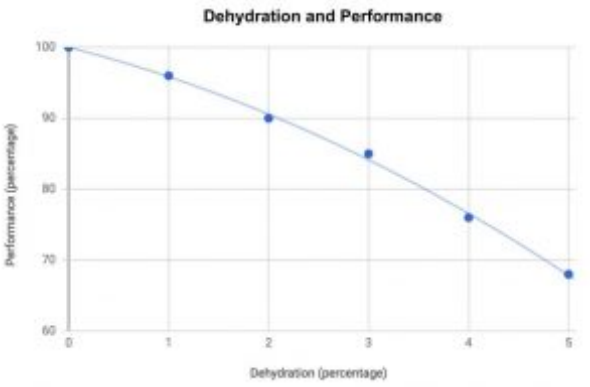


Image by Allison Calabrese / CC BY 4.0

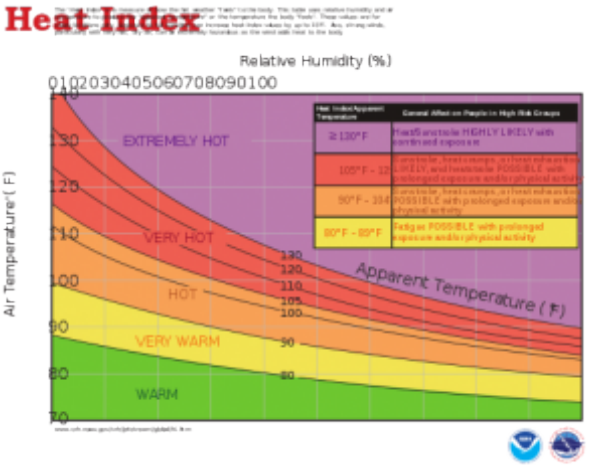
During exercise, thirst is not a reliable short term indicator of the body's needs as it typically is not enough to replace the water loss. Even with the constant replenishing of water throughout an

exercise, it may not be possible to drink enough water to compensate for the losses. Dehydration occurs when the total loss of water is so significant that the total blood volume decreases which leads to the reduction of oxygen and nutrients transported to the muscle cells. A decreased blood volume also reduces the blood flow to the skin and the production of sweat which can increase the body temperature. As a result, the risk of heat related illnesses increases.

Heat cramps are one of the heat related illnesses that can occur during or after exercise. Heat cramps are involuntary muscle spasms that usually involve the muscle being exercised, which causes by an imbalance of electrolytes, usually sodium. Heat exhaustion is caused the the loss of water decreasing the blood volume so much that it is not possible to cool the body as well as provide oxygen and nutrients to the active muscles. Symptoms that arise from heat exhaustion may include low blood pressure, disorientation, profuse sweating, and fainting. Heat exhaustion can progress further if exercise continues into a heat stroke. A heat stroke is the most serious form of heat related illnesses that can occur. During a heat stroke, the internal body temperature rises above 105°F which causes the brain's temperature-regulatory center to shut down. When the brain's temperature regulatory center shuts down, an individual is unable to sweat regardless of their internal body temperature rising. Other symptoms that arise are dry skin, extreme confusion, and unconsciousness. A heat stroke requires immediate medical attention.

The external temperature during exercise can also play a role in the risk of heat related illnesses. As the external temperature increases, it becomes more difficult for the body to dissipate heat. As humidity also increases, the body is unable to cool itself through evaporation. The Heat Index is a measure of how hot the body feels when humidity is added to the air temperature (see Figure 16.10 "The Heat Index").

Figure 16.10 The Heat Index



"*Heat Index*" by National Weather Service, Southern Region Headquarters / *Public Domain*

Hyponatremia

Sweating during exercise helps our bodies to stay cool. Sweat consists of mostly water but it also causes losses of sodium, potassium, calcium and magnesium. During most exercises, the amount of sodium lost is very small.Drinking water after completing an exercise will replenish the sodium in the body. However, during long endurance exercises such as a marathon or triathlon, sodium losses are larger and must be replenished as well. If water is replenished without sodium the sodium already in the body will become diluted. These low levels of sodium in the blood will cause a condition known as hyponatremia (see Figure 16.11 "The Effect of Exercise on Sodium Levels"). When sodium levels in the blood are decreased, water moves into the cell through osmosis which causes swelling. Accumulation of fluid in the lungs and the brain can cause serious life threatening conditions such as a seizure, coma and death.

In order to avoid hyponatremia, athletes should increase their

consumption of sodium in the days leading up to an event and consume sodium-containing sports drinks during their race or game. The early signs of hyponatremia include nausea, muscle cramps, disorientation, and slurred speech. To learn more about the sports drinks that can optimize your performance, refer back to Chapter 3, Water and Electrolytes.

Figure 16.11 The Effect of Exercise on Sodium Levels

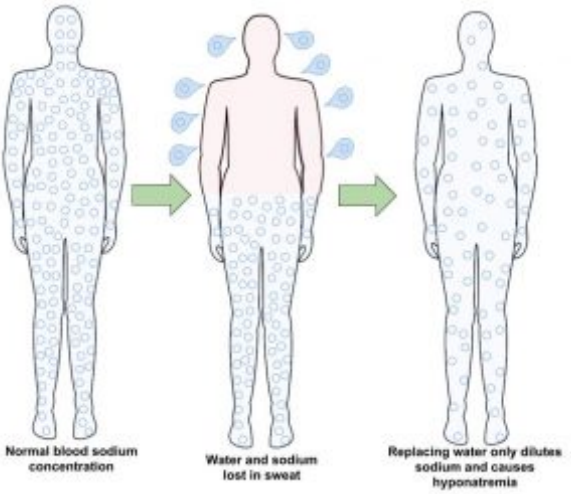


Image by Allison Calabrese / CC BY 4.0

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Food Supplements and Food Replacements

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Current trends also include the use of supplementation to promote health and wellness. Vitamins, minerals, herbal remedies, and supplements of all kinds constitute big business and many of their advertising claims suggest that optimal health and eternal youth are just a pill away. Dietary supplements can be macronutrient (amino acids, proteins, essential fatty acids), micronutrient (vitamins and minerals that promote healthy body functions), probiotic (beneficial bacteria such as the kind found in the intestines), and herbally (often target a specific body part, such as bones) based.

Some public health officials recommend a daily multivitamin due to the poor diet of most North Americans. The US Preventive Task Force also recommends a level of folate intake which can be easier to achieve with a supplement. In addition, the following people may benefit from taking daily vitamin and mineral supplements:[1]

- Women who are pregnant or breastfeeding
- Premenopausal women who may need extra calcium and iron
- Older adults

1. Nutrition and Athletic Performance. (2016). American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, 48(3), 543- 568. https://journals.lww.com/acsm-msse/Fulltext/2016/03000/Nutrition_and_Athletic_Performance.25.aspx. Accessed March 17, 2018.

- People with health issues that affect their ability to eat
- Vegetarians, vegans, and others avoiding certain food groups

However, before you begin using dietary supplementation, consider that the word supplement denotes something being added. Vitamins, minerals, and other assorted remedies should be considered as extras. They are add-ons—not replacements—for a healthy diet. As food naturally contains nutrients in its proper package, remember that food should always be your primary source of nutrients. When considering taking supplements, it is important to recognize possible drawbacks that are specific to each kind:[2]

- Micronutrient Supplements. Some vitamins and minerals are toxic at high doses. Therefore, it is vital to adhere to the Tolerable Upper Intake Levels (UL) so as not to consume too much of any vitamin. For example, too much vitamin A is toxic to the liver. Symptoms of vitamin A toxicity can include tinnitus (ringing in the ears), blurred vision, hair loss, and skin rash. Too much niacin can cause a peptic ulcer, hyperglycemia, dizziness, and gout.
- Herbal Supplements. Some herbs cause side effects, such as heart palpitations and high blood pressure, and must be taken very carefully. Also, some herbs have contraindications with certain medicines. For example, Valerian and St. John's Wort negatively interact with certain prescription medications, most notably antidepressants. Additionally, there is a real risk of overdosing on herbs because they do not come with warning labels or package inserts.

2. Choosing a Vitamin and Mineral Supplement—Topic Overview. WebMD.com. http://www.webmd.com/food-recipes/tc/choosing-a-vitamin -and-mineral-supplement-topic-overview. Last revised March 11, 2018.

- Amino Acid Supplements. Certain amino acid supplements, which are often taken by bodybuilders among others, can increase the risk of consuming too much protein. An occasional amino acid drink in the place of a meal is not a problem. However, problems may arise if you add the supplement to your existing diet. Most Americans receive two to three times the amount of protein required on a daily basis from their existing diets—taking amino acid supplements just adds to the excess. Also, certain amino acids share the same transport systems in the absorption process; therefore, a concentrated excess of one amino acid obtained from a supplement may increase the probability of decreased absorption of another amino acid that uses the same transport system. This could lead to deficiency in the competing amino acid.

Supplement Claims and Restrictions

The Food and Drug Administration (FDA) regulates supplements, but it treats them like food rather than pharmaceuticals. Dietary supplements must meet the FDA's Good Manufacturing Standards, but are not required to meet the standards for drugs, although some companies do so voluntarily. Also, although supplement manufacturers are allowed to say a particular ingredient may reduce the risk of a disease or disorder, or that it might specifically target certain body systems, these claims are not approved by the FDA. This is why labels that make structural and functional claims are required to carry a disclaimer saying the product is not intended "to diagnose, treat, cure, or prevent any disease." In addition, in the United States, supplements are taken off the market only after the

FDA has proven that they are hazardous.[3] To revisit the topic of structural and functional claims refer back to Chapter 12 "Nutrition Applications".

Before Taking Supplements

The phrase caveat emptor means "buyer beware," and it is important to keep the term in mind when considering supplementation. Just because a product is "natural" does not mean it can't be harmful or dangerous, particularly if used inappropriately. The following are helpful questions to explore before deciding to take a supplement:

- Does the scientific community understand how this supplement works and are all its effects well known?
- Is there proof that the supplement actually performs in the manner that it claims?
- Does this supplement interact with food or medication?
- Is taking this supplement necessary for my health?
- Is the supplement affordable?
- Is the supplement safe and free from contaminants?

Lastly, please remember that a supplement is only as good as the diet that accompanies it. We cannot overstate the importance of eating a healthy, well-balanced diet designed to provide all of the necessary nutrients. Food contains many more beneficial substances, such as phytochemicals and fiber, that promote good

3. Watson S. How to Evaluate Vitamins and Supplements. WebMD.com. http://www.webmd.com/vitamins-and-supplements/lifestyle-guide -11/how-to-evaluate-vitamins-supplements. Accessed March 11, 2018.

health and cannot be duplicated with a pill or a regimen of supplements. Therefore, vitamins and other dietary supplements should never be a substitute for food. Nutrients should always be derived from food first.

Food: The Best Medicine

Poor dietary choices and a sedentary lifestyle account for about 300–600 thousand deaths every year according to the US Department of Health and Human Services. That number is thirteen times higher than the deaths due to gun violence.[4] The typical North American diet is too high in saturated fat, sodium, and sugar, and too low in fiber in the form of whole fruits, vegetables, and whole grains to keep people healthy. With so many threats to optimal health it is vital to address those factors that are under your control, namely dietary and lifestyle choices. A diet that supplies your body with the needed energy and nutrients daily will result in efficient body functioning and in protection from disease. Making sound nutritional choices can also provide support for individuals undergoing treatment for short-term or chronic conditions. Finding a balance between nutritional needs with concerns about drug interactions can hasten recovery, improve quality of life, and minimize the side effects from treatment protocols.

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4. Why Good Nutrition Is Important. CSPINET.org. http://www.cspinet.org/nutritionpolicy/nutrition_policy.html. Accessed March 9, 2018.

Learning Activities

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PART XVII

CHAPTER 17. FOOD SAFETY

Introduction

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Ka lepo ke kumu wai, e huaʻi ana ka lepo kai

When the source of water is dirty, the dirt is carried to the sea.

Image by Maarten Van de Heuvel on unsplash.com / CCO

Learning Objectives

By the end of this chapter you will be able to:

- Describe the major types and causes of and contamination
- Describe the purpose and process of food irradiation
- Describe consumer-level techniques for avoiding foodborne illness

Foodborne Illness and Food Safety

Foodborne illness is a serious threat to health. Sometimes called "food poisoning," foodborne illness is a common public health problem that can result from exposure to a pathogen or a toxin via food or beverages. Raw foods, such as seafood, produce, and meats, can all be contaminated during harvest (or slaughter for meats), processing, packaging, or during distribution, though meat and poultry are the most common source of foodborne illness. For all kinds of food, contamination also can occur during preparation and cooking in a home kitchen or in a restaurant. For example in 2009, the Marshall Islands reported 174 cases presenting with vomiting and diarrhea. After an epidemiological investigation was completed, they identified the cause to be egg sandwiches that had been left at room temperature too long resulting in the growth of foodborne toxins in the egg sandwiches.[1]

1. Thein CC, Trinidad RM, Pavlin B. (2010). A Large Foodborne Outbreak on a Small Pacific Island. *Pacific*

In many developing nations, contaminated water is also a major source of foodborne illness. Many people are affected by foodborne illness each year, making food safety a very important issue. Annually, one out of six Americans becomes sick after consuming contaminated foods or beverages.[2] Foodborne illness can range from mild stomach upset to severe symptoms, or even fatalities. The problem of food contamination can not only be dangerous to your health, it can also be harmful to your wallet. Medical costs and lost wages due to salmonellosis, just one foodborne disease, are estimated at over $1 billion per year.

At-Risk Groups

No one is immune from consuming contaminated food but, whether you become seriously ill depends on the microorganism, the amount you have consumed, and your overall health. In addition, some groups have a higher risk than others for developing severe complications to foodborne disease. Who is most at risk? Young children, elderly people, and pregnant women all have a higher chance of becoming very sick after consuming contaminated food. Other high-risk groups include people with compromised immune systems due to HIV/AIDS, immunosuppressive medications (such as after an organ transplant), and long-term steroid use for asthma or arthritis. Exposure to contaminated food could also pose problems

Health Dialogue, *16*(1). https://www.ncbi.nlm.nih.gov/pubmed/20968238. Accessed January 28, 2018.

2. Foodborne Illnesses and Germs. (2018). Centers for Disease Control and Prevention.https://www.cdc.gov/foodsafety/foodborne-germs.html . Updated January 23, 2018. Accessed January 28, 2017.

for diabetics, cancer patients, people who have liver disease, and people who have stomach problems as a result of low stomach acid or previous stomach surgery. People in all of these groups should handle food carefully, make sure that what they eat has been cooked thoroughly, and avoid taking any chances that could lead to exposure.

Learning Activities

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The Major Types of Foodborne Illness

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Foodborne illnesses are either infectious or toxic in nature. The difference depends on the agent that causes the condition. Microbes, such as bacteria, cause food infections, while toxins, such as the kind produced by molds, cause intoxications. Different diseases manifest in different ways, so signs and symptoms can vary with the source of contamination. However the illness occurs, the microbe or toxin enters the body through the gastrointestinal tract, and as a result common symptoms include diarrhea, nausea, and abdominal pain. Additional symptoms may include vomiting, dehydration, lightheadedness, and rapid heartbeat. More severe complications can include a high fever, diarrhea that lasts more than three days, prolonged vomiting, bloody stools, and signs of shock.

One of the biggest misconceptions about foodborne illness is that it is always triggered by the last meal that a person ate. However, it may take several days or more before the onset of symptoms. If you develop a foodborne illness, you should rest and drink plenty of fluids. Avoid antidiarrheal medications, because they could slow the elimination of the contaminant.

Food Infection

According to the CDC, more than 250 different foodborne diseases

have been identified.[1] Majority of these diseases are food infections, which means they are caused from food contaminated by microorganisms, such as bacteria, by microscopic animals called parasites, or by viruses. The infection then grows inside the body and becomes the source of symptoms. Food infections can be sporadic and often are not reported to physicians. However, occasional outbreaks occur that put communities, states and provinces, or even entire nations at risk. For example, in 1994, an outbreak of the infection salmonellosis occurred in the United States due to contaminated ice cream. An estimated 224,000 people became ill. In 1988, contaminated clams resulted in an outbreak of hepatitis A in China, which affected about 300,000 people.[2]

The Reproduction of Microorganisms

Bacteria, one of the most common agents of food infection, are single-celled microorganisms that are too small to be seen with the human eye. Microbes live, die, and reproduce, and like all living creatures, they depend on certain conditions to survive and thrive. In order to reproduce within food, microorganisms require the following:

1. Foodborne Illnesses and Germs. (2018). Centers for Disease Control and Prevention.https://www.cdc.gov/foodsafety/foodborne-germs.html . Updated January 23, 2018. Accessed January 28, 2017.
2. Food Safety. (2017). World Health Organization. http://www.who.int/mediacentre/factsheets/fs399/en/. Updated October 2017. Accessed January 18, 2018.

- Temperature. Between 40°F and 140°F, which is called the danger zone, bacteria grow rapidly.
- Time. More than two hours in the danger zone.
- Water. High moisture content is helpful. Fresh fruits and vegetables have the highest moisture content.
- Oxygen. Most microorganisms need oxygen to grow and multiply, but a few are anaerobic and do not.
- Acidity and pH Level. Foods that have a low level of acidity (or a high pH level) provide an ideal environment, since most microorganisms grow best around pH 7.0 and not many will grow below pH 4.0 . Examples of higher pH foods include egg, meat, seafood, milk, and corn. Examples of low pH foods include citrus fruits, sauerkraut, tomatoes, and pineapples.
- Nutrient Content. Microorganisms need protein, starch, sugars, fats, and other compounds to grow. Typically high-protein foods are better for bacterial growth.

Food Intoxication

Other kinds of foodborne illness are food intoxications, which are caused by natural toxins or harmful chemicals. These and other unspecified agents are major contributors to episodes of acute gastroenteritis and other kinds of foodborne illness.[3] Like pathogens, toxins and chemicals can be introduced to food during cultivation, harvesting, processing, or distribution. Some toxins can

3. Scallan E, Griffin PM, Angulo FJ, et al. (2011). Foodborne Illness Acquired in the United States–Unspecified Agents. *Emerging Infectious Diseases*, *17*(1):16-22. https://wwwnc.cdc.gov/eid/article/17/1/p2-1101_article. Accessed January 28, 2018.

lead to symptoms that are also common to food infection, such as abdominal cramping, while others can cause different kinds of symptoms and complications, some very severe. For example, mercury, which is sometimes found in fish, can cause neurological damage in infants and children. Exposure to cadmium can cause kidney damage, typically in elderly people.

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The Causes of Food Contamination

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Both food infections and food intoxications can create a burden on health systems, when patients require treatment and support, and on food systems, when companies must recall contaminated food or address public concerns. It all begins with the agent that causes the contamination. When a person ingests a food contaminant, it travels to the stomach and intestines. There, it can interfere with the body's functions and make you sick. In the next part, we will focus on different types of food contaminants and examine common microbes, toxins, chemicals, and other substances that can cause food infections and intoxications. Let's begin with pathogens, which include bacteria and viruses. About one hundred years ago, typhoid fever, tuberculosis, and cholera were common diseases caused by food and water contaminated by pathogens. Over time, improvements in food processing and water treatment eliminated most of those problems in North America. Today, other bacteria and viruses have become common causes of food infection.

Bacteria

All foods naturally contain small amounts of bacteria. However, poor handling and preparation of food, along with improper cooking or storage can multiply bacteria and cause illness. In addition, bacteria can multiply quickly when cooked food is left out at room temperature for more than a few hours. Most bacteria grow undetected because they do not change the color or texture of food

or produce a bad odor. Freezing and refrigeration slow or stop the growth of bacteria, but does not destroy the bacteria completely. The microbes can reactivate when the food is taken out and thawed.

Image by NIH NIAID / CC BY 2.0

Many different kinds of bacteria can lead to food infections. One of the most common is Salmonella, which is found in the intestines of birds, reptiles, and mammals. Salmonella can spread to humans via a variety of different animal-origin foods, including meats, poultry, eggs, dairy products, and seafood. The disease it causes, salmonellosis, typically brings about fever, diarrhea, and abdominal cramps within twelve to seventy-two hours after eating. Usually, the illness lasts four to seven days, and most people recover without treatment. However, in individuals with weakened immune systems, Salmonella can invade the bloodstream and lead to life-threatening complications, such as a high fever and severe diarrhea.[1]

1. Salmonella. (2018). Centers for Disease Control and

The bacterium Listeria monocytogenes is found in soft cheeses, unpasteurized milk, meat, and seafood. It causes a disease called listeriosis that can bring about fever, headache, nausea, and vomiting. Listeria monocytogenes mostly affects pregnant women, newborns, older adults, and people with cancer and compromised immune systems.

The food infection by Escherichia coli is found in raw or undercooked meat, raw vegetables, unpasteurized milk, minimally processed ciders and juices, and contaminated drinking water. Symptoms can occur a few days after eating, and include watery and bloody diarrhea, severe stomach cramps, and dehydration. More severe complications may include colitis, neurological symptoms, stroke, and hemolytic uremic syndrome. In young children, an E. coli infection can cause kidney failure and death.

The bacterium Clostridium botulinum causes botulism. Sources include improperly canned foods, lunch meats, and garlic. An infected person may experience symptoms within four to thirty-six hours after eating. Symptoms could include nerve dysfunction, such as double vision, inability to swallow, speech difficulty, and progressive paralysis of the respiratory system. Botulism can also be fatal.

Campylobacter jejuni causes the disease campylobacteriosis. It is the most commonly identified bacterial cause of diarrhea worldwide. Consuming undercooked chicken, or food contaminated with the juices of raw chicken, is the most frequent source of this infection. Other sources include raw meat and unpasteurized milk. Within two to five days after consumption, symptoms can begin and include diarrhea, stomach cramps, fever, and bloody stools. The duration of this disease is about seven to ten days.

The food infection shigellosis is caused by Shigella, of which there are several types. Sources include undercooked liquid or moist food

Prevention. http://www.cdc.gov/salmonella/. Updated January 24, 2018. Accessed January 29, 2018.

that has been handled by an infected person. The onset of symptoms occurs one to seven days after eating, and can include stomach cramps, diarrhea, fever, and vomiting. Another common symptom is blood, pus, or mucus in stool. Once a person has had shigellosis, the individual is not likely to get infected with that specific type again for at least several years. However, they can still become infected with other types of Shigella.

Staphylococcus aureus causes staphylococcal food poisoning. Food workers who carry this kind of bacteria and handle food without washing their hands can cause contamination. Other sources include meat and poultry, egg products, cream-filled pastries, tuna, potato and macaroni salad, and foods left unrefrigerated for long periods of time. Symptoms can begin thirty minutes to eight hours after eating, and include diarrhea, vomiting, nausea, stomach pain, and cramps. This food infection usually lasts one to two days.

