these foods contain vitamin A, which is essential for healthy vision.

Such observations were followed by years of laboratory research before nutritionists came to fully accept the idea that very small amounts of substances present in food were critical to good health. In 1906, the term accessory factors was coined by the English scientist F. G. Hopkins; we now categorize these accessory factors as vitamins and minerals.

**How Are Vitamins Classified?**

**Vitamins** are carbon-containing compounds that regulate a wide range of body processes. Of the thirteen vitamins recognized as essential, humans can synthesize only small amounts of vitamins D and K, so we must consume virtually all of the vitamins in our diets. Almost everyone who eats a varied and healthful diet can readily meet their vitamin needs from foods alone. The exceptions to this will be discussed shortly.

**Fat-Soluble Vitamins**

Vitamins A, D, E, and K are **fat-soluble vitamins** (Table 1). They are found in the fatty portions of foods (butterfat, cod liver oil, corn oil, and so on) and are absorbed along with dietary fat. Fat-containing meats, dairy products, nuts, seeds, vegetable oils, and avocados are all sources of one or more fat-soluble vitamins.

In general, the fat-soluble vitamins are readily stored in the body’s adipose tissue; thus, we don’t need to consume them every single day. While this may simplify day-to-day menu planning, there is also a disadvantage to our ability to store these nutrients. When we consume more of them than we can use, they build up in the adipose tissue, liver, and other tissues and can reach toxic levels. Symptoms of fat-soluble vitamin toxicity, described in Table 1, include damage to our hair, skin, bones, eyes, and nervous system. Overconsumption of vitamin supplements is the most common cause of vitamin toxicity in the United States; rarely do our dietary choices lead to toxicity. Of the four fat-soluble vitamins, vitamins A and D are the most toxic; **megadosing** with ten or more times the recommended intake of either can result in irreversible organ damage and even death.

---

**Vitamins** Micronutrients that contain carbon and assist us in regulating our bodies’ processes. They are classified as water-soluble or fat-soluble.

**fat-soluble vitamins** Vitamins that are not soluble in water but are soluble in fat. These include vitamins A, D, E, and K.

**megadosing** Taking a dose of a nutrient that is 10 or more times greater than the recommended amount.

Want to find out . . .

- how a few fortunate accidents led to the discovery of micronutrients?
- where vitamins and minerals come from?
- why large doses of certain micronutrients could kill you—and which ones?
- whether micronutrient supplements have the same health benefits as nutrients in whole foods?
### Table 1 Fat-Soluble Vitamins

<table>
<thead>
<tr>
<th>Vitamin Name</th>
<th>Primary Functions</th>
<th>Recommended Intake*</th>
<th>Reliable Food Sources</th>
<th>Toxicity/Deficiency Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (retinol, retinal, retinoic acid)</td>
<td>Required for ability of eyes to adjust to changes in light; Protects color vision; Assists cell differentiation; Required for sperm production in men and fertilization in women; Contributes to healthy bone; Contributes to healthy immune system</td>
<td>RDA: Men = 900 µg/day; Women = 700 µg/day; UL = 3,000 µg/day</td>
<td>Preformed retinol: Beef and chicken liver, egg yolks, milk; Carotenoid precursors: Spinach, carrots, mango, apricots, cantaloupe, pumpkin, yams</td>
<td>Toxicity: Fatigue; bone and joint pain; spontaneous abortion and birth defects of fetuses in pregnant women; nausea and diarrhea; liver damage; nervous system damage; blurred vision; hair loss; skin disorders; Deficiency: Night blindness, xerophthalmia; impaired growth, immunity, and reproductive function</td>
</tr>
<tr>
<td>D (cholecalciferol)</td>
<td>Regulates blood calcium levels; Maintains bone health; Assists cell differentiation</td>
<td>AI (assumes that person does not get adequate sun exposure): Adult aged 19 to 50 = 5 µg/day; Adult aged 50 to 70 = 10 µg/day; Adult aged &gt; 70 = 15 µg/day; UL = 50 µg/day</td>
<td>Canned salmon and mackerel, milk, fortified cereals</td>
<td>Toxicity: Hypercalcemia; Deficiency: Rickets in children; osteomalacia and/or osteoporosis in adults</td>
</tr>
<tr>
<td>E (tocopherol)</td>
<td>As a powerful antioxidant, protects cell membranes, polyunsaturated fatty acids, and vitamin A from oxidation; Protects white blood cells; Enhances immune function; Improves absorption of vitamin A</td>
<td>RDA: Men = 15 mg/day; Women = 15 mg/day; UL = 1,000 mg/day</td>
<td>Sunflower seeds, almonds, vegetable oils, fortified cereals</td>
<td>Toxicity: Rare; Deficiency: Hemolytic anemia; impairment of nerve, muscle, and immune function</td>
</tr>
<tr>
<td>K (phyloquinone, menaquinone, menadione)</td>
<td>Serves as a coenzyme during production of specific proteins that assist in blood coagulation and bone metabolism</td>
<td>AI: Men = 120 µg/day; Women = 90 µg/day</td>
<td>Kale, spinach, turnip greens, brussels sprouts</td>
<td>Toxicity: None known; Deficiency: Impaired blood clotting; possible effect on bone health</td>
</tr>
</tbody>
</table>

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake.

Even though we can store the fat-soluble vitamins, deficiencies can occur, especially in people who have a disorder that reduces their ability to absorb dietary fat. In addition, people who are “fat phobic,” or eat very small amounts of dietary fat, are at risk for a deficiency. The consequences of fat-soluble vitamin deficiencies, described in Table 1, include osteoporosis, the loss of night vision, and even death in the most severe cases.

### Water-Soluble Vitamins

Vitamin C (ascorbic acid) and the B vitamins (thiamin, riboflavin, niacin, vitamin B<sub>6</sub>, vitamin B<sub>12</sub>, folate, pantothenic acid, and biotin) are all water-soluble vitamins (Table 2). They are found in a wide variety of foods, including whole grains, fruits, vegetables, meats, and dairy products. They are easily absorbed through the intestinal tract directly into the bloodstream, where they then travel to target cells.

With the exception of vitamin B<sub>12</sub>, we do not store large amounts of water-soluble vitamins. Instead, our kidneys filter from our bloodstream any excess amounts, and they are excreted in urine. Because we do not store large amounts of these vitamins in our body, we need to consume them daily through our diet to maintain adequate levels in our bodies.

**water-soluble vitamins**  Vitamins that are soluble in water. These include vitamin C and the B-vitamins.
<table>
<thead>
<tr>
<th>Vitamin Name (vitamin B)</th>
<th>Primary Functions</th>
<th>Recommended Intake*</th>
<th>Reliable Food Sources</th>
<th>Toxicity/Deficiency Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamin (vitamin B₁)</td>
<td>Required as enzyme cofactor for carbohydrate and amino acid metabolism</td>
<td>RDA: Men = 1.2 mg/day&lt;br&gt;Women = 1.1 mg/day</td>
<td>Pork, fortified cereals, enriched rice and pasta, peas, tuna, legumes</td>
<td>None known&lt;br&gt;Deficiency: Beriberi; fatigue, apathy, decreased memory, confusion, irritability, muscle weakness</td>
</tr>
<tr>
<td>Riboflavin (vitamin B₂)</td>
<td>Required as enzyme cofactor for carbohydrate and fat metabolism</td>
<td>RDA: Men = 1.3 mg/day&lt;br&gt;Women = 1.1 mg/day</td>
<td>Beef liver, shrimp, milk and dairy foods, fortified cereals, enriched breads and grains</td>
<td>None known&lt;br&gt;Deficiency: Ariboflavonosis; swollen mouth and throat; seborrheic dermatitis; anemia</td>
</tr>
<tr>
<td>Niacin, nicotinamide, nicotinic acid</td>
<td>Required for carbohydrate and fat metabolism&lt;br&gt;Plays role in DNA replication and repair and cell differentiation</td>
<td>RDA: Men and women aged 19 to 50 = 1.7 mg/day&lt;br&gt;Men aged &gt; 50 = 1.5 mg/day&lt;br&gt;Women aged &gt; 50 = 1.5 mg/day&lt;br&gt;UL = 100 mg/day</td>
<td>Chickpeas (garbanzo beans), most cuts of meat/fish/poultry, fortified cereals, white potatoes</td>
<td>None known&lt;br&gt;Deficiency: Anemia; seborrheic dermatitis; depression, confusion, and convulsions</td>
</tr>
<tr>
<td>Pyridoxine, pyridoxal, pyridoxamine (vitamin B₆)</td>
<td>Required as enzyme cofactor for carbohydrate and amino acid metabolism&lt;br&gt;Assists synthesis of blood cells</td>
<td>RDA: Men = 2.4 µg/day&lt;br&gt;Women = 2.4 µg/day</td>
<td>Shellfish, all cuts of meat/fish/poultry, milk and dairy foods, fortified cereals</td>
<td>None known&lt;br&gt;Deficiency: Pernicious anemia; neural tube defects in a developing fetus; elevated homocysteine levels</td>
</tr>
<tr>
<td>Folate (folic acid)</td>
<td>Required as enzyme cofactor for amino acid metabolism&lt;br&gt;Required for DNA synthesis&lt;br&gt;Involved in metabolism of homocysteine</td>
<td>RDA: Men = 400 µg/day&lt;br&gt;Women = 400 µg/day&lt;br&gt;UL = 1,000 µg/day</td>