Found in raw oysters and other kinds of seafood, Vibrio vulnificus belongs to the same family as the bacteria which cause cholera. This food contaminant can result in the Vibrio infection. Symptoms can begin anywhere from six hours to a few days after consumption, and include chills, fever, nausea, and vomiting. This disease is very dangerous and can result in fatalities, especially in people with underlying health problems.[2]

2. Foodborne Illnesses and Germs. (2018). Centers for Disease Control and Prevention.https://www.cdc.gov/foodsafety/foodborne-germs.html . Updated January 23, 2018. Accessed January 28, 2017.

Virus

Viruses are another type of pathogen that can lead to food infections, however they are less predominant than bacteria. Viruses differ from bacteria in that they cannot grow and reproduce in foods. Instead, viruses that cause human diseases can only reproduce inside human cells (see Figure 15.1 "Viruses in the Human Body"). Hepatitis A is one of the more well-known food-contaminating viruses. Sources include raw shellfish from polluted water, and food handled by an infected person. This virus can go undetected for weeks and, on average, symptoms do not appear until about one month after exposure. At first, symptoms include malaise, loss of appetite, nausea, vomiting, and fever. Three to ten days later, additional symptoms can manifest, including jaundice and darkened urine. Severe cases of a hepatitis A can result in liver damage and death.

The most common form of contamination from handled foods is the norovirus, which is also known as the Norwalk-like virus, or the calicivirus. Sources include raw shellfish from polluted water, salads, sandwiches, and other ready-to-eat foods handled by an infected person. The norovirus causes gastroenteritis and within one to three days it leads to symptoms, such as nausea, vomiting, diarrhea, stomach pain, headache, and a low-grade fever.[3]

Figure 17.1 Viruses in the Human Body

3. Foodborne Illnesses and Germs. (2018). Centers for Disease Control and Prevention.https://www.cdc.gov/foodsafety/foodborne-germs.html . Updated January 23, 2018. Accessed January 28, 2017.

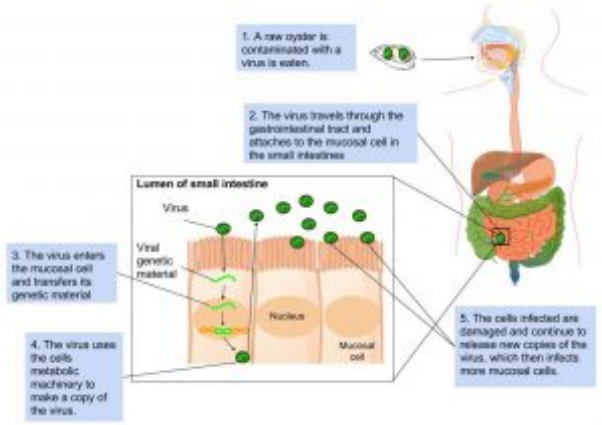

Image by Allison Calabrese / CC BY 4.0

Parasitic Protozoa

Food-contaminating parasitic protozoa are microscopic organisms that may be spread in food and water. Several of these creatures pose major problems to food production worldwide. They include Anisakis, microscopic worms that invade the stomach or the intestines. Sources of this parasite include raw fish. This parasite can result in the Anisakis infection, with symptoms that begin within a day or less and include abdominal pain, which can be severe.

Cryptosporidium lives in the intestines of infected animals. Another common source is drinking water, when heavy rains wash animal wastes into reservoirs. One major problem with this pathogen is that it is extremely resistant to disinfection with chlorine. Cryptosporidium causes the disease cryptosporidiosis, with symptoms that begin one to twelve days after exposure and include watery stools, loss of appetite, vomiting, a low-grade fever, abdominal cramps, and diarrhea. For HIV/AIDS patients and others with weakened immune systems, the disease can be severe, and sometimes can lead to death.

Giardia lamblia is another parasite that is found in contaminated drinking water. In addition, it lives in the intestinal tracts of animals, and can wash into surface water and reservoirs, similar to Cryptosporidium. Giardia causes giardiasis, with symptoms that include abdominal cramping and diarrhea within one to three days. Although most people recover within one to two weeks, the disease can lead to a chronic condition, especially in people with compromised immune systems.

The parasite Toxoplasma gondii causes the infection toxoplasmosis, which is a leading cause of death attributed to foodborne illness in the United States. More than sixty million Americans carry Toxoplasma gondii, but very few have symptoms. Typically, the body's immune system keeps the parasite from causing disease. Sources include raw or undercooked meat and unwashed fruits and vegetables. Handling the feces of a cat with an acute infection can also lead to the disease.[4]

Mold Toxins

Mold can grow on fruits, vegetables, grains, meats, poultry, and dairy products, and typically appears as gray or green "fur."

4. Centers for Disease Control and Prevention. (2010). "Parasites." Last updated November 2, 2010. http://www.cdc.gov/parasites/food.html.

Moldy nectarines by Roger McLassus 1951 / CC BY-SA 3.0

Warm, humid, or damp conditions encourage mold to grow on food. Molds are microscopic fungi that live on animals and plants. No one knows how many species of fungi exist, but estimates range from ten- to three-hundred thousand. Unlike single-celled bacteria, molds are multicellular, and under a microscope look like slender mushrooms. They have stalks with spores that form at the ends. The spores give molds their color and can be transported by air, water, or insects. Spores also enable mold to reproduce. Additionally, molds have root-like threads that may grow deep into food and be difficult to see. The threads are very deep when a food shows heavy mold growth. Foods that contain mold may also have bacteria growing alongside it.

Some molds, like the kind found in blue cheese, are desirable in foods, while other molds can be dangerous. The spores of some molds can cause allergic reactions and respiratory problems. In the right conditions, a few molds produce mycotoxins, which are natural, poisonous substances that can make you sick if they are consumed. Mycotoxins are contained in and around mold threads, and in some cases, may have spread throughout the food. The Food and Agriculture Organization of the United Nations estimates that

mycotoxins affect 25 percent of the world's food crops. They are found primarily in grains and nuts, but other sources include apples, celery, and other produce.

The most dangerous mycotoxins are aflatoxins, which are produced by strains of fungi called Aspergillus under certain temperature and humidity conditions. Contamination has occurred in peanuts, tree nuts, and corn. Aflatoxins can cause aflatoxicosis in humans, livestock, and domestic animals. Symptoms include vomiting and abdominal pain. Possible complications include liver failure, liver cancer, and even death. Many countries try to limit exposure to aflatoxins by monitoring their presence on food and feed products.[5]

5. Molds on Food: Are They Dangerous?.(2013). US Department of Agriculture, Food Safety and Inspection Service. https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/molds-on-food-are-they-dangerous_/ct_index. Updated August 22, 2013. Accessed January 2018.

Poisonous Mushrooms

Amanita Muscaria by Onder Wijsgek / CC BY 3.0

Like molds, mushrooms are fungi and the poisonous kind produces mycotoxins that can cause food intoxication. Toxic mushrooms, also known as toadstools, can cause severe vomiting and other symptoms. However, only a few varieties are fatal. Toxic mushrooms cannot be made safe by cooking, freezing, canning, or processing. The only way to avoid food intoxication is to refrain from eating them. Mushroom guides can help wild gatherers distinguish between the edible and toxic kinds[6].

6. US Department of Agriculture, Food Safety and Inspection Service. (2010). "Molds on Food: Are They Dangerous?" Last modified March 4, 2010. http://www.fsis.usda.gov/FactSheets/Molds_On_Food/.

Pesticides

Pesticides are important in food production to control diseases, insects, and other pests. They protect crops and ensure a large yield. However, synthetic pesticides can leave behind residues, particularly on produce, that can be harmful to human health. Foods that contain the highest levels of pesticide residue include conventionally-grown peaches, apples, bell peppers, celery, nectarines, strawberries, cherries, pears, spinach, lettuce, and potatoes. Foods that contain the lowest levels of pesticide residue include avocados, pineapples, bananas, mangoes, asparagus, cabbage, and broccoli.[7] In many cases, the amount of pesticide exposure is too small to pose a risk. However, harmful exposures can lead to certain health problems and complications, including cancer. Also, infants and young children are more susceptible to the hazards of pesticides than adults. In addition, using synthetic pesticides, herbicides, and fertilizers contributes to soil and water pollution and can be hazardous to farm workers.

To protect the public and their workers, many farmers now rely on alternatives to synthetic pesticide use, including crop rotation, natural pesticides, and planting non food crops nearby to lure pests away. Some consumers choose to reduce their exposure to pesticides by purchasing organic produce. Organic foods are grown or produced without synthetic pesticides or fertilizer, and all growers and processors must be certified by the US Department of Agriculture (USDA). However, conventionally-grown produce

7. Pesticide Residues in Food. (2018). World Health Organization. http://www.who.int/mediacentre/factsheets/pesticide-residues-food/en/. Updated January 2018. Accessed January 28, 2018.

should be fine for fruits and vegetables that appear on the low-residue list.

Pollutants

Pollutants are another kind of chemical contaminant that can make food harmful. Chemical runoff from factories can pollute food products and drinking water. For example, dioxins are chemical compounds created in industrial processes, such as manufacturing and bleaching pulp and paper. Fish that swim in dioxin-polluted waters can contain significant amounts of this pollutant, which causes cancer. When metals contaminate food, it can result in serious and even life-threatening health problems. A common metal contaminant is lead, which can be present in drinking water, soil, and air. Lead exposure most often affects children, who can suffer from physical and mental developmental delays as a result.

Methyl mercury occurs naturally in the environment and is also produced by human activities. Fish can absorb it, and the predatory fish that consume smaller, contaminated fish can have very high levels. This highly toxic chemical can cause mercury poisoning, which leads to developmental problems in children, as well as autoimmune effects. A condition called Minamata disease was identified in 1956 in Japan. It was named for the town of Minamata, which was the site of an environmental disaster when methyl mercury was released into the surface water near a factory. Many residents experienced neurological issues, including numbness in hands and feet, muscle weakness, a narrowing of the field of vision, damage to hearing and speech, and ataxia, which is a lack of muscle coordination.[8]

8. Minamata Disease: The History and Measures. (2002).

PCBs, or polychlorinated biphenyls, are man-made organic compounds that consists of carbon, hydrogen and chlorine. Due to their non-flammability, chemically stable, and high boiling points PCBs were manufactured and used commercially from 1929 until 1979 when it was banned. Like methylmercury, higher concentrations of this contaminant are found in predatory fish. Health effects include complications in physical and neurological development in children, and this compound is potentially a carcinogen. PCB contamination also can affect the immune, reproductive, nervous, and endocrine systems.[9]

Learning Activities

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Ministry of the Environment, Government of Japan.http://www.env.go.jp/en/chemi/hs/minamata2002/. Published 2002. Accessed December 21, 2011.

9. Learn About Polychlorinated Biphenyls. (2017).US Environmental Protection Agency. https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs. Updated August 10, 2017. Accessed January 28, 2018.

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Protecting the Public Health

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Most foodborne infections go unreported and undiagnosed. However, the CDC estimates that about seventy-six million people in the United States become ill from foodborne pathogens or other agents every year. In North America, a number of government agencies work to educate the public about food infections and intoxications, prevent the spread of disease, and quell any major problems or outbreaks. They include the CDC, the FDA, and the USDA, among other organizations.

Efforts on the Governmental Level

A number of government agencies work to ensure food safety and to protect the public from foodborne illness. Food regulatory agencies work to protect the consumer and ensure the safety of our food. Food and drug regulation in the United States began in the late nineteenth century when state and local governments began to enact regulatory policies. In 1906, Congress passed the Pure Food and Drugs Act, which led to the creation of the US Food and Drug Administration (FDA). Today, a number of agencies are in charge of monitoring how food is produced, processed, and packaged.[1]

1. History of Food and Drug Regulation in the United States. (2010). EH.Net Encyclopedia. http://eh.net/?s=History+of+Food+and+Drug+Regulatio

The USDA and the FDA enforce laws regarding the safety of domestic and imported food. In addition, the Federal Food, Drug, and Cosmetic Act of 1938 gives the FDA authority over food ingredients. The FDA enforces the safety of domestic and imported foods. It also monitors supplements, food labels, claims that corporations make about the benefits of products, and pharmaceutical drugs. Sometimes, the FDA must recall contaminated foods and remove them from the market to protect public health. For example, in 2011 contaminated peanut butter led to the recall of thousands of jars of a few popular brands.[2] Recalls are almost always voluntary and often are requested by companies after a problem has been discovered. In rare cases, the FDA will request a recall. But no matter what triggers the removal of a product, the FDA's role is to oversee the strategy and assess the adequacy and effectiveness of the recall.

Many consumers have concerns about safety practices during the production and distribution of food. This is especially critical given recent outbreaks of foodborne illnesses. For example, during fall 2011 in the United States, there was an eruption of the bacteria Listeria monocytogenes in cantaloupe. It was one of the deadliest outbreaks in over a decade and resulted in a number of deaths and hospitalizations.[3] In January 2011, the Food Safety Modernization

n+in+the+United+States. Published February 4, 2010. Accessed January 28, 2018.
2. FDA 101: Product Recalls—From First Alert to Effectiveness Checks. (2011). US Food and Drug Administration. http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm049070.htm. Updated September 9, 2011. Accessed January 18, 2018.
3. Centers for Disease Control and Prevention. (2011). "Multistate Outbreak of Listeriosis Associated with

Act was passed to grant more authority to the FDA to improve food safety. The FDA and other agencies also address consumer-related concerns about protecting the nation's food supply in the event of a terrorist attack.

The USDA headed by the Secretary of Agriculture, develops and executes federal policy on farming and food. This agency supports farmers and ranchers, protects natural resources, promotes trade, and seeks to end hunger in the United States and abroad. The USDA also assures food safety, and in particular oversees the regulation of meat, poultry, and processed egg products. The CDC tracks outbreaks, identifies the causes of food infection and intoxication, and recommends ways to prevent foodborne illness. Other government agencies that play a role in protecting the public include the Food Safety and Inspection Service, a division of the USDA, which enforces laws regulating meat and poultry safety. The Agricultural Research Service, which is the research arm of the USDA, investigates a number of agricultural practices, including those related to animal and crop safety. The National Institute of Food and Agriculture conducts research and education programs on food safety for farmers and consumers.

The Environmental Protection Agency (EPA) works to protect human health and the environment. Founded in 1970, the agency conducts environmental assessment, education, research, and regulation. The EPA also works to prevent pollution and protect natural resources. Two of its many regulatory practices in the area of agriculture include overseeing water quality and the use of pesticides.The EPA approves pesticides and other chemicals used in agriculture, and sets limits on how much residue can remain

Jensen Farms Cantaloupe–United States." August–September, 2011. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6039a5.htm?s_cid=mm6039a5_w.

on food. The FDA analyzes food for surface residue and waxes. Processing methods can either reduce or concentrate pesticide residue in foods. Therefore, the Food Quality Protection Act, which was passed in 1996, requires manufacturers to show that pesticide levels are safe for children.

Efforts within the Food Industry

The Hazard Analysis Critical Control Points (HACCP) is a program within the food industry designed to promote food safety and prevent contamination by identifying all areas in food production and retail where contamination could occur. Companies and retailers determine the points during processing, packaging, shipping, or shelving where potential contamination may occur.. Those companies or retailers must then establish critical control points to prevent, control, or eliminate the potential for food contamination. The USDA requires the food industry to follow HACCP for meat and poultry, while the FDA requires it for seafood, low-acid canned-food, and juice. HACCP is voluntary for all other food products but its main goal is to prevent contamination at all costs.

Everyday Connection

The Seven Steps to HACCP:

1. Conduct a hazard analysis: The manufacturer must first determine any food safety hazards (ex. biological, chemicals, or physical) and identify preventative

measures to control the hazards.

2. Identify the critical control points: Critical control point (CCP) is a point or procedure in food manufacturing where control can be applied to prevent or eliminate food hazards that may cause the food to be unsafe.
3. Establish critical limits: A critical limit is the maximum or minimum value that a food hazard must be controlled at a CCP to prevent, eliminate or reduce it to an acceptable level.
4. Establish monitoring requirements: The manufacture must establish procedures to monitor the control points to ensure the process is under control and not above the CCP.
5. Establish corrective actions: Corrective actions are needed when monitoring indicates a deviation from the established critical limit to ensure that no produce injurious to health has occurred as a result of the deviation.
6. Establish verification procedures: Verification ensures that the HACCP plan is adequate with CCP records, critical limits and microbial sampling and analysis.
7. Record keeping procedure: The manufacturer must maintain certain documents including its hazard analysis, HACCP plan, and records monitoring the CCP, critical limits, and the verification of handling processed deviations.

For more information on the HACCP visit https://www.fsis.usda.gov/Oa/background/keyhaccp.htm.

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The Food System

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Image by Morten Just / CC BY-NC 3.0

The food system is a network of farmers and related operations, including food processing, wholesale and distribution, retail, industry technology, and marketing. The milk industry, for example, includes everything from the farm that raises livestock, to the milking facility that extracts the product, to the processing company that pasteurizes milk and packages it into cartons, to the shipping company that delivers the product to stores, to the markets and groceries that stock and sell the product, to the advertising agency that touts the product to consumers. All of these components play a part in a very large system.

Two important aspects of a food system are preservation and processing. Each provides for or protects consumers in different ways. Food preservation includes the handling or treating of food to prevent or slow down spoilage. Food processing involves

transforming raw ingredients into packaged food, from fresh-baked goods to frozen dinners. Although there are numerous benefits to both, preservation and processing also pose some concerns, in terms of both nutrition and sustainability.

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Food Preservation

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Food preservation protects consumers from harmful or toxic food. There are different ways to preserve food. Some are ancient methods that have been practiced for generations, such as curing, smoking, pickling, salting, fermenting, canning, and preserving fruit in the form of jam. Others include the use of modern techniques and technology, including drying, vacuum packing, pasteurization, and freezing and refrigeration. Preservation guards against foodborne illnesses, and also protects the flavor, color, moisture content, or nutritive value of food.

Food Irradiation: What You Need to Know

Irradiation does not make foods radioactive, compromise nutritional quality, or noticeably change the taste, texture, or appearance of food. In fact, any changes made by irradiation are so minimal that it is not easy to tell if a food has been irradiated.

Food irradiation (the application of ionizing radiation to food) is a technology that improves the safety and extends the shelf life of foods by reducing or eliminating microorganisms and insects. Like pasteurizing milk and canning fruits and vegetables, irradiation can make food safer for the consumer. The Food and Drug Administration (FDA) is responsible for regulating the sources of radiation that are used to irradiate food. The FDA approves a source of radiation for use on foods only after it has determined that irradiating the food is safe.

Why Irradiate Food?

Irradiation can serve many purposes.

- Prevention of Foodborne Illness – to effectively eliminate organisms that cause foodborne illness, such as Salmonella and E. coli.
- Preservation – to destroy or inactivate organisms that cause spoilage and decomposition and extend the shelf life of foods.
- Control of Insects – to destroy insects in or on tropical fruits imported into the United States. Irradiation also decreases the need for other pest-control practices that may harm the fruit.
- Delay of Sprouting and Ripening – to inhibit sprouting (e.g., potatoes) and delay ripening of fruit to increase longevity.
- Sterilization – irradiation can be used to sterilize foods, which can then be stored for years without refrigeration. Sterilized foods are useful in hospitals for patients with severely impaired immune systems, such as patients with AIDS or undergoing chemotherapy. Foods that are sterilized by irradiation are exposed to substantially higher levels of treatment than those approved for general use.

How Is Food Irradiated?

There are three sources of radiation approved for use on foods.

- Gamma rays are emitted from radioactive forms of the element cobalt (Cobalt 60) or of the element cesium (Cesium 137). Gamma radiation is used routinely to sterilize medical, dental, and household products and is also used for the radiation treatment of cancer.
- X-rays are produced by reflecting a high-energy stream of

electrons off a target substance (usually one of the heavy metals) into food. X-rays are also widely used in medicine and industry to produce images of internal structures.
- Electron beam (or e-beam) is similar to X-rays and is a stream of high-energy electrons propelled from an electron accelerator into food.

Is Irradiated Food Safe to Eat?

The FDA has evaluated the safety of irradiated food for more than 30 years and has found the process to be safe. The World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC) and the U.S. Department of Agriculture (USDA) have also endorsed the safety of irradiated food.

The FDA has approved a variety of foods for irradiation in the United States including:

- Beef and Pork
- Crustaceans (e.g., lobster, shrimp, and crab)
- Fresh Fruits and Vegetables
- Lettuce and Spinach
- Poultry
- Seeds for Sprouting (e.g., for alfalfa sprouts)
- Shell Eggs
- Shellfish – Molluscan (e.g., oysters, clams, mussels, and scallops)
- Spices and Seasonings

Image by USDA / CC BY 4.0

How Will I Know if My Food Has Been Irradiated?

The FDA requires that irradiated foods bear the international symbol for irradiation. Look for the Radura symbol along with the statement "Treated with radiation" or "Treated by irradiation" on the food label. Bulk foods, such as fruits and vegetables, are required to be individually labeled or to have a label next to the sale container. The FDA does not require that individual ingredients in multi-ingredient foods (e.g., spices) be labeled. It is important to remember that irradiation is not a replacement for proper food handling practices by producers, processors, and consumers. Irradiated foods need to be stored, handled, and cooked in the same way as non-irradiated foods, because they could still become contaminated with disease-causing organisms after irradiation if the rules of basic food safety are not followed.[1]

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1. Food Irradiation. (2018). U.S. Food and Drug Administration. https://www.fda.gov/food/

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resourcesforyou/consumers/ucm261680.htm. Updated January 4, 2018. Accessed January 18, 2018.

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Food Processing

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Food processing includes the methods and techniques used to transform raw ingredients into packaged food. Workers in this industry use harvested crops or slaughtered and butchered livestock to create products that are marketed to the public. There are different ways in which food can be processed, from a one-off product, such as a wedding cake, to a mass-produced product, such as a line of cupcakes packaged and sold in stores.

The Pros and Cons of Food Processing

Image by Dean Hochman / CC BY 2.0

Food processing has a number of important benefits, such as

creating products that have a much longer shelf life than raw foods. Also, food processing protects the health of the consumer and allows for easier shipment and the marketing of foods by corporations. However, there are certain drawbacks. Food processing can reduce the nutritional content of raw ingredients. For example, canning involves the use of heat, which destroys the vitamin C in canned fruit. Also, certain food additives that are included during processing, such as high fructose corn syrup, can affect the health of a consumer. However, the level of added sugar can make a major difference. Small amounts of added sugar and other sweeteners, about 6 to 9 teaspoons a day or less, are not considered harmful.[1]

Food Additives

If you examine the label for a processed food product, it is not unusual to see a long list of added materials. These natural or synthetic substances are food additives and there are more than three hundred used during food processing today. The most popular additives are benzoates, nitrites, sulfites, and sorbates, which prevent molds and yeast from growing on food.[2] Food additives

1. Sugar and Carbohydrates. American Heart Association. http://www.heart.org/HEARTORG/GettingHealthy/NutritionCenter/HealthyDietGoals/Sugars-and-Carbohydrates_UCM_303296_Article.jsp#. Updated April 20, 2017. Accessed January 4, 2018.
2. The Dangers of Food Additives. How Stuff Works. http://health.howstuffworks.com/wellness/food-

are introduced in the processing stage for a variety of reasons. Some control acidity and alkalinity, while others enhance the color or flavor of food. Some additives stabilize food and keep it from breaking down, while others add body or texture. Table 17.1 "Food Additives" lists some common food additives and their uses:

Table 17.1 Food Additives

Additive	Reason for Adding
Beta-carotene	Adds artificial coloring to food
Caffeine	Acts as a stimulant
Citric acid	Increases tartness to prevent food from becoming rancid
Dextrin	Thickens gravies, sauces, and baking mixes
Gelatin	Stabilizes, thickens, or texturizes food
Modified food starch	Keeps ingredients from separating and prevents lumps
MSG	Enhances flavor in a variety of foods
Pectin	Gives candies and jams a gel-like texture
Polysorbates	Blends oil and water and keep them from separating
Soy lecithin	Emulsifies and stabilizes chocolate, margarine, and other items
Sulfites	Prevent discoloration in dried fruits
Xanthan gum	Thickens, emulsifies, and stabilizes dairy products and dressings

Source: Chemical Cuisine: Learn about Food Additives. Center for Science in the Public Interest.http://www.cspinet.org/reports/chemcuisine.htm. Published 2012. Accessed January 20, 2018.

nutrition/facts/dangers-of-food -additives.htm. Accessed October 5, 2011.

The Pros and Cons of Food Additives

The FDA works to protect the public from potentially dangerous additives. Passed in 1958, the Food Additives Amendment states that a manufacturer is responsible for demonstrating the safety of an additive before it can be approved. The Delaney Clause that was added to this legislation prohibits the approval of any additive found to cause cancer in animals or humans. However, most additives are considered to be "generally recognized as safe," a status that is determined by the FDA and referred to as GRAS.

Food additives are typically included in the processing stage to improve the quality and consistency of a product. Many additives also make items more "shelf stable," meaning they will last a lot longer on store shelves and can generate more profit for store owners. Additives can also help to prevent spoilage that results from changes in temperature, damage during distribution, and other adverse conditions. In addition, food additives can protect consumers from exposure to rancid products and foodborne illnesses.

Food additives aren't always beneficial, however. Some substances have been associated with certain diseases if consumed in large amounts. For example, the FDA estimates that sulfites can cause allergic reactions in 1 percent of the general population and in 5 percent of asthmatics. Similarly, the additive monosodium glutamate, which is commonly known as MSG, may cause headaches, nausea, weakness, difficulty breathing, rapid heartbeat, and chest pain in some individuals.[3]

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3. The Issues: Additives. Sustainable Table. http://www.sustainabletable.org/issues/additives/#fn14. Accessed October 10, 2011.

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The Effect of New Technologies

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As mentioned earlier, new technology has had a tremendous effect on the food we eat and the customs and culture related to food consumption. For example, microwaves are used to reduce cooking time or to heat up leftover food. Refrigerators and freezers allow produce to travel great distances and last longer. On the extreme end of making food last longer, there is special food for astronauts that is appropriate for consumption in space. It is safe to store, easy to prepare in the low-gravity environment of a spacecraft, and contains balanced nutrition to promote the health of people working in space. In the military, soldiers consume Meals Ready-to-Eat (MREs), which contain an entire meal in a single pouch.

Consumer Info About Food From Genetically Engineered Plants

FDA regulates the safety of food for humans and animals, including foods produced from genetically engineered (GE) plants. Foods from GE plants must meet the same food safety requirements as foods derived from traditionally bred plants. Read more at Consumer Info About Food From Genetically Engineered Plants.[1]

1. Foods from Genetically Engineered Plants. U.S. Food and Drug Administration. https://www.fda.gov/food/

Genetically Modified Foods

Genetically modified foods (also known as GM or GMO foods), are plants or animals that have undergone some form of genetic engineering. In the United States, much of the soybean, corn, and canola crop is genetically modified. The process involves the alteration of an organism's DNA, which allows farmers to cultivate plants with desirable characteristics.[2] For example, scientists could extract a gene that produces a chemical with antifreeze properties from a fish that lives in an arctic region (such as a flounder). They could then splice that gene into a completely different species, such as a tomato, to make it resistant to frost, which would enable farms to grow that crop year-round.[3]

Certain modifications can be beneficial in resisting pests or pesticides, improving the ripening process, increasing the nutritional content of food, or providing resistance to common viruses. Although genetic engineering has improved productivity for farmers, it has also stirred up debate about consumer safety and environmental protection. Possible side effects related to the

ingredientspackaginglabeling/geplants/default.htm. Updated January 4, 2018. Accessed January 20, 2018.
2. What Are Genetically Modified Foods?. Genomics.Energy.gov. http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml. Last modified November 5, 2008. Accessed October 11, 2011.
3. Whitman DB. Genetically Modified Foods: Harmful or Helpful?. CSA Discovery Guides. 2000; 1-13. https://biomed.brown.edu/arise/resources/docs/GM%20foods%20review.pdf. Accessed January 20, 2018.

consumption of GM foods include an increase in allergenicity, or tendencies to provoke allergic reactions. There is also some concern related to the possible transfer of the genes used to create genetically engineered foods from plants to people. This could influence human health if antibiotic-resistant genes are transferred to the consumer. Therefore, the World Health Organization (WHO) and other groups have encouraged the use of genetic engineering without antibiotic-resistance genes. Genetically modified plants may adversely affect the environment as well and could lead to the contamination of non-genetically engineered organisms.[4]

Genetically modified foods fall under the purview of the EPA, the USDA, and the FDA. Each agency has different responsibilities and concerns in the regulation of GM crops. The EPA ensures that pesticides used for GM plants are safe for the environment. The USDA makes sure genetically engineered seeds are safe for cultivation prior to planting. The FDA determines if foods made from GM plants are safe to eat. Although these agencies act independently, they work closely together and many products are reviewed by all three.[5]

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4. Food Safety: 20 Questions on Genetically Modified Foods. World Health Organization. http://www.who.int/foodsafety/publications/biotech/20questions/en/. Updated May 2014. Accessed January 18, 2018.
5. Whitman DB. Genetically Modified Foods: Harmful or Helpful?. CSA Discovery Guides. 2000; 1-13. https://biomed.brown.edu/arise/resources/docs/GM%20foods%20review.pdf. Accessed January 20, 2018.

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Efforts on the Consumer Level: What You Can Do

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Consumers can also take steps to prevent foodborne illness and protect their health. Although you can often detect when mold is present, you can't see, smell, or taste bacteria or other agents of foodborne disease. Therefore, it is crucial to take measures to protect yourself from disease. The four most important steps for handling, preparing, and serving food are[1]:

- **Clean.** Wash hands thoroughly. Clean surfaces often and wash utensils after each use. Wash fruits and vegetables (even if you plan to peel them).
- **Separate.** Don't cross-contaminate food during preparation and storage. Use separate cutting boards for produce and for meat, poultry, seafood, and eggs. Store food products separately in the refrigerator.
- **Cook.** Heat food to proper temperatures. Use a food thermometer to check the temperature of food while it is cooking. Keep food hot after it has been cooked.
- **Chill.** Refrigerate any leftovers within two hours. Never thaw or marinate food on the counter.

Know when to keep food and when to throw it out. It can be helpful

1. US Department of Health and Human Services. "Keep Food Safe." Food Safety.gov. Accessed December 21, 2011. http://www.foodsafety.gov/keep/index.html.

to check the website http://www.stilltasty.com, which explains how long refrigerated food remains fresh.

Buying Food

It is best to buy your food from reputable grocers with clean, sanitary facilities, that keep products at appropriate temperatures. Consumers should examine food carefully before they purchase it. It is important to look at food in glass jars, check the stems on fresh produce, and avoid bruised fruit. Do not buy canned goods with dents or bulges, which are at risk for contamination with Clostridium botulinum. Fresh meat and poultry are usually free from mold, but cured and cooked meats should be examined carefully. Also, avoid torn, crushed, or open food packages, and do not buy food with frost or ice crystals, which indicates that the product has been stored for a long time, or thawed and refrozen. It is also a good idea to keep meat, poultry, seafood, and eggs separate from other items in your shopping cart as you move through the grocery store.

Storing Food

Refrigerate perishable foods quickly; they should not be left out for more than two hours. The refrigerator should be kept at 40°F (or 4°C) or colder, and checked periodically with a thermometer. Store eggs in a carton on a shelf in the refrigerator, and not on the refrigerator door where the temperature is warmest. Wrap meat packages tightly and store them at the bottom of the refrigerator, so juices won't leak out onto other foods. Raw meat, poultry, and seafood should be kept in a refrigerator for only two days. Otherwise, they should be stored in the freezer, which should be

kept at 0°F (or –18°C). Store potatoes and onions in a cool, dark place, but not under a sink because leakage from pipes could contaminate them. Empty cans of perishable foods or beverages that have been opened into containers, and promptly place them in a refrigerator. Also, be sure to consume leftovers within three to five days, so mold does not have a chance to grow.

Preparing Food

Wash hands thoroughly with warm, soapy water for at least twenty seconds before preparing food and every time after handling raw foods. Washing hands is important for many reasons. One is to prevent cross-contamination between foods. Also, some pathogens can be passed from person to person, so hand washing can help to prevent this. Fresh fruits and vegetables should also be rinsed thoroughly under running water to clean off pesticide residue[2].

This is particularly important for produce that contains a high level of residue, such as apples, pears, spinach, and potatoes. Washing also removes most dirt and bacteria from the surface of produce.

Other tips to keep foods safe during preparation include defrosting meat, poultry, and seafood in the refrigerator, microwave, or in a water-tight plastic bag submerged in cold water. Never defrost at room temperature because that is an ideal temperature for bacteria to grow. Also, marinate foods in the

2. California Department of Pesticide Regulation. "Pesticides and Food: How We Test for Safety." Pesticide Info: What You Should Know about Pesticides, no. #E09/REV. Accessed December 21, 2011. http://www.cdpr.ca.gov/docs/dept/factshts/residu2.

refrigerator and discard leftover marinade after use because it contains raw juices. Always use clean cutting boards, which should be washed with soap and warm water by hand or in a dishwasher after each use. Another way to sanitize cutting boards is to rinse them with a solution of 5 milliliters (1 teaspoon) chlorine bleach to about 1 liter (1 quart) of water. If possible, use separate cutting boards for fresh produce and for raw meat. Also, wash the top before opening canned foods to prevent dirt from coming into contact with food.

Cooking Food

Cooked food is safe to eat only after it has been heated to an internal temperature that is high enough to kill bacteria. You cannot judge the state of "cooked" by color and texture alone. Instead, use a food thermometer to be sure. The appropriate minimum cooking temperature varies depending on the type of food. Seafood should be cooked to an internal temperature of 145°F, beef, lamb, and pork to 160°F, ground chicken and turkey to 165°F, poultry breasts to 165°F, and whole poultry and thighs to 180°F. When microwaving, rotate the dish and stir contents several times to ensure even cooking.

Serving Food

After food has been cooked, the possibility of bacterial growth increases as the temperature drops. So, food should be kept above the safe temperature of 140°F, using a heat source such as a chafing dish, warming tray, or slow cooker. Cold foods should be kept at 40°F or lower. When serving food, keep it covered to block exposure

to any mold spores hanging in the air. Use plastic wrap to cover foods that you want to remain moist, such as fresh fruits, vegetables, and salads. After a meal, do not keep leftovers at room temperature for more than two hours. They should be refrigerated as promptly as possible. It is also helpful to date leftovers, so they can be used within a safe time, which is generally three to five days when stored in a refrigerator.

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PART XVIII

CHAPTER 18. NUTRITIONAL ISSUES

Introduction

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Mai ka piko o ke poʻo a ka poli o ka wāwae, a laʻa ma na kihi ʻhā o ke kino

From the crown of the head to the soles of the feet, and the four corners of the body

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"Earth in Hand" Image from flickr.com

Learning Objectives

By the end of this chapter, you will be able to:

- Describe the different types of diets
- Describe the relationship between nutrition and health
- Describe overnutrition, undernutrition, and malnutrition
- Describe different careers in nutrition

There are a multitude of diets across the globe, in all regions and cultures. Each is influenced by the traditions of the past, along with the produce and livestock available. Traditional diets around the globe, such as for Native Hawaiians, were comprised of foods low in fats like fresh fish, and high in complex carbohydrates such as kalo (taro) and ʻulu (breadfruit). However, with modernization and the influence from other ethnic groups that have migrated to the Hawaiian Island chain, the diet has transitioned to be high in animal fat, processed meats, and simple carbohydrates. These changes have played a role in the shift in health issues that many Native Hawaiians are facing today. To learn more about the nutrition transition in the Pacific, visit http://manoa.hawaii.edu/ctahr/pacificfoodguide/index.php/regional-information/.

Good nutrition equates to receiving enough (but not too much) of the macronutrients (proteins, carbohydrates, fats, and water) and micronutrients (vitamins and minerals) so that the body can stay healthy, grow properly, and work effectively. The phrase "you are what you eat" means that your body will respond to the food it receives, either good or bad. Processed, sugary, high-fat, and excessively salted foods leave the body unable to perform

effectively. By contrast, eating a variety of foods from all food groups fuels the body by providing what it needs to produce energy, promote metabolic activity, prevent micronutrient deficiencies, ward off chronic disease, and bolstering a sense of overall health and well-being.

Comparing Diets

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Diet Trends and Health

In the past, health was regarded merely as the absence of illness. However, a growing understanding of the complexity and potential of the human condition has prompted a new way of thinking about health. Today, we focus on the idea of wellness, which involves a great deal more than just not being sick. Wellness is a state of optimal well-being that enables an individual to maximize their potential. This concept includes a host of dimensions–physical, mental, emotional, social, environmental, and spiritual–which affect one's quality of life.[1] Striving for wellness begins with an examination of dietary choices.

Dietary Food Trends

Hundreds of years ago, when food was less accessible and daily life required much more physical activity, people worried less about

1. Understanding Wellness. University of Illinois at Urbana-Champaign, McKinley Health Center. 2011 The Board of Trustees of the University of Illinois at Urbana-Champaign. https://mckinley.illinois.edu/health-education/wellness. Accessed April 15, 2018.

obesity and more about simply getting enough to eat. In today's industrialized nations, conveniences have solved some problems and introduced new ones, including the hand-in-hand obesity and diabetes epidemics. Fad diets gained popularity as more North Americans struggled with excess pounds. However, new evidence-based approaches that emphasize more holistic measures are on the rise. These new dietary trends encourage those seeking to lose weight to eat healthy, whole foods first, while adopting a more active lifestyle. These sound practices put dietary choices in the context of wellness and a healthier approach to life.

Everyday Connections

In the past, people's culture and location determined the foods they ate and the manner in which they prepared their meals. For example, in Hawai'i, taro was a staple complex carbohydrate that could be eaten in various ways such as poi and pa'ia'i. Today, most people have access to a wide variety of food and can prepare them any way they choose. However, customs and traditions still strongly influence diet and cuisine in most areas of the world. To learn more about the food and culture in the pacific, visit http://manoa.hawaii.edu/ctahr/pacificfoodguide/index.php/regional-information/

Functional Foods

Many people seek out foods that provide the greatest health benefits. This trend is giving rise to the idea of functional foods,

which not only help meet basic nutritional needs but also are reported to fight illness and aging. According to the Academy of Nutrition and Dietetics (AND), formerly known as the The American Dietetic Association, functional foods may reduce the risk of disease or promote optimal health. The AND recognizes four types of functional foods. They are: conventional foods, modified foods, medical foods, and special dietary use foods.[2]

The first group, conventional foods, represents the simplest form of functional foods. They are whole foods that have not been modified. Examples include whole fruits and vegetables (which are abundant in phytochemicals and antioxidants), yogurt and kefir (which contain natural probiotic bacteria that can help maintain digestive system health), and moderate amounts of dark chocolate, made with 70% or more cacao (which contains antioxidants).

Modified foods have been fortified, enriched, or enhanced with additional nutrients or bioactive compounds. Foods are modified using biotechnology to improve their nutritional value and health attributes. Examples of modified foods include calcium-fortified orange juice, breads enriched with B vitamins, iodized salt, cereals fortified with vitamins and minerals, margarine enhanced with plant sterols, and energy drinks that have been enriched with herbs (ginseng or guarana) or amino acids (taurine). It is important to consider that the health claims of some modified foods may be debatable, or entirely fraudulent. Check with a health professional regarding the effects of modified foods on your health.

Medical foods are designed for enteric administration under the guidance of a medical professional. (During enteric administration, food is treated so that it goes through the stomach undigested.

2. Functional Foods. The Academy of Nutrition and Dietetics. https://www.eatright.org/food/nutrition/healthy-eating/functional-foods. Published July 5, 2018. Accessed April 15, 2018.

Instead, the food is broken down in the intestines only.) Medical foods are created to meet very specific nutritional requirements. Examples of medical foods include liquid formulas for people with kidney disease, liver disease, diabetes, or other health issues. Medical food is also given to comatose patients through a gastronomy tube because they cannot eat by mouth.

Special dietary use foods do not have to be administered under a doctor's care and can be found in a variety of stores. Similar to medical foods, they address special dietary needs and meet the nutritional requirements of certain health conditions. For example, a bottled oral supplement administered under medical supervision is a medical food, but it becomes a special dietary use food when it is sold to retail customers. Examples of special dietary use foods include gluten-free foods, lactose-free dairy products, and formulas and shakes that promote weight loss.

Popular Diets

The concept of functional foods represents initiatives aimed at addressing health problems. Certain diet plans take this concept one step further, by striving to prevent or treat specific conditions. For example, it is widely understood that people with diabetes need to follow a particular diet. Although some of these diet plans may be nutritionally sound, use caution because some diets may be fads or be so extreme that they actually cause health problems.

Before experimenting with a diet, discuss your plans with your doctor or a registered dietitian. Throughout this section, we will discuss some of the more popular diets. Some fall under the category of fad diets, while others are backed by scientific evidence. Those that fall into the latter category provide a good foundation to build a solid regimen for optimal health.

The DASH Diet

The Dietary Approaches to Stop Hypertension, or DASH diet, focuses on reducing sodium intake to either 2,300 milligrams per day (as recommended by the Dietary Guidelines for Americans) or 1,500 milligrams per day for certain populations. The DASH diet is an evidence-based eating plan that can help reduce high blood pressure. This plan may also decrease the risk of heart attack, stroke, diabetes, osteoporosis, and certain cancers.[3]

DASH tips to lower sodium include:

- Using spices instead of salt to add flavor
- Reading sodium content on processed or canned food labels, and choosing low-sodium options
- Removing some sodium from canned foods (such as beans) by rinsing the product before consumption
- Avoiding salt when cooking

DASH dieters are recommended to consume a variety of whole grains and high-fiber fruits and vegetables, and moderate amounts of low-fat dairy products, lean meats, and heart-healthy fish. In addition, DASH limits the use of saturated fats to less than 7 percent of total calories, and limits the consumption of sweets and alcohol. The DASH diet also calls for consuming less added sugar and drinking fewer sugar-sweetened drinks. It replaces red meat with fish and legumes and calls for increased calcium, magnesium, potassium, and fiber. Also, even though some people on the DASH diet may find it lowers their HDL (good) cholesterol along with their

3. DASH Diet Eating Plan. DASH Diet Oregon. http://www.dashdietoregon.org/. Accessed April 12, 2018.

LDL (bad) cholesterol, it still has a positive cumulative effect on heart health.[4]

The Gluten-Free Diet

The gluten-free diet helps people whose bodies cannot tolerate gluten, a protein found in wheat, barley, and rye. One of the most important ways to treat this condition is to avoid the problematic foods, which is not easy. Although following a gluten-free diet is challenging, it is prescribed for patients with gluten intolerance and celiac disease, an autoimmune disorder with a genetic link. People who have celiac disease cannot consume gluten products without damaging their intestinal lining. Eating a gluten-free diet means finding replacements for bread, cereal, pasta, and more. It also means emphasizing fresh fruits, vegetables, and other foods without gluten. However, it is important to note that the gluten-free trend has become something of a fad even for those without a gluten intolerance. Celiac disease is a relatively rare condition found in only 1 percent of the population. Therefore, a gluten-free diet should be followed only with a physician's recommendation.

Low-Carb Diets

Low-carb diets, which include the Atkins Diet and the South Beach Diet, focus on limiting carbohydrates—such as grains, fruit, and starchy vegetables—to promote weight loss. Other low-carb diets

4. DASH Diet Eating Plan. DASH Diet Oregon. http://www.dashdietoregon.org/. Accessed April 12, 2018.

include the Paleolithic (Paleo) and Ketogenic (Keto) Diet. The Paleo diet mimics foods that humans consumed during the Stone Age or the Paleolithic period. This diet promotes higher amounts of grass-fed only animal protein, healthy fats, and non-starchy vegetables (i.e. okra, bok choy, carrots).[5] Similarly, the Keto diet highlights high protein intake and healthy fats however there is more flexibility with the source of animal protein and it does not have to be limited to grass-fed.[6] Furthermore, the Paleo diet does not allow for dairy foods while the Keto diet allows dairy foods without added sugar.

The theory behind the low-carb diet is that insulin prevents the breakdown of fat by allowing sugar in the form of blood glucose to be used for energy. Proponents of this approach believe that because limiting carbohydrates generally lowers insulin levels, it would then cause the body to burn stored fat instead. They believe this method not only brings about weight loss, but also reduces the risk factors for a number of conditions. However, some studies have shown that people who followed certain low-carb diet plans for two years lost an average of nearly 9 pounds, which is similar to the amount of weight lost on higher carbohydrate diets.[7]

5. Paleolithic Nutrition – A Consideration of Its Nature and Current Implications | NEJM. https://www-nejm-org.eres.library.manoa.hawaii.edu/doi/full/10.1056/NEJM198501313120505?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub%3Dpubmed. Accessed January 21, 2020.
6. Ludwig DS. (2019). The Ketogenic Diet: Evidence for Optimism but High-Quality Research Needed. *Journal of Nutrition*,nxz308. doi:10.1093/jn/nxz308
7. Low-Carb Diet: Can It Help You Lose Weight?.The Mayo Clinic. http://www.mayoclinic.com/health/low-carb-diet/NU00279. Accessed March 6, 2018.

The benefits of this kind of diet include an emphasis on whole, unprocessed foods and a de-emphasis of refined carbohydrates, such as white flour, white bread, and white sugar. However, there are a number of downsides. Typically, the first two weeks allow for only 20 grams of carbs per day, which can be dangerously low. In addition, dieters using the low-carb approach tend to consume twice as many saturated fats as people on a diet high in healthy carbohydrates. Low-carb diets are also associated with a higher energy intake, and the notion that "calories don't count," which is prevalent in this kind of diet, is not supported by scientific evidence.[8]

The Macrobiotic Diet

The macrobiotic diet is part of a health and wellness regimen based in Eastern philosophy. It combines certain tenets of Zen Buddhism with a vegetarian diet and supports a balance of the oppositional forces of yin and yang. Foods are paired based on their so-called yin or yang characteristics. Yin foods are thought to be sweet, cold, and passive, while yang foods are considered to be salty, hot, and aggressive.

Whole grains make up about 50 percent of the calories consumed and are believed to have the best balance of yin and yang. Raw and cooked vegetables comprise about 30 percent of the diet and include kale, cabbage, collards, bok choy, and broccoli on a daily

8. Steele V. Health and Nutritional Effects of Popular Diets. Kellogg Nutrition Symposium, The Team of Registered Dietitians & Nutrition Professionals at Kellogg Canada Inc. Insert to Canadian Journal of Dietetic Practice and Research 64, no. 3.

basis, along with mushrooms and celery a few times a week. Bean or vegetable-based soups and broths can make up 5 to 10 percent of daily caloric intake. Additionally, the diet allows small amounts of fish and seafood several times a week, along with a few servings of nuts. The macrobiotic diet prohibits certain foods, such as chocolate, tropical fruits, and animal products, because they are believed to fall on the far end of the yin-yang spectrum, which would make it difficult to achieve a Zen-like balance.

The macrobiotic diet focuses on foods that are low in saturated fats and high in fiber, which can help to lower the risk of cardiovascular disease. Proponents of this diet also believe that it may protect against cancer. However, many nutritionists and healthcare providers express concerns, particularly if the diet is followed strictly. Extreme macrobiotic eating can be low in protein, low in calories, and pose a risk for starvation. In addition, the diet is also very low in essential vitamins and minerals.[9]

The Mediterranean Diet

The traditional Mediterranean diet incorporates many elements of the dietary choices of people living in Greece and southern Italy. The Mediterranean diet focuses on small portions of nutritionally-sound food. This diet features food from plant sources, including vegetables, fruits, whole grains, beans, nuts, seeds, breads and potatoes, and olive oil. It also limits the consumption of processed foods and recommends eating locally grown foods rich in micronutrients and antioxidants. Other aspects of this eating plan include consuming fish and poultry at least twice per week, eating

9. Zelman, KM. Macrobiotic Diet. http://www.webmd.com/diet/features/macrobiotic-diet. Updated February 9, 2018. Accessed April 12, 2018.

red meat only a few times per month, having up to seven eggs per week, and drinking red wine in moderation. Unlike most diets, the Mediterranean diet does not cut fat consumption across the board. Instead, it incorporates low-fat cheese and dairy products, and it substitutes olive oil, canola oil, and other healthy oils for butter and margarine.

More than fifty years of nutritional and epidemiological research has shown that people who follow the Mediterranean diet have some of the lowest rates of chronic disease and the highest rates of longevity among the populations of the world. Studies have shown that the Mediterranean diet also helps to decrease excess body weight, blood pressure, blood fats, and blood sugar and insulin levels significantly.[10]

Tools for Change

For six years, researchers from the University of Bordeaux in France followed the dietary habits of more than seven thousand individuals age sixty-five and over. Participants who described greater consumption of extra-virgin olive oil reportedly lowered their risk of suffering a stroke by 41 percent. The study controlled for stroke risk factors, such as smoking, alcohol intake, high blood pressure, and a sedentary lifestyle. To increase the amount of olive oil in your diet, try spreading olive oil instead of

10. Robinson, K. The Mediterranean Diet. http://www.webmd.com/diet/features/the-mediterranean-diet. Published February 6, 2018. Accessed April 15, 2018.

butter on your toast, making your own salad dressing using olive oil, vinegar or lemon juice, and herbs, cooking with olive oil exclusively, or simply adding a dose of it to your favorite meal.[11]

The Raw Food Diet

The raw food diet is followed by those who avoid cooking as much as possible in order to take advantage of the full nutrient content of foods. The principle behind raw foodism is that plant foods in their natural state are the most wholesome for the body. The raw food diet is not a weight-loss plan, it is a lifestyle choice. People who practice raw foodism eat only uncooked and unprocessed foods, emphasizing whole fruits and vegetables. Staples of the raw food diet include whole grains, beans, dried fruits, seeds and nuts, seaweed, sprouts, and unprocessed produce. As a result, food preparation mostly involves peeling, chopping, blending, straining, and dehydrating fruits and vegetables.

The positive aspects of this eating method include consuming foods that are high in fiber and nutrients, and low in calories and saturated fat. However, the raw food diet offers little in the way of protein, dairy, or fats, which can cause deficiencies of the vitamins A, D, E, and K. In addition, not all foods are healthier uncooked, such as spinach and tomatoes. Also, cooking eliminates potentially

11. More Olive Oil in Diet Could Cut Stroke Risk: Study. MedicineNet.com. https://www.medicinenet.com/script/main/art.asp?articlekey=145823. Published 2011. Accessed April 15,2018.

harmful microorganisms that can cause foodborne illnesses. Therefore, people who primarily eat raw foods should thoroughly clean all fruit and vegetables before eating them. Poultry and other meats should always be cooked before eating.[12]

Vegetarian and Vegan Diets

Vegetarian and vegan diets have been followed for thousands of years for different reasons, including as part of a spiritual practice, to show respect for living things, for health reasons, or because of environmental concerns. For many people, being a vegetarian is a logical outgrowth of "thinking green." A meat-based food system requires more energy, land, and water resources than a plant-based food system. This may suggest that the plant-based diet is more sustainable than the average meat-based diet in the U.S.By avoiding animal flesh, vegetarians hope to look after their own health and that of the planet at the same time. Broadly speaking, vegetarians eat beans, grains, and fruits and vegetables, and do not eat red meat, poultry, seafood, or any other animal flesh. Some vegetarians, known as lacto vegetarians, will eat dairy products. Others, known as lacto-ovo vegetarians, will eat dairy products and eggs. A vegan diet is the most restrictive vegetarian diet—vegans do not eat dairy, eggs, or other animal products, and some do not eat honey.

Vegetarian diets have a number of benefits. Well-balanced eating plans can lower the risk of a number of chronic conditions, including heart disease, diabetes, and obesity. They also help to promote sustainable agriculture. However, if a vegetarian does not vary his or her food choices, the diet may be insufficient in calcium,

12. Raw Food Diet. WebMD.com.https://www.webmd.com/diet/a-z/raw-foods-diet. Published November 21, 2016. Accessed April 15, 2018.

iron, omega-3 fatty acids, zinc, and vitamin B12. Also, if people who follow these diets do not plan out their meals, they may gravitate toward foods high in fats.

Table 18.1 The Pros and Cons of Seven Popular Diets

Diet	Pros	Cons
DASH Diet	• Recommended by the National Heart, Lung, and Blood Institute, the American Heart Association, and many physicians • Helps to lower blood pressure and cholesterol • Reduces risk of heart disease and stroke • Reduces risk of certain cancers • Reduces diabetes risk	• There are very few negative factors associated with the DASH diet • Risk for hyponatremia
Gluten-Free Diet	• Reduces the symptoms of gluten intolerance, such as chronic diarrhea, cramping, constipation, and bloating • Promotes healing of the small intestines for people with celiac disease, preventing malnutrition • May be beneficial for other autoimmune diseases, such as Parkinson's disease, rheumatoid arthritis, and multiple sclerosis	• Risk of folate, iron, thiamin, riboflavin, niacin, and vitamin B6 deficiencies • Special gluten-free products can be hard to find and expensive • Requires constant vigilance and careful food label reading, since gluten is found in many products
Low-Carb Diet	• Restricts refined carbohydrates, such as white flour and white sugar • May temporarily improve blood sugar or blood cholesterol levels	• Not entirely evidence-based • Results in higher fat and protein consumption • Does not meet the RDA for carbohydrates to provide glucose to the brain

Macrobiotic Diet	• Low in saturated fats and high in fiber • Emphasizes whole foods and de-emphasizes processed foods • Rich in phytoestrogens, which may reduce the risk of estrogen-related cancers	• Not entirely evidence-based • Lacks certain vitamins and minerals; supplements are often required • Can result in a very low caloric intake • Lack of energy may result from inadequate protein
Mediterranean Diet	• A reduced risk of cardiovascular disease and mortality • A lower risk of cancer • De-emphasizes processed foods and emphasizes whole foods and healthy fats • Lower sodium intake, due to fewer processed foods • Emphasis on monosaturated fats leads to lower cholesterol • Highlighting fruits and vegetables raises consumption of antioxidants	• Does not specify daily serving amounts • Potential for high fat and high calorie intake as nuts and oils are calorie-dense foods • Drinking one to two glasses of wine per day may not be healthy for those with certain conditions
Raw Food Diet	• Emphasizes whole foods • Focuses on nutritionally-rich foods	• Not entirely evidence-based • Very restrictive and limits protein and healthy fat intake • Could encourage the development of foodborne illness • Extremely difficult to follow • High in fiber which can cause essential nutrient deficiencies

Vegetarianism and Veganism	• May reduce some chronic diseases such as cancer, heart disease, and Type 2 diabetes • May help with weight reduction and weight maintenance	• Guidelines regarding fat and nutrient consumption must be followed • Higher risk for nutrient deficiencies such as protein, iron, zinc, omega-3, vitamin B12 • Consumption of a high fiber diet interferes with mineral and nutrient bioavailability • Vegetarian and vegan protein sources are lower quality with majority missing at least one essential amino acids

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly

recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

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http://pressbooks.oer.hawaii.edu/humannutrition2/?p=549

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1. Calories In Versus Calories Out

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The ability to estimate energy expenditure and quantify calories consumed, has led to the simple conclusion that tracking or counting "calories in" compared to "calories out" will result in an easy way to manage body weight. This logic does not take into account the complexity and individuality of the human body. Human bodies are not static, meaning there are fluctuations from day to day in energy needs related to set point, sleep patterns, stress levels, activity levels, and eating patterns. Something as simple as the timing and macronutrient composition of meals, will impact the thermic effect of food, resulting in a change in energy expenditure.

Dieting Basics/ Dieting 101

The diet and weight loss industry is big business. In 2017, The U.S. Weight Loss and Diet Control Market reported a record $72 billion dollar value to the weight loss market.[1] This dollar amount is expected to continue to rise. At the same time, there is evidence that diets do not lead to long term weight loss for the majority of people. In observational studies, dieting was the best predictor of future weight gain and onset of obesity.[2][3][4] Meta-analysis and

1. *The U.S. weight loss & diet control market*. (2019). Marketdata LLC. https://www.researchandmarkets.com/research/qm2gts/the_72_billion?w=4
2. Neumark-Sztainer, D., Wall, M., Story, M., & Standish, A. R. (2012). *Dieting and unhealthy weight control behaviors during adolescence: Associations with 10-year changes in body mass index*. The Journal of Adolescent Health, 50(1), 80–86.
3. Neumark-Sztainer, D., Wall, M., Guo, J., Story, M., Haines, J., & Eisenberg, M. (2006). Obesity, disordered eating, and eating disorders in a longitudinal study of adolescents: How do dieters fare 5 years later? *Journal of the American Dietetic Association*, 106(4), 559–568.
4. Stice, E., Cameron, R. P., Killen, J. D., Hayward, C., & Taylor, C. B. (1999). Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *Journal of Consulting and Clinical Psychology*, 67(6), 967–974.

reviews of randomized clinical trials reported that on average, obesity treatments cause weight gain.[56] This additional weight gain leads to an increase in the set point, making it more difficult for an individual to lose weight in the future. Others reported a 3-5 % weight loss was possible 4 years later if participants continued all aspects of treatment.[7] For a 200 pound person, this represents a 6-10 pound weight loss. The health benefits of this modest weight loss are unclear and it is far less what is expected or desired when following a diet. In conclusion, the diet industry makes money from a product that is proven not to work.

5. Mann, T., Tomiyama, A. J., Westling, E., Lew, A.-M., Samuels, B., & Chatman, J. (2007). Medicare's search for effective obesity treatments: Diets are not the answer. *The American Psychologist*, 62(3), 220–233.
6. Ayyad, C., & Andersen, T. (2000). Long-term efficacy of dietary treatment of obesity: A systematic review of studies published between 1931 and 1999. *Obesity Reviews*, 1(2), 113–119.
7. Franz, M. J., VanWormer, J. J., Crain, A. L., Boucher, J. L., Histon, T., Caplan, W., Bowman, J. D., & Pronk, N. P. (2007). Weight-loss outcomes: A systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. *Journal of the American Dietetic Association*, 107(10), 1755–1767.

Dieting and Health

Image by Kellie Taguchi / CC BY 4.0

The scientific evidence shows that diets lead to modest weight loss for some and future weight gain for the majority of people. This often leads to a behavior called weight cycling or yo-yo dieting. The person continues to seek weight loss and a new diet, hoping to get a new result. This repetition of starting and stopping diets leads to losing and gaining a similar amount of weight over and over again. The weight goes up and down like a yo-yo. In addition, when someone cuts out food groups and restricts certain foods from their diet, the interest in the food increases. This in combination with intense hunger resulting from energy restriction, leads to a feeling of being out of control around foods and binge eating. To compensate for the feeling out of control, the person then restricts

the food again and is then in a restriction/ binge or overeating cycle.

The majority (up to 95%) of people regain the weight within three years and often gain back more.[89] Weight cycling puts stress on the body causing physical complications that are harmful, resulting in lowered or slowed metabolism, a reduction in lean body mass or muscle tissue, lowered body temperature, and increased risk for eating disorders.[1011] Dieting and weight cycling also have a negative impact on mental health including lower self-esteem, and increases in depression, anxiety, irritability, and nervousness.[12] The evidence shows that dieting reduces both physical and emotional health.

8. Mann, T., Tomiyama, A. J., Westling, E., Lew, A.-M., Samuels, B., & Chatman, J. (2007). Medicare's search for effective obesity treatments: Diets are not the answer. *The American Psychologist*, 62(3), 220–233.
9. Wooley, S. C., & Garner, D. M. (1994). Dietary treatments for obesity are ineffective. *BMJ*, 309(6955), 655–656.
10. Bacon, L. (2010). *Health at every size: The surprising truth about your weight*. BenBella Books, Incorporated.
11. Karelis, A. D., Messier, V., Brochu, M., & Rabasa-Lhoret, R. (2008). Metabolically healthy but obese women: Effect of an energy-restricted diet. *Diabetologia*, 51(9), 1752–1754.
12. French, S. A., & Jeffery, R. W. (1994). Consequences of dieting to lose weight: Effects on physical and mental health. *Health Psychology*, 13(3), 195–212.

Health and Body Weight

Image by 272447 / Pixabay License

The assumption that health is determined by body weight, or a number on the scale, is outdated and not supported by science. As obesity rates continue to rise, it has been speculated that a higher BMI stands alone as a health risk. However, there is substantial scientific evidence to support the notion that obesity in itself does not put an individual at increased risk of disease. The majority of epidemiological studies demonstrate that five pounds "underweight" is more harmful than 75 pounds "overweight".

[1314151617] The results of multiple studies have indicated that using weight as a criterion for health is off-target and potentially

13. Flegal, K. M., Graubard, B. I., Williamson, D. F., & Gail, M. H. (2005). Excess deaths associated with underweight, overweight, and obesity. *JAMA*, *293*(15), 1861–1867.
14. Flegal K.M., Graubard B.I., Williamson D. F., & Gail M. H. (2018, March). Excess deaths associated with underweight, overweight, and obesity: An evaluation of potential bias. *Vital & Health Statistics*. 42, 1-21
15. Orpan H. M., Berthaelot J. M., Kaplan M. S. , Feeny D. H., McFarland B., & Ross N. A. (2010). BMI and mortality: Results from a longitudinal study of Canadian adults. *Obesity (Silver Springs)*. 18(1), 214-8.
16. Tamakoshi A., Hiroshi Y., Lin Y., Tamakoshi K., Kondo T., Suzuki S., Yagyu K., Kikuchi S., & the JACC Study Group (2010). BMI and all-cause mortality among Japanese older adults: Findings from the Japan collaborative cohort study. *Obesity*. 18(2), 362-9.
17. Campos P. (2004). *The Obesity Myth*. Gotham Books.

harmful.[181920] This suggests that it is not possible to tell how healthy an individual is simply by looking at them or calculating their BMI.

The following are measurable risk factors and markers of health that are not connected to body weight. These are good targets for nutrition education and counseling and ways to monitor improvements of health status over time.

- Biomarkers: blood pressure, blood glucose, total cholesterol, high-density lipoproteins, low-density lipoproteins, triglycerides
- Regular movement/ activity/ exercise
- Stress and inflammation
- Hormone balance
- Mental health status

18. Kang X., Shaw L. J., Hayes S. W., Hachamovitch R., Abidov A., Cohen I., Friedman J. D., Thomson L. E., Polk D., Germano G., & Berman D. S. (2006). Impact of body mass index on cardiac mortality in patients with known or suspected coronary artery disease undergoing myocardial perfusion single-photon emission computed tomography. *Journal of the American College of Cardiology*. 47(7), 1418-26
19. Oreopoulos A., Padwal R., Kalantar-Zadeh K., Fonarow G. C., Norris C. M., & McAlister F. A. (2008). Body mass index and mortality in heart failure: A meta-analysis. *American Heart Journal*. 156(1), 13-22.
20. Olsen T. S., Dehlendorft C., Petersen H. G., & Andersen K. K. (2008). Body mass index and prestroke mortality. *Neuroepidemiology*. 30, 93-100.

- Sleep
- Quality of life
- Connection to the community
- Spiritual health
- Intellectual health
- Occupational health

Health at Every Size

At its foundation, Health at Every Size (HAES) supports behavior changes that create sustainable habits to improve health and promote a better quality of life.[21] The HAES approach is an alternative to the weight/size-based approach with a focus on improving health without a focus on weight loss. The research shows this model is able to promote sustainable improvements in health.

"In a study comparing the HAES model to a diet approach, though only dieters lost weight, both groups initially had similar improvements in metabolic fitness, activity levels, psychological measures, and eating behaviors. After two years, dieters had regained their weight and lost the health improvements, while the HAES group sustained their health improvements".[22]

21. Association for Size Diversity and Health. (2020). HAES Principles. www.sizediversityandhealth.org
22. Bacon L., Stern J. S., Van Loan M. D., & Keim N. L. (2005). Size acceptance and intuitive eating improve health for obese female chronic dieters. *Journal of the American Dietetic Association*. 105(6), 929-36.

The Health At Every Size® Principles are:

1. **Weight Inclusivity**: Accepting and respecting the diversity of body shapes and sizes
2. **Health Enhancement**: Recognizing that health and well-being are multi-dimensional and that they include physical, social, spiritual, occupational, emotional, and intellectual aspects
3. **Respectful Care**: Promoting all aspects of health and well-being for people of all sizes
4. **Eating for Well-being**: Promoting eating in a manner which balances individualized nutritional needs, hunger, satiety, appetite, and pleasure
5. **Life-Enhancing Movement**: Promoting individually appropriate, enjoyable, life-enhancing physical activity, rather than exercise that is focused on a goal of weight loss

In the Hawaiian language, Lokahi means "unity, agreement, accord, and harmony".[23] The concept of Lokahi can be used to describe the balance between the relationship an individual has with the body, the mind, the spirit, and the rest of the world.

The image below illustrates the overlap of the Hawaiian principle of Lokahi with the Health at Every Size principle #2: Health enhancement.

23. Ulukau Hawaiian Electronic Library. http://wehewehe.org/

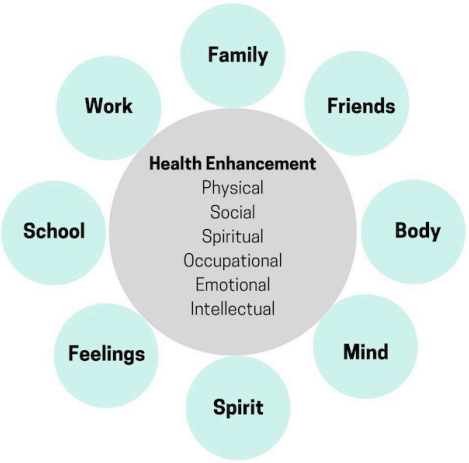

Image by Jennifer Draper / CC BY 4.0

Intuitive Eating

Image by CDC / Unsplash License

Intuitive eating is a non-diet approach to eating that promotes a

connection to body cues of hunger and fullness and the selection of foods based on both pleasure and nutrient density.[24] When an individual is able to disconnect from diet culture and a focus on weight loss, they are able to eat in ways that support having energy throughout the day and feel competent around all foods. Instead of an outward focus on counting calories, dietary restriction, and measuring food portions, intuitive eating teaches a mindfulness practice of going inward and learning to respond to the cues and rhythms of the body. A review of 22 intervention studies that compared traditional weight loss to the intuitive eating approach concluded that the participants in the non-diet groups were able to stop unhealthy weight controlling behaviors, improve metabolic fitness and reduce risk factors, increase body satisfaction, and improve psychological distress.[25] While the non-diet approach has not been shown to promote weight loss, a review of clinical trials concluded that intuitive eating was able to stabilize weight and help to prevent future weight gain, in addition to an improvement in blood pressure and cholesterol levels, and dietary intake.[26]

24. The Original Intuitive Eating Pros. (2007 - 2019). 10 Principles of Intuitive Eating. https://www.intuitiveeating.org/10-principles-of-intuitive-eating/
25. Schaefer J. T., Magnuson A. B. (2014). A review of interventions that promote eating my internal cues. *Journal of the Academy of Nutrition and Dietetics*. 114(5), 734-760.
26. Van Dyke N., Drinkwater E. J. (2014). Relationships between intuitive eating and health indicators: Literature review. *Public Health Nutrition*. 17(8), 1757-1766.

The 10 Principles of Intuitive Eating

1. Reject the diet mentality
2. Honor your hunger
3. Make peace with food
4. Challenge the food police
5. Discover the satisfaction factor
6. Feel your fullness
7. Cope with your emotions with kindness
8. Respect your body
9. Movement- Feel the difference
10. Honor your health – gentle nutrition

Nutrition, Health and Disease

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Disorders That Can Compromise Health

When nutrients and energy are in short supply, cells, tissues, organs, and organ systems do not function properly. Unbalanced diets can cause diseases and, conversely, certain illnesses and diseases can cause an inadequate intake and absorption of nutrients, simulating the health consequences of an unbalanced diet. Overeating high-fat foods and nutrient-poor foods can lead to obesity and exacerbate the symptoms of gastroesophageal reflux disease (GERD) and irritable bowel syndrome (IBS). Many diseases and illnesses, such as celiac disease, interfere with the body getting its nutritional requirements. A host of other conditions and illnesses, such as food allergies, cancer, stomach ulcers, Crohn's disease, and kidney and liver disease, also can impair the process of digestion and/or negatively affect nutrient balance and decrease overall health. Some illnesses that can compromise health are chronic and persist for a long time, some are communicable and can be transmitted between people, and some are non-communicable and are not infectious.

Gastroesophageal Reflux Disease

Gastroesophageal reflux disease (GERD) is a persistent form of acid reflux that occurs more than two times per week. Acid reflux occurs when the acidic contents of the stomach leak backward into the

esophagus and cause irritation. It is estimated that GERD affects 25 to 35 percent of the US population. An analysis of several studies published in the August 2005 issue of Annals of Internal Medicine concludes that GERD is much more prevalent in people who are obese.[1] The most common GERD symptom is heartburn, but people with GERD may also experience regurgitation (flow of the stomach's acidic contents into the mouth), frequent coughing, and trouble swallowing.

There are other causative factors of GERD that may be separate from or intertwined with obesity. The sphincter that separates the stomach's internal contents from the esophagus often does not function properly and acidic gastric contents seep upward. Sometimes the peristaltic contractions of the esophagus are also sluggish and compromise the clearance of acidic contents. In addition to having an unbalanced, high-fat diet, some people with GERD are sensitive to particular foods—chocolate, garlic, spicy foods, fried foods, and tomato-based foods—which worsen symptoms. Drinks containing alcohol or caffeine may also worsen GERD symptoms. GERD is diagnosed most often by a history of the frequency of recurring symptoms. A more proper diagnosis can be made when a doctor inserts a small device into the lower esophagus that measures the acidity of the contents during one's daily activities. About 50 percent of people with GERD have inflamed tissues in the esophagus.

The first approach to GERD treatment is dietary and lifestyle modifications. Suggestions are to reduce weight if you are overweight or obese, avoid foods that worsen GERD symptoms,

1. Hampel H, Abraham NS, El-Serag HB. (2005). Meta-Analysis: Obesity and the Risk for Gastroesophageal Reflux Disease and Its Complications. *Annuals of Internal Medicine*, 143(3), 199–211. http://www.ncbi.nlm.nih.gov/pubmed/16061918. Accessed April 12, 2018.

eat smaller meals, stop smoking, and remain upright for at least three hours after a meal. People with GERD may not take in the nutrients they need because of the pain and discomfort associated with eating. As a result, GERD can be caused by an unbalanced diet and its symptoms can lead to a worsening of nutrient inadequacy, a vicious cycle that further compromises health. Some evidence from scientific studies indicates that medications used to treat GERD may accentuate certain nutrient deficiencies, namely zinc and magnesium. When these treatment approaches do not work surgery is an option. The most common surgery involves reinforcing the sphincter that serves as a barrier between the stomach and esophagus.

Irritable Bowel Syndrome

Irritable bowel syndrome (IBS) is characterized by muscle spasms in the colon that result in abdominal pain, bloating, constipation, and/or diarrhea. Interestingly, IBS produces no permanent structural damage to the large intestine as often happens to patients who have Crohn's disease or inflammatory bowel disease. It is estimated that one in five Americans displays symptoms of IBS. The disorder is more prevalent in women than men. Two primary factors that contribute to IBS are an unbalanced diet and stress.

Symptoms of IBS significantly decrease a person's quality of life as they are present for at least twelve consecutive or nonconsecutive weeks in a year. Large meals and foods high in fat and added sugars, or those that contain wheat, rye, barley, peppermint, and chocolate intensify or bring about symptoms of IBS. Additionally, beverages containing caffeine or alcohol may worsen IBS. Stress and depression compound the severity and frequency of IBS symptoms. As with GERD, the first treatment approaches for IBS are diet and lifestyle modifications. People with IBS are often told to keep a daily food journal to help identify and eliminate foods that cause the most

problems. Other recommendations are to eat slower, add more fiber to the diet, drink more water, and to exercise. There are some medications (many of which can be purchased over-the-counter) to treat IBS and the resulting diarrhea or constipation. Sometimes antidepressants and drugs to relax the colon are prescribed.

Celiac Disease

Celiac disease is an autoimmune disorder affecting between 0.5 and 1.0 percent of Americans—that is, one in every one- to two-hundred people. It is caused by an abnormal immune reaction of small intestine cells to a type of protein, called gluten. Gluten forms in the presence of water and is composed of two protein parts, glutenin and gliadin. Glutenin and gliadin are found in grains that are commonly used to make bread, such as wheat, rye, and barley. When bread is made, yeast eats the flour and makes a waste product, carbon dioxide, which forms bubbles in the dough. As the dough is kneaded, gluten forms and stretches. The carbon dioxide gas bubbles infiltrate the stretchy gluten, giving bread its porosity and tenderness. For those who are sensitive to gluten, it is good to know that corn, millet, buckwheat, and oats do not contain the proteins that make gluten. However, some people who have celiac disease also may have a response to products containing oats. This is most likely the result of cross-contamination of grains during harvest, storage, packaging, and processing.

Celiac disease is most common in people of European descent and is rare in people of African American, Japanese, and Chinese descent. It is much more prevalent in women and in people with Type 1 diabetes, autoimmune thyroid disease, and Down and Turner syndromes. Symptoms can range from mild to severe and can include pale, fatty, loose stools, gastrointestinal upset, abdominal pain, weight loss and, in children, a failure to grow and thrive. The symptoms can appear in infancy or much later in life, even

by age seventy. Celiac disease is not always diagnosed because the symptoms may be mild. A large number of people have what is referred to as “silent” or “latent” celiac disease.

Celiac disease diagnosis requires a blood test and a biopsy of the small intestine. Because celiac disease is an autoimmune disease, antibodies produced by white blood cells circulate in the body and can be detected in the blood. When gluten-containing foods are consumed the antibodies attack cells lining the small intestine leading to a destruction of the small villi projections. This tissue damage can be detected with a biopsy, a procedure that removes a portion of tissue from the damaged organ. Villi destruction is what causes many of the symptoms of celiac disease. The destruction of the absorptive surface of the small intestine also results in the malabsorption of nutrients, so that while people with this disease may eat enough, nutrients do not make it to the bloodstream because absorption is reduced. The effects of nutrient malabsorption are most apparent in children and the elderly as they are especially susceptible to nutrient deficiencies. Over time these nutrient deficiencies can cause health problems. Poor absorption of iron and folic acid can cause anemia, which is a decrease in red blood cells. Anemia impairs oxygen transport to all cells in the body. Calcium and vitamin D deficiencies can lead to osteoporosis, a disease in which bones become brittle.

If you think you or someone close to you may have celiac disease, do not despair; it is a very treatable disease. Once diagnosed, a person follows a gluten-free diet for life. This requires dedication and careful detective work to seek out foods with hidden gluten, but some stores carry gluten-free foods. After eliminating gluten from the diet, the tissues of the small intestine rapidly repair themselves and heal in less than six months.

Food Allergies

Paying attention to the way individuals react to various foods is essential in determining what foods may specifically affect a person adversely. Food allergies are one of the many ways in which different body make-ups affect nutritional concerns. Although an estimated twelve million Americans have food allergies, there are likely many more people who say they have food allergies than actually do. This is because food sensitization is different from a medically-determined food allergy. When someone has a food allergy, the immune system mistakenly attacks a certain kind of food (usually the protein component of a food), such as peanuts, as if it were a threat and IgE antibodies are produced. Doctors sometimes test for food allergies by using skin-prick tests or blood tests to look for the presence of IgE antibodies. However, these types of tests are not always reliable as they can sometimes yield a false positive result. By far, the most valuable tests for determining a food allergy is the Double Blind Placebo Controlled Food Challenge (DBPCFC), which involves administering the food orally and then denoting the signs and symptoms of the allergic response.

Food allergy symptoms usually develop within a few minutes to two hours after a person has eaten a food to which they are allergic. These symptoms can range from the annoying to the potentially fatal, and include:

- A tingling mouth
- Swelling tongue and/or throat
- Difficulty breathing
- Hives
- Stomach cramps
- Diarrhea
- Vomiting
- Drop in blood pressure
- Loss of consciousness

- Death

There are no clear treatments for food allergies. Epinephrine is sometimes used to control severe reactions, and individuals with known and dangerous allergies may get prescriptions for self-injectable devices. The only certain way to avoid allergic reactions to food is to avoid the foods that cause them. Beyond avoidance, this can mean reading food labels carefully, or even calling manufacturers for product information.

Ninety percent of food allergies are caused by these eight foods:

1. Milk
2. Eggs
3. Peanuts
4. Tree nuts
5. Fish
6. Shellfish
7. Wheat
8. Soy

The prevalence of food allergies is a complex and growing problem. In response to this situation, the National Institute of Allergy and Infectious Diseases (NIAID) collaborated with thirty-four professional organizations, federal agencies, and patient-advocacy groups to develop a comprehensive guide to diagnosing and managing food allergies and treating acute food allergy reactions. The guide defines various food allergies, allergens, and reactions, provides comprehensive information on the prevalence of different food allergies, tracks the history of food allergies, and reviews medical management techniques for people with food allergies.

Oral Disease

Oral health refers not only to healthy teeth and gums, but also to the health of all the supporting tissues in the mouth such as ligaments, nerves, jawbone, chewing muscles, and salivary glands. Over ten years ago the Surgeon General produced its first report dedicated to oral health, stating that oral health and health in general are not separate entities.[2]

Instead, oral health is an integral part of overall health and well-being. Soft drinks, sports drinks, candies, desserts, and fruit juices are the main sources of "fermentable sugars" in the American diet. (Fermentable sugars are those that are easily metabolized by bacteria in a process known as fermentation. Glucose, fructose, and maltose are three examples.) Bacteria that inhabit the mouth metabolize fermentable sugars and starches in refined grains to acids that erode tooth enamel and deeper bone tissues. The acid creates holes (cavities) in the teeth that can be extremely painful. Gums are also damaged by bacteria produced by acids, leading to gingivitis (characterized by inflamed and bleeding gums). Saliva is actually a natural mouthwash that neutralizes the acids and aids in building up teeth that have been damaged.

Figure 18.1 Gingivitis

2. Office of the Surgeon General (US). National Call To Action To Promote Oral Health. National Institute of Dental and Craniofacial Research (US). 2003; 03-5303. https://www.ncbi.nlm.nih.gov/books/NBK47472/. Accessed April 15, 2018.

"Gingivitis" / CC0 1.0

According to Healthy People 2010, 23 percent of US children have cavities by the age of four, and by second grade, one-half of all children in this country have at least one cavity.[3]

Cavities are an epidemic health problem in the United States and are associated with poor diet, but other contributors include poor dental hygiene and the inaccessibility to regular oral health care. A review in Academic Pediatrics reports that "frequent consumption of fast-releasing carbohydrates, primarily in the form of dietary sugars, is significantly associated with increased dental caries risk."[4] In regards to sugary soft drinks, the American Dental Association says that drinking sugary soft drinks increases the risk of decay formation.[5]

3. Continuing MCH Education in Oral Health. Oral Health and Health Care. http://ccnmtl.columbia.edu/projects/otm/index.html. Accessed April 12, 2018.
4. Mobley C, Marshall T. (2009). The Contribution of Dietary Factors to Dental Caries and Disparities in Caries. *Academy of Pediatrics*, 9(6), 410–14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2862385/. Accessed April 15, 2018.
5. Foods that Affects your Teeth. American Dental

Colon Health

A substantial health benefit of whole grain foods is that fiber actively supports digestion and optimizes colon health. (This can be more specifically attributed to the insoluble fiber content of whole grains.) There is good evidence supporting that insoluble fiber prevents the irritating problem of constipation and the development of diverticulosis and diverticulitis. Diverticulosis is a benign condition characterized by outpouches of the colon. Diverticulitis occurs when the outpouches in the lining of the colon become inflamed. Interestingly, diverticulitis did not make its medical debut until the early 1900s, and in 1971 was defined as a deficiency of whole-grain fiber. According to the National Digestive Diseases Information Clearinghouse, 10 percent of Americans over the age of forty have diverticulosis, and 50 percent of people over the age of sixty have the disorder.[6] Ten to 25 percent of people who have diverticulosis go on to develop diverticulitis.[7] Symptoms include lower abdominal pain, nausea, and alternating between constipation and diarrhea.

The chances of developing diverticulosis can be reduced with

Association. https://www.mouthhealthy.org/en/nutrition/food-tips. Accessed April 15, 2018.

6. Diverticular Disease. National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Health. http://digestive.niddk.nih.gov/ddiseases/pubs/diverticulosis/. Accessed April 15, 2018.
7. Diverticular Disease. National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Health. http://digestive.niddk.nih.gov/ddiseases/pubs/diverticulosis/. Accessed April 15, 2018.

fiber intake because of what the breakdown products of the fiber do for the colon. The bacterial breakdown of fiber in the large intestine releases short-chain fatty acids. These molecules have been found to nourish colonic cells, inhibit colonic inflammation, and stimulate the immune system (thereby providing protection of the colon from harmful substances). Additionally, the bacterial indigestible fiber, mostly insoluble, increases stool bulk and softness increasing transit time in the large intestine and facilitating feces elimination. One phenomenon of consuming foods high in fiber is increased gas, since the byproducts of bacterial digestion of fiber are gases.

Figure 18.2 Diverticulitis: A Disease of Fiber Deficiency

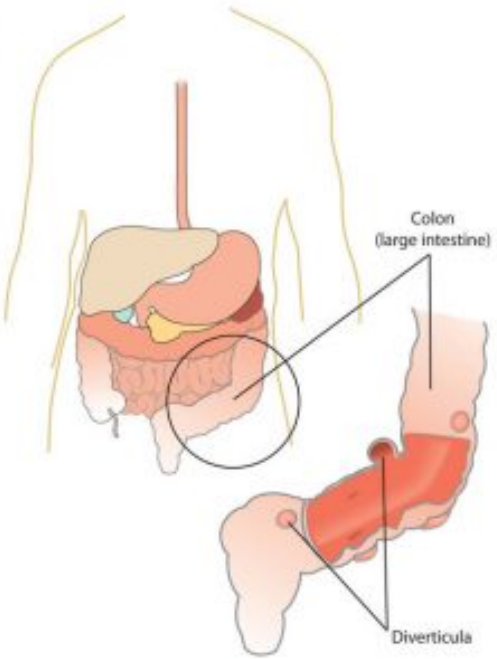

Image by Allison Calabrese / CC BY 4.0

Some studies have found a link between high dietary-fiber intake and a decreased risk for colon cancer. However an analysis of

several studies, published in the Journal of the American Medical Association 2005, did not find that dietary-fiber intake was associated with a reduction in colon cancer risk.[8] There is some evidence that specific fiber types (such as inulin) may protect against colon cancer, but more studies are needed to conclusively determine how certain fiber types (and at what dose) inhibit colon cancer development.

Osteoporosis

There are several factors that lead to loss of bone quality during aging, including a reduction in hormone levels, decreased calcium absorption, and increased muscle deterioration. It is comparable to being charged with the task of maintaining and repairing the structure of your home without having all of the necessary materials to do so. However, you will learn that there are many ways to maximize your bone health at any age.

Osteoporosis is the excessive loss of bone over time. It leads to decreased bone strength and an increased susceptibility to bone fracture. The Office of the Surgeon General (OSG) reports that approximately ten million Americans over age fifty are living with osteoporosis, and an additional thirty-four million have osteopenia, which is lower-than-normal bone mineral density.[9]

8. Park Y, Hunter DJ. (2005). Dietary Fiber Intake and Risk of Colorectal Cancer. *Journal of the American Medical Association*, 294(22), 2849–57. https://www.ncbi.nlm.nih.gov/pubmed/16352792. Accessed April 15,2018.
9. Office of the Surgeon General (US). Bone Health and

Osteoporosis is a debilitating disease that markedly increases the risks of suffering from bone fractures. A fracture in the hip causes the most serious consequences—and approximately 20 percent of senior citizens who have one will die in the year after the injury. Osteoporosis affects more women than men, but men are also at risk for developing osteoporosis, especially after the age of seventy. These statistics may appear grim, but many organizations—including the National Osteoporosis Foundation and the OSG—are disseminating information to the public and to health-care professionals on ways to prevent the disease, while at the same time, science is advancing in the prevention and treatment of this disease.[10]

As previously discussed, bones grow and mineralize predominantly during infancy, childhood, and puberty. During this time, bone growth exceeds bone loss. By age twenty, bone growth is fairly complete and only a small amount (about 10 percent) of bone mass accumulates in the third decade of life. By age thirty, bone mass is at its greatest in both men and women and then gradually declines after age forty. Bone mass refers to the total weight of bone tissue in the human body. The greatest quantity of bone tissue a person develops during his or her lifetime is called peak bone mass. The decline in bone mass after age forty occurs because bone loss is greater than bone growth. The increased bone degradation decreases the mineral content of bone tissue leading to a decrease in bone strength and increased fracture risk.

Osteoporosis is referred to as a silent disease, much like high blood pressure, because symptoms are rarely exhibited. A person

Osteoporosis. 2004. https://www.ncbi.nlm.nih.gov/books/NBK45513/. Accessed April 12,2018.

10. Facts and Statistics. International Osteoporosis Foundation. https://www.iofbonehealth.org/facts-statistics#category-14. Accessed March 17, 2018.

with osteoporosis may not know he has the disease until he experiences a bone break or fracture. Detection and treatment of osteoporosis, before the occurrence of a fracture, can significantly improve the quality of life. To detect osteopenia or osteoporosis, BMD must be measured by the DEXA procedure.

During the course of osteoporosis, BMD decreases and the bone tissue microarchitecture is compromised. Excessive bone resorption in the trabecular tissue increases the size of the holes in the lattice-like structure making it more porous and weaker. A disproportionate amount of resorption of the strong cortical bone causes it to become thinner. The deterioration of one or both types of bone tissue causes bones to weaken and, consequently, become more susceptible to fractures. The American Academy of Orthopaedic Surgeons reports that one in two women and one in five men older than sixty-five will experience a bone fracture caused by osteoporosis.[11]

Figure 18.3 Osteoporosis in Vertebrae

11. Osteoporosis. American Academy of Orthopaedic Surgeons.OrthoInfo. http://orthoinfo.aaos.org/topic.cfm?topic=a00232. Updated August 2009. Accessed April 16, 2018.

Image by BruceBlaus/ CC BY 4.0

When the vertebral bone tissue is weakened, it can cause the spine to curve. The increase in spine curvature not only causes pain, but also decreases a person's height. Curvature of the upper spine produces what is called Dowager's hump, also known as kyphosis. Severe upper-spine deformity can compress the chest cavity and cause difficulty breathing. It may also cause abdominal pain and loss of appetite because of the increased pressure on the abdomen.

Risk Factors for Osteoporosis

A risk factor is defined as a variable that is linked to an increased probability of developing a disease or adverse outcome. Recall that advanced age and being female increases the likelihood for developing osteoporosis. These factors present risks that should signal doctors and individuals to focus more attention on bone health, especially when the risk factors exist in combination. This is because not all risk factors for osteoporosis are out of your control. Risk factors such as age, gender, and race are biological risk factors, and are based on genetics that cannot be changed. By contrast, there are other risk factors that can be modified, such as physical activity, alcohol intake, and diet. The changeable risk factors for osteoporosis provide a mechanism to improve bone health even though some people may be genetically predisposed to the disease.

Image by Tomasz Sienick / CC BY- SA 3.0

Physical Activity

Bone is a living tissue, like muscle, that reacts to exercise by gaining

strength. Physical inactivity lowers peak bone mass, decreases BMD at all ages, and is linked to an increase in fracture risk, especially in the elderly. Recall that mechanical stress increases bone remodeling and leads to increased bone strength and quality. Weight-bearing exercise puts mechanical stress on bones and therefore increases bone quality. Weight-bearing exercises such as strength training with weights, and aerobic weight-bearing activities, such as walking, running, and stair climbing are the most helpful for maintaining BMD. Certain aerobic exercises such as biking and swimming do not build bones, although they are very good for cardiovascular fitness.The stimulation of new bone growth occurs when a person participates in weight-bearing or resistance activities that force the body to work against gravity. Research has shown that this is an excellent way to activate osteoblasts to build more new bone. Conversely, physical inactivity lowers peak bone mass, decreases BMD at all ages, and is linked to an increase in fracture risk, especially in the elderly.

Being Underweight

Being underweight significantly increases the risk for developing osteoporosis. This is because people who are underweight often also have a smaller frame size and therefore have a lower peak bone mass. Maintaining a normal, healthy weight is important and acts as a form of weight-bearing exercise for the skeletal system as a person moves about. Additionally, inadequate nutrition negatively impacts peak bone mass and BMD. The most striking relationship between being underweight and bone health is seen in people with the psychiatric illness anorexia nervosa. Anorexia nervosa is strongly correlated with low peak bone mass and a low BMD. In fact, more than 50 percent of men and women who have this illness

develop osteoporosis and sometimes it occurs very early in life.[12] Women with anorexia nervosa are especially at risk because they not only have inadequate nutrition and low body weight, but also the illness is also associated with estrogen deficiency.

Smoking, Alcohol, and Caffeine

Smoking cigarettes has long been connected to a decrease in BMD and an increased risk for osteoporosis and fractures. However, because people who smoke are more likely to be physically inactive and have poor diets, it is difficult to determine whether smoking itself causes osteoporosis. What is more, smoking is linked to earlier menopause and therefore the increased risk for developing osteoporosis among female smokers may also be attributed, at least in part, to having stopped estrogen production at an earlier age. A review of several studies, published in the British Medical Journal in 1997, reports that in postmenopausal women who smoked, BMD was decreased an additional 2 percent for every ten-year increase in age and that these women had a substantial increase in the incidence of hip fractures.[13]

12. Mehler PS, Weiner K. The Risk of Osteoporosis in Anorexia Nervosa. Eating Disorders Recovery Today. http://www.eatingdisordersrecoverytoday.com/the-risk-of-osteoporosis-in-anorexia-nervosa/. Published May 14, 2017. Accessed April 15, 2018.
13. Law MR, Hackshaw, AK. (1997). A Meta-Analysis of Cigarette Smoking, Bone Mineral Density and Risk of Hip Fracture: Recognition of a Major Effect. *British Medical Journal*, 315 (7112), 841–6. http://www.ncbi.nlm.nih.gov/pubmed/9353503. Accessed April 15, 2018.

Alcohol intake's effect on bone health is less clear. In some studies, excessive alcohol consumption was found to be a risk factor for developing osteoporosis, but the results of other studies suggests consuming two drinks per day is actually associated with an increase in BMD and a decreased risk for developing osteoporosis. The International Osteoporosis Foundation states that consuming more than two alcoholic drinks per day is a risk factor for developing osteoporosis and sustaining a hip fracture in both men and women.[14] Moreover, excessive alcohol intake during adolescence and young adulthood has a more profound effect on BMD and osteoporosis risk than drinking too much alcohol later in life.

Some studies have found that, similar to alcohol intake, excessive caffeine consumption has been correlated to decreased BMD, but in other studies moderate caffeine consumption actually improves BMD. Overall, the evidence that caffeine consumption poses a risk for developing osteoporosis is scant, especially when calcium intake is sufficient. Some evidence suggests that carbonated soft drinks negatively affect BMD and increase fracture risk. Their effects, if any, on bone health are not attributed to caffeine content or carbonation. It is probable that any effects of the excessive consumption of soft drinks, caffeinated or not, on bone health can be attributed to the displacement of milk as a dietary source of calcium.

14. New IOF Report Shows Smoking, Alcohol, Being Underweight, and Poor Nutrition Harm Our Bones. International Osteoporosis Foundation. https://www.iofbonehealth.org/new-iof-report-shows-smoking-alcohol-being-underweight-and-poor-nutrition-harm-our-bones. Published October 19, 2007. Accessed April 15, 2018.

Nutrition

Ensuring adequate nutrition is a key component in maintaining bone health. Having low dietary intakes of calcium and vitamin D are strong risk factors for developing osteoporosis. Another key nutrient for bone health is protein. Remember that the protein collagen comprises almost one third of bone tissue. A diet inadequate in protein is a risk factor for osteoporosis. Multiple large observational studies have shown that diets high in protein increase BMD and reduce fracture risk and that diets low in protein correlate to decreased BMD and increased fracture risk. There has been some debate over whether diets super high in animal protein decreases bone quality by stimulating bone resorption and increasing calcium excretion in the urine. A review in the May 2008 issue of the American Journal of Clinical Nutrition concludes that there is more evidence that diets adequate in protein play a role in maximizing bone health and there is little consistent evidence that suggests high protein diets negatively affect bone health when calcium intake is adequate.[15]

Osteoporosis Prevention and Treatment

Although the symptoms of osteoporosis do not occur until old age, osteoporosis is referred to as a childhood disease with old-age consequences. Thus, preventing osteoporosis in old age begins with

15. Heaney, RP, Layman DK. (2008). Amount and Type of Protein Influences Bone Health. *The American Journal of Clinical Nutrition*, 87(5), 1567S–70S. http://www.ajcn.org/content/87/5/1567S.long. Accessed April 15, 2018.

building strong bones when you are growing. Remember, the more bone mass a person has to start with, the greater the loss a person can withstand without developing osteopenia or osteoporosis. Growing and maintaining healthy bones requires good nutrition, adequate intake of minerals and vitamins that are involved in maintaining bone health, and weight-bearing exercise.

Prevention extends throughout life, and people with one or more risk factors for osteoporosis should have their BMD measured. The National Osteoporosis Foundation recommends the following groups of people get BMD screening:[16]

- Women who are sixty-five or older
- Men who are seventy or older
- Women and men who break a bone after age fifty
- Women going through menopause with other risk factors
- Men fifty to sixty-nine years of age with risk factors

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are

16. Bone Density Exam/Test. National Osteoporosis Foundation. https://www.nof.org/patients/diagnosis-information/bone-density-examtesting/. Accessed April 15, 2018.

available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

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http://pressbooks.oer.hawaii.edu/humannutrition2/?p=562

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http://pressbooks.oer.hawaii.edu/humannutrition2/?p=562

Threats to Health

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Chronic Diseases

Chronic diseases are ongoing, life-threatening, and life-altering health challenges. They are the leading cause of death worldwide. Chronic conditions are increasing in frequency. They cause significant physical and emotional suffering and are an impediment to economic growth and vitality. It is important, now more than ever, to understand the different risk factors for chronic disease and to learn how to prevent their development.

The Risk Factors of Chronic Disease

A risk factor is a signal that your chances for acquiring a chronic disease may be increased. You might liken a risk factor to the flags that lifeguards sometimes set up at beaches. When you see these flags, you know immediately that swimming within the marked areas could be hazardous, and that if you choose to swim within these parameters anyway, you are doing so at your own risk. But, if you heed the warnings, you are taking the necessary step to protect your safety and health. Similarly, risk factors are warning signs that coincide with the development and progression of disease. However, risk factors are not a 100-percent guarantee that a person will develop a chronic disease, only that the conditions are right. For example, if a person gets sick with the flu, we can say with certainty that the illness was caused by a virus. However, we cannot

say that a sedentary lifestyle caused the onset of cardiovascular disease in a patient, because a risk factor indicates a correlation, not a causation.

Chronic disease usually develops alongside a combination of the following risk factors: genetics, a prior disease such as obesity or hypertension, dietary and lifestyle choices, and environmental problems. Risk factors such as genetics and age cannot be changed. However, some risk factors can be altered to promote health and wellness,such as diet. For example, a person who continuously eats a diet high in sugars, saturated fats, and red meat is at risk for becoming obese and developing Type 2 diabetes, cardiovascular disease, or several other conditions. Making more healthy dietary choices can greatly reduce that risk. Being a woman over age sixty-five is a risk factor for developing osteoporosis, but that cannot be changed. Also, people without a genetic predisposition for a particular chronic illness can still develop it. Not having a genetic predisposition for a chronic disease is not a guarantee of immunity.

Identifying Your Risk Factors

To estimate your own risk factors for developing certain chronic diseases, search through your family's medical history. What diseases do you note showing up among close blood relatives? At your next physical, pay attention to your blood tests and ask the doctor if any results are out of normal range. It is also helpful to note your vital signs, particularly your blood pressure and resting heart rate. In addition, you may wish to keep a food diary to make a note of the dietary choices that you make on a regular basis and be aware of foods that are high in saturated fat, among other unhealthy options. As a general rule, it is important to look for risk factors that you can modify to promote your health. For example, if you discover that your grandmother, aunt, and uncle all suffered from high blood pressure, then you may decide to avoid a high sodium

diet. Identifying your risk factors can arm you with the information you need to help ward off disease.

The Crisis of Obesity

Excessive weight gain has become an epidemic. According to the National Institutes of Health, over two-thirds of American adults are overweight, and one in three is obese. Obesity in particular puts people at risk for a host of complications, including Type 2 diabetes, heart disease, high cholesterol, hypertension, osteoarthritis, and some forms of cancer. The more overweight a person is, the greater his or her risk of developing life-threatening complications. There is no single cause of obesity and no single way to treat it. However, a healthy, nutritious diet is generally the first step, including consuming more fruits and vegetables, whole grains, and lean meats and dairy products.[1]

Cardiovascular Disease

Throughout the remainder of this section, we will examine some of the more prevalent chronic diseases, their risk factors, and the choices that can help to discourage their development or progression. Let's begin with cardiovascular disease. According to

1. Overweight and Obesity Statistics.National Institute of Diabetes and Digestive and Kidney Diseases. https://www.niddk.nih.gov/health-information/health-statistics/overweight-obesity. Accessed April 15, 2018.

the Centers for Disease Control and Prevention (CDC), heart disease is the leading cause of death in the United States.[2]

The disease generally starts with atherosclerosis, or a hardening of the arteries, a chronic condition so common that most people show signs of it by the time they turn thirty. Arteries start to narrow and harden when fats accumulate along their inner walls and form plaques. A plaque is made of fat, cholesterol, calcium, and other substances found in blood.

Plaque formation causes arteries to narrow and harden, which elevates blood pressure because the vessels can't expand effectively to accommodate blood pulses. Higher blood pressure strains the heart and causes more damage. Arterial walls can become so weakened due to high blood pressure that they balloon and form what is known as an aneurysm. If the aneurysm bursts, it becomes a life-threatening event. The plaques themselves can also rupture due to a spike in blood pressure or a tremor along an arterial wall, and the body responds to this perceived injury by forming blood clots. These clots are serious health threats, whether they are stationary (a thrombus) or moving (an embolus). A stable clot can slowly kill off surrounding tissue, or grow so big that it blocks blood circulation and causes thrombosis. When a moving clot becomes stuck in an artery too small for its passage, it cuts off blood flow and causes cell death. This is referred to as an embolism. Blood clots in heart and brain arteries can cause heart attacks or strokes.

Table 18.2 The Risk Factors for Cardiovascular Disease

2. Leading Causes of Death. CDC.gov. https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm. Updated March 17, 2017. Accessed April 15, 2018.

Unmodifiable Risk Factors	Modifiable Risk Factors
• Age. Risk increases for men at forty-five, and for women at fifty-five. • Sex. Men have a higher risk than women, though the risk for women steeply rises after menopause. • Family history. The more family members who have heart disease, the greater the risk.	• Cigarette smoking. Nicotine constricts blood vessels, and carbon monoxide damages their inner lining, which increases the risk of atherosclerosis. • Obesity. Excess weight worsens other risk factors. • Diabetes. This condition is associated with an increased risk of heart disease. Both types have certain risk factors in common, including obesity and high blood pressure. • Physical inactivity. Lack of exercise is associated with heart disease. • Cholesterol levels. High levels of blood cholesterol can increase the risk. A high level of low-density lipoprotein (LDL), or the "bad" cholesterol, is a common contributing factor. However, a low level of high-density lipoprotein (HDL), or "good" cholesterol, can also promote atherosclerosis.

Steps to Reducing the Risk of Cardiovascular Disease

Diet and nutrition can play a significant role in reducing the risk of cardiovascular disease. It is helpful to lower sodium intake, increase consumption of dietary fiber, and limit consumption of saturated fat, which promotes plaque formation. In addition, it is important to replace refined starches and added sugar, which can boost triglycerides, with whole grains, fruits, and vegetables. Eating foods rich in omega-3 fatty acids, especially fish, using alcohol in moderation, and opting for low or no-fat dairy products can all help reduce your cardiovascular disease risk. Emphasizing vegetable-based sources of protein, such as beans and legumes, can be

beneficial, as well as consuming more soy products. It is also important to maintain a healthy weight and avoid smoking or chewing tobacco.

Hypertension

Chronic high blood pressure, also known as hypertension, is a significant health hazard affecting one out of three adults in the United States.[3] This chronic condition is a major cause of heart attacks and strokes, yet it has no symptoms until blood pressure reaches very high levels, which is why it is known as "the silent killer." The only way to find out if you have high blood pressure is to get an accurate reading of your resting blood pressure rate, which is best done by a medical professional and should be monitored regularly.

High blood pressure is such an important factor in cardiovascular disease, that keeping it within a healthy range is vitally important. Blood pressure readings consist of two numbers. The top number measures systolic pressure (when the heart contracts) and the bottom number measures diastolic pressure (when the heart is at rest). The key blood pressure numbers to keep in mind are:

- Ideal. 120 over 80 or below
- Prehypertension. Higher than 120 over 80 and lower than 139 over 89
- Hypertension. Greater than 139 over 89

Table 18.3 The Risk Factors for Hypertension

3. High Blood Pressure Facts. Center for Disease Control and Prevention. https://www.cdc.gov/bloodpressure/facts.htm. Updated April 5, 2018. Accessed April 15, 2018.

Unmodifiable Risk Factors	Modifiable Risk Factors
• Age. After fifty-five, the risk of developing high blood pressure is 90 percent. • Race. African-Americans are more likely to develop hypertension, manifest it at a younger age, and have higher blood pressure readings. • Family history. There is a strong genetic component to high blood pressure, and an individual's risk goes up along with the number of family members who have hypertension.	• Weight. Roughly 60 percent of people with hypertension are obese. • Sodium consumption. The more salt in a person's diet, the more likely they are to have high blood pressure. • Alcohol. Drinking more than two drinks per day for men and one drink for women increases the likelihood of hypertension. • Diet. In addition to salt and alcohol consumption, other dietary factors increase chances of developing hypertension.

Steps to Reducing the Risk of High Blood Pressure

Although it is not possible to change one's age or genetics, there are actions that people can take to decrease their risk of hypertension. Techniques to reduce blood pressure include becoming physically active, maintaining a healthy weight, reducing sodium intake below 2,400 milligrams per day (or below 1,500 milligrams if you are in a high-risk group or already have been diagnosed with hypertension), using alcohol moderately, and following the DASH diet. Additionally, vitamin C, calcium, and potassium have all been shown to promote healthy blood pressure. It is also vital to monitor your blood pressure levels on a regular basis. Prompt intervention when readings rise above the ideal level (120 over 80) can save lives, which is why everyone should know the status of their blood pressure.

Cancer

More than one hundred diseases are classified as different forms of cancer, all of them characterized by the uncontrolled growth of abnormal cells. Cancer is triggered by mutations in a cell's genetic material. The cause of these changes may be inherited, or it may result from exposure to carcinogens, which are agents that can cause cancer. Carcinogens include chemicals, viruses, certain medical treatments such as radiation, pollution, or other substances and exposures that are known or suspected to cause cancer.[4] The National Institutes of Health has classified fifty-four different compounds as known cancer-causing agents in humans.[5]

Under normal conditions, a healthy cell will either repair any damage that has been done or self destruct so that no future cells will be affected. Cells become cancerous when their DNA is damaged, but they do not self-destruct or stop reproducing as normal cells would. As these abnormal cells continue their rapid growth, in most cancers they coalesce in a mass called a tumor. Cancer cells can overwhelm healthy cells and interfere with the

4. Known and Probable Human Carcinogens. American Cancer Society.http://www.cancer.org/Cancer/CancerCauses/OtherCarcinogens/GeneralInformationaboutCarcinogens/known-and-probable -human-carcinogens. Updated November 3, 2016. Accessed April 15, 2018.
5. Israel B. How Many Cancers Are Caused by the Environment?. https://www.scientificamerican.com/article/how-many-cancers-are-caused-by-the-environment. Published May 10, 2010. Accessed April 15, 2018.

healthy functioning of the body. They can also invade other organs and spread throughout the body in a process known as metastasis. Scientists and the medical community are giving considerable attention to the early stages of cancer, from the moment a healthy cell is exposed to a carcinogen to the point where cells with damaged DNA are replicating out of control. Intervention at any of these early stages could prove to be quite beneficial, because it is thought that most cancers are the result of lifestyle choices and environmental exposure.

The risk factors for different cancers can vary. For example, exposure to ultraviolet radiation from the sun and from tanning beds is a risk factor for skin cancer, while exposure to asbestos is a risk factor for mesothelioma cancer. Table 18.4 "The Risk Factors for Cancer" shows some common risk factors for a number of different types of cancer.

Table 18.4 The Risk Factors for Cancer

Unmodifiable Risk Factors	Modifiable Risk Factors
• Age. Most cancers occur in people over the age of sixty-five. However, people of all ages, including children, can get cancer. • Family history. Certain types of cancer have a genetic link. However, environmental factors may also play a part.	• Tobacco. Smoking or chewing tobacco greatly increases the risk for certain cancers, including cancer of the lungs, bladder, cervix, kidneys, mouth, and pancreas. • Alcohol. Drinking alcohol is linked to cancers of the mouth, throat, esophagus, and breast, as well as to cancers of the neck and head. • Obesity. Linked to cancers of the colon, uterus, pancreas, esophagus, kidney, and breast. • Cooking techniques. Grilling, smoking, and preparing meat at high temperatures forms carcinogens. • Red meat. The risk of colon cancer seems to increase with the consumption of red meat and processed meat. • Cured meats. According to a recent study, there is a mild risk of pancreatic cancer with the consumption of cured meats, such as sausage, pepperoni, bacon, ham, smoked turkey, salami, and hot dogs. • Physical inactivity. Linked to colon, breast, and other cancers. • Exposure to chemicals. People who have jobs that expose them to chemicals on a regular basis, such as construction workers and painters, have an increased risk of cancer. • Viruses or bacteria. Certain viruses or bacteria may increase the risk of developing cancer. For example, human papillomaviruses, which are sexually transmitted, are the primary cause of cervical cancer.

Steps to Reducing the Risk of Cancer

According to the American Cancer Society, half of all American men and one-third of American women will be diagnosed with some

form of cancer in their lifetime.[6] Although cancer is one of the leading causes of death worldwide, ongoing research and innovations in treatment have improved the outlook for cancer patients to the point where millions now survive or live with cancer, making it a chronic disease.

The American Institute for Cancer Research (AICR) has published guidelines for preventing cancer and staying healthy. They include several dietary and lifestyle choices, such as participating in physical activity for thirty minutes per day or more, and maintaining a healthy weight. In addition, AICR recommends consuming a plant-based diet.[7]

Several epidemiological studies have found a link between eating plenty of fruits and vegetables and a low incidence of certain cancers. Fruits and vegetables containing a wide variety of nutrients and phytochemicals may either prevent or reduce the oxidative damage to cell structures. Cruciferous vegetables, such as cauliflower, broccoli, and Brussels sprouts, may also reduce the risk of certain cancers, such as endometrial, esophageal, and others. Also, studies have shown that the more fiber you have in your diet, the lower your risk of colon cancer.

6. What Is Cancer? American Cancer Society. http://www.cancer.org/Cancer/CancerBasics/what-is-cancer. Updated December 8, 2015. Accessed April 15, 2018.
7. Cancer Prevention and Early Detection Facts and Figures 2013. American Cancer Society. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/cancer-prevention-and-early-detection-facts-and-figures/cancer-prevention-and-early-detection-facts-and-figures-2013.pdf. Published 2013. Accessed April 15, 2018.

Supplementation may also be helpful to a limited degree. Vitamin D and antioxidants have been linked to lowering the risk of some cancers (however taking an iron supplement may promote others), but, obtaining vital nutrients from food first is the best way to help prevent or manage cancer. In addition, regular and vigorous exercise can lower the risk of breast and colon cancers, among others. Also, wear sunblock, stay in the shade, and avoid the midday sun to protect yourself from skin cancer, which is one of the most common kinds of cancer.[8]

Diabetes

What Is Diabetes?

Diabetes is one of the top three diseases in America. It affects millions of people and causes tens of thousands of deaths each year. Diabetes is a metabolic disease of insulin deficiency and glucose over-sufficiency. Like other diseases, genetics, nutrition, environment, and lifestyle are all involved in determining a person's risk for developing diabetes. One sure way to decrease your chances of getting diabetes is to maintain an optimal body weight by adhering to a diet that is balanced in carbohydrate, fat, and protein intake. There are three different types of diabetes: Type 1 diabetes, Type 2 diabetes, and gestational diabetes.

8. Cancer Prevention: 7 Steps to Reduce Your Risk. Mayo Clinic. http://www.mayoclinic.com/health/cancer-prevention/CA00024. Updated November 29, 2017. Accessed April 15, 2018.

Type 1 Diabetes

Type 1 diabetes is a metabolic disease in which insulin-secreting cells in the pancreas are killed by an abnormal response of the immune system, causing a lack of insulin in the body. Its onset typically occurs before the age of thirty. The only way to prevent the deadly symptoms of this disease is to inject insulin under the skin.

A person with Type 1 diabetes usually has a rapid onset of symptoms that include hunger, excessive thirst and urination, and rapid weight loss. Because the main function of glucose is to provide energy for the body, when insulin is no longer present there is no message sent to cells to take up glucose from the blood. Instead, cells use fat and proteins to make energy, resulting in weight loss. If Type 1 diabetes goes untreated individuals with the disease will develop a life-threatening condition called ketoacidosis. This condition occurs when the body uses fats and not glucose to make energy, resulting in a build-up of ketone bodies in the blood. It is a severe form of ketosis with symptoms of vomiting, dehydration, rapid breathing, and confusion and eventually coma and death. Upon insulin injection these severe symptoms are treated and death is avoided. Unfortunately, while insulin injection prevents death, it is not considered a cure. People who have this disease must adhere to a strict diet to prevent the development of serious complications. Type 1 diabetics are advised to consume a diet low in the types of carbohydrates that rapidly spike glucose levels (high-GI foods), to count the carbohydrates they eat, to consume healthy-carbohydrate foods, and to eat small meals frequently. These guidelines are aimed at preventing large fluctuations in blood glucose. Frequent exercise also helps manage blood-glucose levels. Type 1 diabetes accounts for between 5 and 10 percent of diabetes cases.

Type 2 Diabetes

The other 90 to 95 percent of diabetes cases are Type 2 diabetes. Type 2 diabetes is defined as a metabolic disease of insulin insufficiency, but it is also caused by muscle, liver, and fat cells no longer responding to the insulin in the body (Figure 18.4 “Healthy Individuals and Type 2 Diabetes” . In brief, cells in the body have become resistant to insulin and no longer receive the full physiological message of insulin to take up glucose from the blood. Thus, similar to patients with Type 1 diabetes, those with Type 2 diabetes also have high blood-glucose levels.

Figure 18.4 Healthy Individuals and Type 2 Diabetes

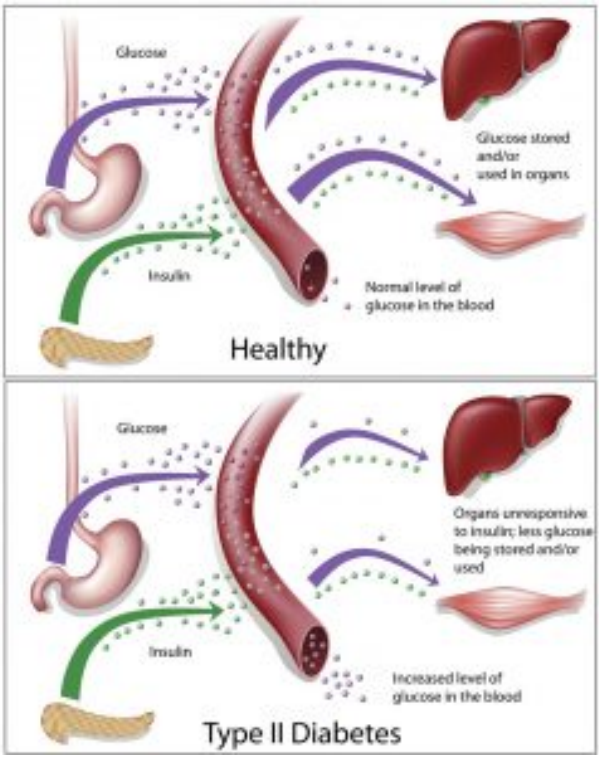

Image by Allison Calabrese / CC BY 4.0

For Type 2 diabetics, the onset of symptoms is more gradual and less noticeable than for Type 1 diabetics. The first stage of Type 2 diabetes is characterized by high glucose and insulin levels. This is because the insulin-secreting cells in the pancreas attempt to compensate for insulin resistance by making more insulin. In the second stage of Type 2 diabetes, the insulin-secreting cells in the pancreas become exhausted and die. At this point, Type 2 diabetics also have to be treated with insulin injections. Healthcare providers is to prevent the second stage from happening. As with Type 1 diabetes, chronically high-glucose levels cause big detriments to health over time, so another goal for patients with Type 2 diabetes is to properly manage their blood-glucose levels. The front-line approach for treating Type 2 diabetes includes eating a healthy diet and increasing physical activity.

The Centers for Disease Control Prevention (CDC) estimates that as of 2010, 25.8 million Americans have diabetes, which is 8.3 percent of the population.[9] In 2007 the cost of diabetes to the United States was estimated at $174 billion.[10] The incidence of Type 2 diabetes has more than doubled in America in the past thirty years and the rise is partly attributed to the increase in obesity in this country. Genetics, environment, nutrition, and lifestyle all play a role in determining a person's risk for Type 2 diabetes. We have the power to change some of the determinants of disease but

9. Diabetes Research and Statistics.Centers for Disease Control and Prevention. https://www.cdc.gov/diabetes/data/index.html. Updated March 14, 2018. Accessed April 15, 2018.
10. Diabetes Quick Facts. Centers for Disease Control and Prevention. https://www.cdc.gov/diabetes/basics/quick-facts.html. Updated July 24, 2017. Accessed April 15, 2018.

not others. The Diabetes Prevention Trial that studied lifestyle and drug interventions in more than three thousand participants who were at high risk for Type 2 diabetes found that intensive lifestyle intervention reduced the chances of getting Type 2 diabetes by 58 percent.[11]

Gestational Diabetes

During pregnancy some women develop gestational diabetes. Gestational diabetes is characterized by high blood-glucose levels and insulin resistance. The exact cause is not known but does involve the effects of pregnancy hormones on how cells respond to insulin. Gestational diabetes can cause pregnancy complications and it is common practice for healthcare practitioners to screen pregnant women for this metabolic disorder. The disorder normally ceases when the pregnancy is over, but the National Diabetes Information Clearing House notes that women who had gestational diabetes have between a 40 and 60 percent likelihood of developing Type 2 diabetes within the next ten years.[12] Gestational diabetes not only affects the health of a pregnant woman but also is associated with an increased risk of obesity and Type 2 diabetes in her child.

11. Knowler WC. (2002). Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin. The New *England Journal of Medicine*, 346(6), 393–403. http://www.nejm.org/doi/full/10.1056/NEJMoa012512. Accessed April 15, 2018.
12. Diabetes Overview. National Institute of Diabetes and Digestive and Kidney Disease. https://www.niddk.nih.gov/health-information/diabetes/overview. Accessed April 15, 2018.

Prediabetes

As the term infers, prediabetes is a metabolic condition in which people have moderately high glucose levels, but do not meet the criteria for diagnosis as a diabetic. Over seventy-nine million Americans are prediabetic and at increased risk for Type 2 diabetes and cardiovascular disease.[13] The National Diabetes Information Clearing House reports that 35 percent of adults aged twenty and older, and 50 percent of those over the age of sixty-five have prediabetes.[14]

Long-Term Health Consequences of Diabetes

The long-term health consequences of diabetes are severe. They are the result of chronically high glucose concentrations in the blood accompanied by other metabolic abnormalities such as high blood-lipid levels. People with diabetes are between two and four times more likely to die from cardiovascular disease. Diabetes is the number one cause of new cases of blindness, lower-limb amputations, and kidney failure. Many people with diabetes develop peripheral neuropathy, characterized by muscle weakness, loss of feeling and pain in the lower extremities. More recently, there is

13. Diabetes Overview. National Institute of Diabetes and Digestive and Kidney Disease. https://www.niddk.nih.gov/health-information/diabetes/overview. Accessed April 15, 2018.
14. Diabetes Overview. National Institute of Diabetes and Digestive and Kidney Disease. https://www.niddk.nih.gov/health-information/diabetes/overview. Accessed April 15, 2018.

scientific evidence to suggest people with diabetes are also at increased risk for Alzheimer's disease.

Diabetes Treatment

Keeping blood-glucose levels in the target range (70–130 mg/dL before a meal) requires careful monitoring of blood-glucose levels with a blood-glucose meter, strict adherence to a healthy diet, and increased physical activity. Type 1 diabetics begin insulin injections as soon as they are diagnosed. Type 2 diabetics may require oral medications and insulin injections to maintain blood-glucose levels in the target range. The symptoms of high blood glucose, also called hyperglycemia, are difficult to recognize, diminish in the course of diabetes, and are mostly not apparent until levels become very high. The symptoms are increased thirst and frequent urination. Having too low blood glucose levels, known as hypoglycemia, is also detrimental to health. Hypoglycemia is more common in Type 1 diabetics and is most often caused by injecting too much insulin or injecting it at the wrong time. The symptoms of hypoglycemia are more acute including shakiness, sweating, nausea, hunger, clamminess, fatigue, confusion, irritability, stupor, seizures, and coma. Hypoglycemia can be rapidly and simply treated by eating foods containing about ten to twenty grams of fast-releasing carbohydrates. If symptoms are severe a person is either treated by emergency care providers with an intravenous solution of glucose or given an injection of glucagon, which mobilizes glucose from glycogen in the liver. Some people who are not diabetic may experience reactive hypoglycemia. This is a condition in which people are sensitive to the intake of sugars, refined starches, and high GI foods. Individuals with reactive hypoglycemia have some symptoms of hypoglycemia. Symptoms are caused by a higher than normal increase in blood-insulin levels. This rapidly decreases blood-glucose levels to a level below what is required for proper brain function.

The major determinants of Type 2 diabetes that can be changed are overnutrition and a sedentary lifestyle. Therefore, reversing or improving these factors by lifestyle interventions markedly improve the overall health of Type 2 diabetics and lower blood-glucose levels. In fact it has been shown that when people are overweight, losing as little as nine pounds (four kilograms) decreases blood-glucose levels in Type 2 diabetics. The Diabetes Prevention Trial demonstrated that by adhering to a diet containing between 1,200 and 1,800 kilocalories per day with a dietary fat intake goal of less than 25 percent and increasing physical activity to at least 150 minutes per week, people at high risk for Type 2 diabetes achieved a weight loss of 7 percent and significantly decreased their chances of developing Type 2 diabetes.[15]

The American Diabetes Association (ADA) has a website that provides information and tips for helping diabetics answer the question, "What Can I Eat". In regard to carbohydrates the ADA recommends diabetics keep track of the carbohydrates they eat and set a limit. These dietary practices will help keep blood-glucose levels in the target range.

Figure 18.5 Metabolic Syndrome: A Combination of Risk Factors Increasing the Chances for Chronic Disease

15. Knowler WC. (2002). Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin. *The New England Journal of Medicine*, 346(6), 393–403. http://www.nejm.org/doi/full/10.1056/NEJMoa012512. Accessed April 15, 2018.

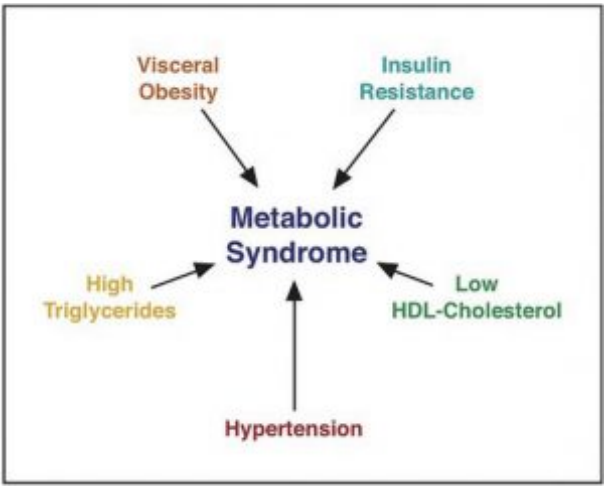

Image by Allison Calabrese / CC BY 4.0

Having more than one risk factor for Type 2 diabetes substantially increases a person's chances for developing the disease. Metabolic syndrome refers to a medical condition in which people have three or more risk factors for Type 2 diabetes and cardiovascular disease. According to the International Diabetes Federation (IDF) people are diagnosed with this syndrome if they have central (abdominal) obesity and any two of the following health parameters: triglycerides greater than 150 mg/dL; high density lipoproteins (HDL) lower than 40 mg/dL; systolic blood pressure above 100 mmHg, or diastolic above 85 mmHg; fasting blood-glucose levels greater than 100 mg/dL.[16] The IDF estimates that between 20 and

16. The IDF Consensus Worldwide Definition of the Metabolic Syndrome. International Diabetes Federation.https://www.idf.org/our-activities/advocacy-awareness/resources-and-tools/

25 percent of adults worldwide have metabolic syndrome. Studies vary, but people with metabolic syndrome have between a 9 and 30 times greater chance for developing Type 2 diabetes than those who do not have the syndrome.[17]

Everyday Connection

In 2010, the Pacific Islands Health Officers Association declared a regional state of health emergency for the epidemic of chronic diseases in the United States Affiliated Pacific (USAP). Due to the high risk factors that many of these Pacific Islanders, the leading cause of mortality of adults in the USAP from chronic diseases. To learn more about this declaration, visit http://www.pihoa.org/fullsite/newsroom/wp-content/uploads/downloads/2012/06/NCD_Emergency_Declaration.pdf

60:idfconsensus-worldwide-definitionof-the-metabolic-syndrome.html. Accessed April 15, 2018.

17. The IDF Consensus Worldwide Definition of the Metabolic Syndrome. International Diabetes Federation.https://www.idf.org/our-activities/advocacy-awareness/resources-and-tools/60:idfconsensus-worldwide-definitionof-the-metabolic-syndrome.html. Accessed April 15, 2018.

Disease Prevention and Management

Eating fresh, healthy foods not only stimulates your taste buds, but also can improve your quality of life and help you to live longer. As discussed, food fuels your body and helps you to maintain a healthy weight. Nutrition also contributes to longevity and plays an important role in preventing a number of diseases and disorders, from obesity to cardiovascular disease. Some dietary changes can also help to manage certain chronic conditions, including high blood pressure and diabetes. A doctor or a nutritionist can provide guidance to determine the dietary changes needed to ensure and maintain your health.

Learning Activities

Technology Note: The second edition of the Human Nutrition Open Educational Resource (OER) textbook features interactive learning activities. These activities are available in the web-based textbook and not available in the downloadable versions (EPUB, Digital PDF, Print_PDF, or Open Document).

Learning activities may be used across various mobile devices, however, for the best user experience it is strongly recommended that users complete these activities using a desktop or laptop computer and in Google Chrome.

An interactive or media element has been excluded from this version of the text. You can view it online here:
http://pressbooks.oer.hawaii.edu/humannutrition2/?p=566

Undernutrition, Overnutrition, and Malnutrition

UNIVERSITY OF HAWAIʻI AT MĀNOA FOOD SCIENCE AND HUMAN NUTRITION PROGRAM AND HUMAN NUTRITION PROGRAM

For many, the word "malnutrition" produces an image of a child in a third-world country with a bloated belly, and skinny arms and legs. However, this image alone is not an accurate representation of the state of malnutrition. For example, someone who is 150 pounds overweight can also be malnourished.

Malnutrition refers to one not receiving proper nutrition and does not distinguish between the consequences of too many nutrients or the lack of nutrients, both of which impair overall health. Undernutrition is characterized by a lack of nutrients and insufficient energy supply, whereas overnutrition is characterized by excessive nutrient and energy intake. Overnutrition can result in obesity, a growing global health threat. Obesity is defined as a metabolic disorder that leads to an overaccumulation of fat tissue.

Although not as prevalent in America as it is in developing countries, undernutrition is not uncommon and affects many subpopulations, including the elderly, those with certain diseases, and those in poverty. Many people who live with diseases either have no appetite or may not be able to digest food properly. Some medical causes of malnutrition include cancer, inflammatory bowel syndrome, AIDS, Alzheimer's disease, illnesses or conditions that cause chronic pain, psychiatric illnesses, such as anorexia nervosa, or as a result of side effects from medications. Overnutrition is an epidemic in the United States and is known to be a risk factor for many diseases, including Type 2 diabetes, cardiovascular disease, inflammatory disorders (such as rheumatoid arthritis), and cancer.

Health Risks of Being Underweight

The 2003–2006 National Health and Nutrition Examination Survey (NHANES) estimated that 1.8 percent of adults and 3.3 percent of children and adolescents in the United States are underweight.[1]

Being underweight is linked to nutritional deficiencies, especially iron-deficiency anemia, and to other problems such as delayed wound healing, hormonal abnormalities, increased susceptibility to infection, and increased risk of some chronic diseases such as osteoporosis. In children, being underweight can stunt growth. The most common underlying cause of underweight in America is inadequate nutrition. Other causes are wasting diseases, such as cancer, multiple sclerosis, tuberculosis, and eating disorders. People with wasting diseases are encouraged to seek nutritional counseling, as a healthy diet greatly affects survival and improves responses to disease treatments. Eating disorders that result in underweight affect about eight million Americans (seven million women and one million men).

Anorexia Nervosa

Anorexia nervosa, more often referred to as "anorexia," is a psychiatric illness in which a person obsesses about their weight

1. Prevalence of Underweight among Children and Adolescents: United States, 2003–2006. Centers for Disease Control and Prevention. http://www.cdc.gov/nchs/data/hestat/underweight/underweight_children.htm. Updated November 6, 2015. Accessed April 15, 2018.

and about food that they eat. Anorexia results in extreme nutrient inadequacy and eventually to organ malfunction. Anorexia is relatively rare—the National Institute of Mental Health (NIMH) reports that 0.9 percent of females and 0.3 percent of males will have anorexia at some point in their lifetime, but it is an extreme example of how an unbalanced diet can affect health.[2]

Anorexia frequently manifests during adolescence and it has the highest rate of mortality of all mental illnesses. People with anorexia consume, on average, fewer than 1,000 kilocalories per day and exercise excessively. They are in a tremendous caloric imbalance. Moreover, some may participate in binge eating, self-induced vomiting, and purging with laxatives or enemas. The very first time a person starves him- or herself may trigger the onset of anorexia. The exact causes of anorexia are not completely known, but many things contribute to its development including economic status, as it is most prevalent in high-income families. It is a genetic disease and is often passed from one generation to the next. Pregnancy complications and abnormalities in the brain, endocrine system, and immune system may all contribute to the development of this illness.

The primary signs of anorexia are fear of being overweight, extreme dieting, an unusual perception of body image, and depression. The secondary signs and symptoms of anorexia are all related to the caloric and nutrient deficiencies of the unbalanced diet and include excessive weight loss, a multitude of skin abnormalities, diarrhea, cavities and tooth loss, osteoporosis, and liver, kidney, and heart failure. There is no physical test that can be used to diagnose anorexia and distinguish it from other mental

2. Eating Disorders. The National Institute of Mental Health. https://www.nimh.nih.gov/health/statistics/eating-disorders.shtml#part_155061. Accessed April 15, 2018.

illnesses. Therefore a correct diagnosis involves eliminating other mental illnesses, hormonal imbalances, and nervous system abnormalities. Eliminating these other possibilities involves numerous blood tests, urine tests, and x-rays. Coexisting organ malfunction is also examined. Treatment of any mental illness involves not only the individual, but also family, friends, and a psychiatric counselor. Treating anorexia also involves a dietitian, who helps to provide dietary solutions that often have to be adjusted over time. The goals of treatment for anorexia are to restore a healthy body weight and significantly reduce the behaviors associated with causing the eating disorder. Relapse to an unbalanced diet is high. Many people do recover from anorexia, however most continue to have a lower-than-normal body weight for the rest of their lives.

Bulimia Nervosa

Bulimia nervosa, like anorexia, is a psychiatric illness that can have severe health consequences. The NIMH reports that 0.5 percent of females and 0.1 percent of males will have bulimia nervosa, or otherwise known as bulimia, at some point in their lifetime.[3]

Bulimia is characterized by episodes of eating large amounts of food followed by purging, which is accomplished by vomiting and with the use of laxatives and diuretics. Unlike people with anorexia, those with bulimia often have a normal weight, making the disorder more difficult to detect and diagnose. The disorder is characterized

3. Eating Disorders. The National Institute of Mental Health. https://www.nimh.nih.gov/health/statistics/eating-disorders.shtml#part_155061. Accessed April 15, 2018.

by signs similar to anorexia such as fear of being overweight, extreme dieting, and bouts of excessive exercise. Secondary signs and symptoms include gastric reflux, severe erosion of tooth enamel, dehydration, electrolyte imbalances, lacerations in the mouth from vomiting, and peptic ulcers. Repeated damage to the esophagus puts people with bulimia at an increased risk for esophageal cancer. The disorder is also highly genetic, linked to depression and anxiety disorders, and most commonly occurs in adolescent girls and young women. Treatment often involves antidepressant medications and, like anorexia, has better results when both the family and the individual with the disorder participate in nutritional and psychiatric counseling.

Binge-Eating Disorder

Similar to those who experience anorexia and bulimia, people who have a binge-eating disorder have lost control over their eating. Binge-eating disorder is not currently diagnosed as a distinct psychiatric illness, although there is a proposal from the American Psychiatric Association to categorize it more specifically. People with binge-eating disorder will periodically overeat to the extreme, but their loss of control over eating is not followed by fasting, purging, or compulsive exercise. As a result, people with this disorder are often overweight or obese, and their chronic disease risks are those linked to having an abnormally high body weight such as hypertension, cardiovascular disease, and Type 2 diabetes. Additionally, they often experience guilt, shame, and depression. Binge-eating disorder is commonly associated with depression and anxiety disorders. According to the NIMH, binge-eating disorder is more prevalent than anorexia and bulimia, and affects 3.5 percent of females and 2.0 percent of males at some point during their

lifetime.[4] Treatment often involves antidepressant medication as well as nutritional and psychiatric counseling.

Orthorexia Nervosa

Orthorexia nervosa was coined in 1997 by physician Steven Bratman.[5] The term uses "ortho," in its meaning as straight, correct and true and refers to a fixation on eating proper food.[6] Fixation on 'healthy eating' by those with orthorexia nervosa often results in behaviors that end up damaging one's well-being such as extreme weight loss or a refusal to dine out with friends. Orthorexia nervosa like anorexia nervosa involves restriction of the amount and variety of foods eaten, however those with orthorexia nervosa do not have

4. Eating Disorders. The National Institute of Mental Health. https://www.nimh.nih.gov/health/statistics/eating-disorders.shtml#part_155061. Accessed April 15, 2018.
5. Mathieu J.(2005). What is orthorexia? *Journal of the American Dietetic Association*, 105(10), 1510-1512. Bratman, S. Health Food Junkie. Yoga Journal. 1997, September/October, 42-50. Available at https://www.orthorexia.com/original-orthorexia-essay/.
6. Donini LM, Marsili D, Graziani MP, Imbriale M, Cannella C. (2004). Orthorexia nervosa: a preliminary study with a proposal for diagnosis and an attempt to measure the dimension of the phenomenon. *Eating and Weight Disorders*, 9(2), 151-157.

an incessant fear of weight gain but instead have an obsession with "feeling pure, healthy and natural."[7] People affected by orthorexia nervosa tend to follow diets tied to a philosophy or theory and believe that their theory of eating is the best.[8] [9] Such diets often have a redemptive quality that involves denying oneself of "bad" or "wrong" foods.[10] In extreme cases, affected individuals may also fear contamination or harm from water and electricity leading them to use filters to purify their environment from electrical emissions.

7. Mathieu J. (2005). What is orthorexia? *Journal of the American Dietetic Association*, 105(10), 1510-1512. Bratman, S. Health Food Junkie. Yoga Journal. 1997, September/October, 42-50. Available at https://www.orthorexia.com/original-orthorexia-essay/.
8. Donini LM, Marsili D, Graziani MP, Imbriale M, Cannella C. (2004). Orthorexia nervosa: a preliminary study with a proposal for diagnosis and an attempt to measure the dimension of the phenomenon. *Eating and Weight Disorders*, 9(2), 151-157.
9. *Orthorexia.* (2017, February 26). National Eating Disorders Association. https://www.nationaleatingdisorders.org/learn/by-eating-disorder/other/orthorexia
10. Mathieu J. (2005). What is orthorexia? *Journal of the American Dietetic Association*, 105(10), 1510-1512. Bratman, S. Health Food Junkie. Yoga Journal. 1997, September/October, 42-50. Available at https://www.orthorexia.com/original-orthorexia-essay/.

Orthorexia nervosa has similar physical consequences to anorexia nervosa despite the lack of motivation for weight loss by affected individuals.

Although awareness of orthorexia nervosa is increasing, it is not formally recognized in the Diagnostic Statistical Manual and thus it is difficult to get an estimate of how many persons are affected by orthorexia nervosa. Additionally, the lack of formal diagnostic criteria makes it impossible to know if orthorexia nervosa occurs with other types of existing disorders like anorexia or a form of obsessive-compulsive disorder (OCD) or if it's a stand-alone eating disorder. Studies show that many persons with orthorexia nervosa also have OCD. Many experts view orthorexia nervosa as a variety of anorexia or OCD. Treatment usually involves psychotherapy and weight restoration as needed.[11] OCD may be a consequence of malnutrition, being underweight and a starved brain thus weight restoration may resolve the OCD.

Warning signs and symptoms of orthorexia nervosa:[12]

- Compulsive checking of ingredients lists and nutritional labels
- An increased concern about the health of ingredients
- Cutting out an increasing number of food groups such as all sugars, all carbohydrates, all dairy or all animal products
- An inability to eat anything but a narrow group of foods that are deemed 'healthy' or 'pure'

11. *Orthorexia*. (2017, February 26). National Eating Disorders Association. https://www.nationaleatingdisorders.org/learn/by-eating-disorder/other/orthorexia
12. *Orthorexia*. (2017, February 26). National Eating Disorders Association. https://www.nationaleatingdisorders.org/learn/by-eating-disorder/other/orthorexia

- Unusual interest in the health of what others are eating
- Spending hours per day thinking about what food might be served at upcoming events
- Showing high levels of distress when 'safe' or 'healthy' foods are not available
- Obsessive following of food and 'healthy lifestyle' blogs on social media
- Body image concerns may or may not present

The Healing Process

With all wounds, from a paper cut to major surgery, the body must heal itself. Healing is facilitated through proper nutrition while malnutrition inhibits and complicates this vital process. The following nutrients are important for proper healing:[13]

- Vitamin A. Helps to enable the epithelial tissue (the thin outer layer of the body and the lining that protects your organs) and bone cells form.
- Vitamin C. Helps form collagen, an important protein in many body tissues.
- Protein. Facilitates tissue formation.
- Fats. Play a key role in the formation and function of cell membranes.
- Carbohydrates. Fuel cellular activity, supplying needed energy to support the inflammatory response that promotes healing.

13. MacKay D, Miller AL. (2003). Nutritional Support for Wound Healing. *Alternative Medicine Review*, 8(4), 359–77. https://www.ncbi.nlm.nih.gov/pubmed/14653765. Accessed April 15, 2018.

Learning Activities

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Food Insecurity

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Addressing Hunger

Government agencies also play an important role in addressing hunger via federal food-assistance programs. The agencies provide debit cards (formerly distributed in the form of food vouchers or food stamps) to consumers to help them purchase food and they also provide other forms of aid to low-income adults and families who face hunger and nutritional deficits. This topic will be discussed in greater detail later in this chapter.

Hunger relates to appetite and is the body's response to a need for nourishment. Through stomach discomfort or intestinal rumbling, the body alerts the brain that it requires food. This uneasy sensation is easily addressed with a snack or a full meal. However, the term "hunger" also relates to a weakened condition that is a consequence of a prolonged lack of food. People who suffer from this form of hunger typically experience malnourishment, along with poor growth and development.

Hunger

Adequate food intake that meets nutritional requirements is essential to achieve a healthy, productive lifestyle. However, millions of people in North America, not to mention globally, go hungry and are malnourished each year due to a recurring and involuntary lack

of food. The economic crisis of 2008 caused a dramatic increase in hunger across the United States.[1]

In 2010, 925 million people around the world were classified as hungry. Although this was a decrease from a historic high of more than one billion people from the previous year, it is still an unbearable number. Every night, millions and millions of people go to sleep hungry due to a lack of the money or resources needed to acquire an adequate amount of food. This graph shows the division of hungry people around the globe. A number of terms are used to categorize and classify hunger. Two key terms, food security and food insecurity, focus on status and affect hunger statistics. Another term, malnutrition, refers to the deficiencies that a hungry person experiences.

Food Security

Most American households are considered to be food secure, which means they have adequate access to food and consume enough nutrients to achieve a healthy lifestyle. However, a minority of US households experiences food insecurity at certain points during the year, which means their access to food is limited due to a lack of money or other resources. This graphic shows the percentage of food-secure and food-insecure households in the United States during the year 2010.

1. Hunger in America: 2016 United States Hunger and Poverty Facts. World Hunger Education Service. Retrieved from http://www.worldhunger.org/articles/Learn/us_hunger_facts.htm. Accessed April 15, 2018.

Food Insecurity

Food insecurity is defined as not having adequate access to food that meets nutritional needs. According to the USDA, about 48.8 million people live in food-insecure households and have reported multiple indications of food access problems. About sixteen million of those have "very low food security," which means one or more people in the household were hungry at some point over the course of a year due to the inability to afford enough food. The difference between low and very low food security is that members of low insecurity households have reported problems of food access, but have reported only a few instances of reduced food intake, if any.[2] African American and Hispanic households experience food insecurity at much higher rates than the national average.[3]

Households with limited resources employ a variety of methods to increase their access to adequate food. Some families purchase junk food and fast food—cheaper options that are also very unhealthy. Other families who struggle with food security supplement the groceries they purchase by participating in government assistance

2. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture, Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.
3. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture, Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.

programs. They may also obtain food from emergency providers, such as food banks and soup kitchens in their communities.

Malnutrition

A person living in a food-insecure household may suffer from malnutrition, which results from a failure to meet nutrient requirements. This can occur as a result of consuming too little food or not enough key nutrients. There are two basic types of malnutrition. The first is macronutrient deficiency and relates to the lack of adequate protein, which is required for cell growth, maintenance, and repair. The second type of malnutrition is micronutrient deficiency and relates to inadequate vitamin and mineral intake.[4] Even people who are overweight or obese can suffer from this kind of malnutrition if they eat foods that do not meet all of their nutritional needs.

Worldwide, three main groups are most at risk of hunger: the rural poor in developing nations who also lack access to electricity and safe drinking water, the urban poor who live in expanding cities and lack the means to buy food, and victims of earthquakes, hurricanes, and other natural and man-made catastrophes.[5]

4. Hunger in America: 2016 United States Hunger and Poverty Facts. World Hunger Education Service. Retrieved from http://www.worldhunger.org/articles/Learn/us_hunger_facts.htm. Accessed April 15, 2018.
5. SOFI: Questions and Answers. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/a-BT851E.pdf. Accessed April 15, 208.

In the United States, there are additional subgroups that are at risk and are more likely than others to face hunger and malnutrition. They include low-income families and the working poor, who are employed but have incomes below the federal poverty level.

Senior citizens are also a major at-risk group. Many elderly people are frail and isolated, which affects their ability to meet their dietary requirements. In addition, many also have low incomes, limited resources, and difficulty purchasing or preparing food due to health issues or poor mobility. As a result, more than six million senior citizens in the United States face the threat of hunger.[6]

One of the groups that struggles with hunger are the millions of homeless people across North America. According to a recent study by the US Conference of Mayors, the majority of reporting cities saw an increase in the number of homeless families.[7] Hunger and homelessness often go hand-in-hand as homeless families and adults turn to soup kitchens or food pantries or resort to begging for food.

Rising hunger rates in the United States particularly affect children. Nearly one out of four children, or 21.6 percent of all American children, lives in a food-insecure household and spends at least part of the year hungry.[8] Hunger delays their growth and

6. About Meals on Wheels. Meals on Wheels. https://www.mealsonwheelsamerica.org/signup/aboutmealsonwheels. Accessed April 15, 2018.
7. Hunger and Homelessness Survey: A Status Report on Hunger and Homelessness in America's Cities, a 27-City Survey. The United States Conference of Mayors. https://endhomelessness.atavist.com/mayorsreport2016. Accessed April 15, 2018.
8. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture,

development and affects their educational progress because it is more difficult for hungry or malnourished students to concentrate in school. In addition, children who are undernourished are more susceptible to contracting diseases, such as measles and pneumonia.[9]

Government Programs

The federal government has established a number of programs that work to alleviate hunger and ensure that many low-income families receive the nutrition they require to live a healthy life. A number of programs were strengthened by the passage of the Healthy, Hunger-Free Kids Act of 2010. This legislation authorized funding and set the policy for several key core programs that provide a safety net for food-insecure children across the United States.

The federal poverty level (FPL) is used to determine eligibility for food-assistance programs. This monetary figure is the minimum amount that a family would need to acquire shelter, food, clothing, and other necessities. It is calculated based on family size and is adjusted for annual inflation. Although many people who fall below the FPL are unemployed, the working poor can qualify for food

Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.

9. 2011 World Hunger and Poverty Facts and Statistics. World Hunger Education Service.https://www.worldhunger.org/articles/Learn/old/world%20hunger%20facts%202002in2011.htm. Accessed April 15, 2018.

programs and other forms of public assistance if their income is less than a certain percentage of the federal poverty level, along with other qualifications.

USDA Food Assistance Programs

Government food and nutrition assistance programs that are organized and operated by the USDA work to increase food security. They provide low-income households with access to food, the tools for consuming a healthy diet, and education about nutrition. The USDA monitors the extent and severity of food insecurity via an annual survey. This contributes to the efficiency of food assistance programs as well as the effectiveness of private charities and other initiatives aimed at reducing food insecurity.[10]

The Supplemental Nutrition Assistance Program

Formerly known as the Food Stamp Program, the Supplemental Nutrition Assistance Program (SNAP) provides monthly benefits for low-income households to purchase approved food items at authorized stores. Clients qualify for the program based on available household income, assets, and certain basic expenses. In an average month, SNAP provides benefits to more than forty million people

10. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture, Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.

in the United States.[11] The program provides Electronic Benefit Transfers (EBT) which work similarly to a debit card. Clients receive a card with a certain allocation of money for each month that can be used only for food. In 2010, the average benefit was about $134 per person, per month and total federal expenditures for the program were $68.2 billion.[12]

The Special, Supplemental Program for Women, Infants, and Children

The Special, Supplemental Program for Women, Infants and Children (WIC) provides food packages to pregnant and breastfeeding women, as well as to infants and children up to age five, to promote adequate intake for healthy growth and development. Most state WIC programs provide vouchers that participants use to acquire supplemental packages at authorized stores. In 2010, WIC served approximately 9.2 million participants

11. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture, Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.
12. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture, Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.

per month at an average monthly cost of about forty-two dollars per person.[13]

The National School Lunch Program

The National School Lunch Program (NSLP) and School Breakfast Program (SBP) ensure that children in elementary and middle schools receive at least one healthy meal each school day, or two if both the NSLP and SBP are provided. According to the USDA, these programs operate in over 101,000 public and nonprofit private schools and residential child-care institutions.[14] In 2010, the programs provided meals to an average of 31.6 million children each school day. Fifty-six percent of the lunches served were free, and an additional 10 percent were provided at reduced prices.

Meals on Wheels

An organization known as Meals on Wheels delivers meals to elderly people who have difficulty buying or making their own food because of poor health or limited mobility. It is the oldest and largest

13. Coleman-Jensen A. Household Food Security in the United States in 2010. US Department of Agriculture, Economic Research Report, no. ERR-125. 2011. https://www.ers.usda.gov/publications/pub-details/?pubid=44909. Accessed April 15, 2018.
14. National School Lunch Program. US Department of Agriculture. https://www.fns.usda.gov/nslp/national-school-lunch-program-nslp. Accessed April 15, 2018.

program dedicated to addressing the nutritional needs of senior citizens. Each day, Meals on Wheels volunteers deliver more than one million meals across the United States. The first Meals on Wheels program began in Philadelphia in the 1950s. In the decades since, the organization has expanded into a vast network that serves the elderly in all fifty states and several US territories. Today, Meals on Wheels remains committed to ending hunger among the senior citizen community.[15]

Nutrition and Your Health

The adage, "you are what you eat," seems to be more true today than ever. In recent years, consumers have become more conscientious about the decisions they make in the supermarket. Organically grown food is the fastest growing segment of the food industry. Also, farmers' markets and chains that are health-food-oriented are thriving in many parts of North America. Shoppers have begun to pay more attention to the effect of food on their health and well-being. That includes not only the kinds of foods that they purchase, but also the manner in which meals are cooked and consumed. The preparation of food can greatly affect its nutritional value. Also, studies have shown that eating at a table with family members or friends can promote both health and happiness.

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15. The Problem and Our Solution. Meals on Wheels. https://www.mealsonwheelsamerica.org/theissue/problemandsolution. Accessed April 15, 2018.

Learning Activities

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Careers in Nutrition

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If you are considering a career in nutrition, it is important to understand the opportunities that may be available to you. Both registered dietitians (RD) and nutritionists provide nutrition-related services to people in the private and public sectors. A RD is a healthcare professional who has credentials from the Commission on Dietetic Registration and can provide nutritional care in the areas of health and wellness for both individuals and groups. A nutritionist is an unregistered professional who may have acquired the knowledge via other avenues. RDs are nutrition professionals who work to apply nutritional science, using evidence-based best practices, to help people nourish their bodies and improve their lives.

Becoming a RD requires a Bachelor's or Master's degree in dietetics from an accredited program, including courses in biology, chemistry, biochemistry, microbiology, anatomy and physiology, nutrition, and food-service management. Other suggested courses include economics, business, statistics, computer science, psychology, and sociology. In addition, people who pursue this path must complete a dietetic internship and pass a national exam. Also, some states have licensure that requires additional forms and documentation. To become a dietetic technician registered you must complete an undergraduate dietetic program and pass a national exam. Forty-seven states have licensure requirements for RDs and nutritionists. A few remaining states do not have laws

that regulate this profession.[1] Go to https://www.cdrnet.org/certifications to learn more.

Working in Nutrition

Registered dietitians (RDs)/registered dietitians nutritionist (RDNs) and nutritionists plan food and nutrition programs, promote healthy eating habits, and recommend dietary modifications based on the needs of individuals or groups. For example, an RD/RDN might teach a patient with hypertension how to follow the DASH diet and reduce their sodium intake. Nutrition-related careers can be extremely varied. Some individuals work in the government, while others are solely in the private sectors (i.e., private practice, worksite wellness, hospitals, outpatient clinics, etc). Some jobs in nutrition focus on working with elite athletes, while others provide guidance to patients with long-term, life-threatening diseases. But no matter the circumstance or the clientele, working in the field of diet and nutrition focuses on helping people improve their dietary habits by translating nutritional science and evidence-based recommendations into food choices.

In the public sector, careers in nutrition span from government work to community outreach. RDs who work for the government may become involved with federal food programs, federal agencies, communication campaigns, or creating and analyzing public policy. On the local level, clinical careers include working in hospitals and

1. Dietitians and Nutritionists. Bureau of Labor Statistics. Occupational Outlook Handbook, 2010-11 Edition. https://www.bls.gov/ooh/healthcare/dietitians-and-nutritionists.htm. Updated April 13, 2018. Accessed April 15, 2018.

nursing-care facilities. This requires creating meal plans and providing nutritional guidance to help patients restore their health or manage chronic conditions. Clinical dietitians also confer with doctors and other health-care professionals to coordinate dietary recommendations with medical needs. Nutrition jobs in the community often involve working in public health clinics, cooperative extension offices, and HMOs to prevent disease and promote the health of the local community. Nutrition jobs in the nonprofit world involve anti-hunger organizations, public health organizations, and activist groups.

Nutritionists and dietitians can also find work in the private sector. Increased public awareness of food, diet, and nutrition has led to employment opportunities in advertising, marketing, and food manufacturing. Dietitians working in these areas analyze foods, prepare marketing materials, or report on issues such as the impact of vitamins and herbal supplements. Consultant careers can include working in wellness programs, supermarkets, physicians' offices, gyms, and weight-loss clinics. Consultants in private practice perform nutrition screenings for clients and use their findings to provide guidance on diet-related issues, such as weight reduction. Nutrition careers in the corporate world include designing wellness strategies and nutrition components for companies, working as representatives for food or supplement companies, designing marketing and educational campaigns, and becoming lobbyists. Others in the private sector work in food-service management at health-care facilities or at company and school cafeterias. Sustainable agricultural practices are also providing interesting private sector careers on farms and in food systems. There are employment opportunities in farm management, marketing and sales, compliance, finance, and land surveying and appraisal.

Working toward Tomorrow

Whether you pursue nutrition as a career or simply work to improve your own dietary choices, what you have learned in this course can provide a solid foundation for the future. Remember, your ability to wake up, to think clearly, communicate, hope, dream, go to school, gain knowledge, and earn a living are totally dependent upon one factor—your health. Good health allows you to function normally and work hard to pursue your goals. Yet, achieving optimal health cannot be underestimated. It is a complex process, involving multiple dimensions of wellness, along with your physical or medical reality. The knowledge you have now acquired is also key. However, it is not enough to pass this nutrition class with good grades. Nutrition knowledge must be applied to make a difference in your life, throughout your life.

Throughout this textbook, we have focused on the different aspects of nutrition science, which helps to optimize health and prevent disease. Scientific evidence provides the basis for dietary guidelines and recommendations. In addition, researchers in the field of nutrition work to advance our knowledge of food production and distribution. Nutrition science also examines the ill effects of malnutrition and food insecurity. The findings that are uncovered today will influence not only what we eat, but how we grow it, distribute it, prepare it, and even enjoy it tomorrow.

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PART XIX

APPENDICES

Appendix A

Appendix A

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This table compares the typical levels of recommended daily nutrient intake to the United States Tolerable Upper Intake Levels (ULs) and the United Kingdom's Safe Upper Levels (SULs). The Recommended Dietary Allowance (RDA) and Adequate Intake (AI) values are considered to be levels of nutrient intake that meet or exceed the needs of practically all healthy people. The Daily Value amounts, that are currently used as reference values on food and supplement labels, are similar to the RDA/AI values, but differ in some cases. UL values are the amounts that are considered to be the maximum safe level of intake from food and supplements combined. SUL values are the maximum level of intake of a nutrient from dietary supplements that can be considered to be reasonably safe.

How much is too much?

Comparison of Dietary Reference Intake Values (for adult men and women) and Daily Values for Micronutrients with the Tolerable Upper Intake Levels (UL),[a],[c] Safe Upper Levels (SUL),[d] and Guidance Levels[d]

Nutrient	RDA/ AI[b] (men / women) ages 31-50	Daily Value (Food Labels)	UL[c]	SUL or Guidance Level[d]	Selected Potential Effects of Excess Intake
Vitamin A (mcg)	900 / 700	1500 (5000 IU)	3000	1500** (5000 IU)	Liver damage, bone & joint pain, dry skin, loss of hair, headache, vomiting
beta-Carotene (mg)	–	–	–	7 (11,655 IU)	Increased risk of lung cancer in smokers and those heavily exposed to asbestos
Vitamin D (mcg)	15 (600 IU)	10 (400 IU)	100	25 (1000 IU)	Calcification of brain, arteries, increased blood calcium, loss of appetite, nausea
Vitamin E (mg)	15	20 (30 IU)	1000	540 (800 IU)	Deficient blood clotting
Vitamin K (mcg)	120 / 90*	80	–	1000**	Red blood cell damage/anemia; liver damage
Thiamin (B1) (mg)	1.2 / 1.1	1.5	–	100**	Headache, nausea, irritability, insomnia, rapid pulse, weakness (7000+ mg dose)
Riboflavin (B2) (mg)	1.3 / 1.1	1.7	–	40**	Generally considered harmless; yellow discoloration of urine
Niacin (mg)	16 / 14	20	35	500**	Liver damage, flushing, nausea, gastrointestinal problems
Vitamin B6 (mg)	1.3	2	100	10	Neurological problems, numbness and pain in limbs
Vitamin B12 (mcg)	2.4	6	–	2000**	

Folic acid (mcg)	400	400	1000	1000**	Masks B12 deficiency (which can cause neurological problems)
Pantothenic acid (mg)	5*	10	–	200**	Diarrhea & gastrointestinal disturbance (10,000+ mg/day)
Biotin (mcg)	30*	300	–	900**	No reports of toxicity from oral ingestion
Choline (mcg)	550/ 425*	–	3500	–	Fishy body odor (trimethylaminuria), hepatotoxicity
Vitamin C (mg)	90 / 75	60	2000	1000**	Nausea, diarrhea, kidney stones
Boron (mg)	–	–	20	9.6	Adverse effects on male and female reproductive system
Calcium (mg)	1000	1000	2500	1500**	Nausea, constipation, kidney stones
Chloride (mg)	2300*	3400	3600	–	Increased blood pressure in salt-sensitive individuals (when consumed as sodium chloride)
Chromium (mcg)	35/25*	120	–	10,000**	Potential adverse effects on liver and kidneys; picolinate form possibly mutagenic
Cobalt (mg)	–	–	–	1.4**	Cardiotoxic effects; not appropriate in a dietary supplement except as vitamin B-12
Copper (mcg)	900	2000	10000	10000	Gastrointestinal distress, liver damage

Fluoride (mg)	4 / 3*	–	10	–	Bone, kidney, muscle, and nerve damage; supplement with professional guidance
Germanium	–	–	–	zero**	Kidney toxin; should not be in a dietary supplement
Iodine (mcg)	150	150	1100	500**	Elevated thyroid hormone concentration
Iron (mg)	8 / 18	18	45	17**	Gastrointestinal distress, increased risk of heart disease, oxidative stress
Magnesium (mg)	420 / 320	400	350[e]	400**	Diarrhea
Manganese (mg)	2.3 / 1.8*	2	11	4**	Neurotoxicity
Molybdenum (mcg)	45	75	2000	zero**	Gout-like symptom; joint pains; increased uric acid
Nickel (mcg)	–	–	1000	260**	Increased sensitivity of skin reaction to nickel in jewelry
Phosphorus (mg)	700	1000	4000	250**	Alteration of parathyroid hormone levels; reduced bone mineral density
Potassium (mg)	4700*	3500	–	3700**	Gastrointestinal damage
Selenium (mcg)	55	70	400	450	Nausea, diarrhea, fatigue, hair and nail loss
Silicon (mg)	–	–	–	700	Low toxicity; possibility of kidney stones

Sodium (mg)	1500*	2400	2300	–	Increased blood pressure in salt-sensitive individuals (when consumed as sodium chloride)
Vanadium (mg)	–	–	1.8	zero	Gastrointestinal irritation; fatigue
Zinc (mg)	11 / 8	15	40	25	Impaired immune function, low HDL-cholesterol

[a]Food and Nutrition Board, Institute of Medicine (U.S.). Dietary Reference Intakes Tables.

[b](RDA) = Recommended Dietary Allowance, AI = Adequate Intake, indicated with *

[c]UL = Tolerable Upper Intake Level (from food & supplements combined)

[d]SUL = Safe Upper Levels; SULs and Guidance Levels (indicated by **) set by the Expert Group on Vitamins and Minerals of the Food Standards Agency, United Kingdom. These are intended to be levels of daily intake of nutrients in dietary supplements that potentially susceptible individuals could take daily on a life-long basis without medical supervision in reasonable safety. When the evidence base was considered inadequate to set a SUL, Guidance Levels were set based on limited data. SULs and Guidance Levels tend to be conservative and it is possible that, for some vitamins and minerals, greater amounts could be consumed for short periods without risk to health. The values presented are for a 60 kg (132 lb) adult. Consult the full publication for values expressed per kg body weight. This FSA publication, Safe Upper Levels for Vitamins and Minerals, is available at: http://www.foodstandards.gov.uk/multimedia/pdfs/vitmin2003.pdf

[e]The UL for magnesium represents intake specifically from pharmacological agents and/or dietary supplements in addition to dietary intake.

Appendix B

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