<td>Fortified cereals, enriched breads and grains, spinach, legumes (lentils, chickpeas, pinto beans), greens (spinach, romaine lettuce), liver</td>
<td>Masked symptoms of vitamin B₁₂ deficiency, specifically signs of nerve damage&lt;br&gt;Deficiency: Macrocytic anemia; neural tube defects in a developing fetus; elevated homocysteine levels</td>
</tr>
<tr>
<td>Cobalamin (vitamin B₁₂)</td>
<td>Assists with formation of blood&lt;br&gt;Required for healthy nervous system function&lt;br&gt;Involved as enzyme cofactor in metabolism of homocysteine</td>
<td>RDA: Men = 2.4 µg/day&lt;br&gt;Women = 2.4 µg/day</td>
<td>Shellfish, all cuts of meat/fish/poultry, milk and dairy foods, fortified cereals</td>
<td>None known&lt;br&gt;Deficiency: Pernicious anemia; neural tube defects in a developing fetus; elevated homocysteine levels</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>Assists with fat metabolism</td>
<td>AI: Men = 5 mg/day&lt;br&gt;Women = 5 mg/day</td>
<td>Meat/fish/poultry, shiitake mushrooms, fortified cereals, egg yolk</td>
<td>None known&lt;br&gt;Deficiency: Rare</td>
</tr>
<tr>
<td>Biotin</td>
<td>Involved as enzyme cofactor in carbohydrate, fat, and protein metabolism</td>
<td>RDA: Men = 30 µg/day&lt;br&gt;Women = 30 µg/day</td>
<td>Nuts, egg yolk</td>
<td>None known&lt;br&gt;Deficiency: Rare</td>
</tr>
<tr>
<td>Ascorbic acid (vitamin C)</td>
<td>Antioxidant in extracellular fluid and lungs&lt;br&gt;Regenerates oxidized vitamin E&lt;br&gt;Assists with collagen synthesis&lt;br&gt;Enhances immune function&lt;br&gt;Assists in synthesis of hormones, neurotransmitters, and DNA&lt;br&gt;Enhances iron absorption</td>
<td>RDA: Men = 90 mg/day&lt;br&gt;Women = 75 mg/day&lt;br&gt;Smokers = 35 mg more per day than RDA&lt;br&gt;UL = 2,000 mg</td>
<td>Sweet peppers, citrus fruits and juices, broccoli, strawberries, kiwi</td>
<td>Nausea and diarrhea, nosebleeds, increased oxidative damage, increased formation of kidney stones in people with kidney disease&lt;br&gt;Deficiency: Scurvy; bone pain and fractures, depression, and anemia</td>
</tr>
</tbody>
</table>

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake.
Major minerals are those that are required in amounts of at least 100 mg per day. In addition, these minerals are found in the human body in amounts of 5 g (5,000 mg) or higher. There are seven major minerals: sodium, potassium, phosphorus, chloride, calcium, magnesium, and sulfur. Table 3 summarizes the primary functions, recommended intakes, food sources, and toxicity/deficiency symptoms of these minerals.
<table>
<thead>
<tr>
<th>Mineral Name</th>
<th>Primary Functions</th>
<th>Recommended Intake*</th>
<th>Reliable Food Sources</th>
<th>Toxicity/Deficiency Symptoms</th>
</tr>
</thead>
</table>
| Sodium       | Fluid balance    | AI: Adults = 1.5 g/day (1,500 mg/day) | Table salt, pickles, most canned soups, snack foods, cured luncheon meats, canned tomato products | Toxicity: Water retention, high blood pressure, loss of calcium in urine  
Deficiency: Muscle cramps, dizziness, fatigue, nausea, vomiting, mental confusion |
| Potassium    | Fluid balance    | AI: Adults = 4.7 g/day (4,700 mg/day) | Most fresh fruits and vegetables: potatoes, bananas, tomato juice, orange juice, melons | Toxicity: Muscle weakness, vomiting, irregular heartbeat  
Deficiency: Muscle weakness, paralysis, mental confusion, irregular heartbeat |
| Phosphorus   | Fluid balance    | RDA: Adults = 700 mg/day | Milk/cheese/yogurt, soy milk and tofu, legumes (lentils, black beans), nuts (almonds, peanuts and peanut butter), poultry | Toxicity: Muscle spasms, convulsions, low blood calcium  
Deficiency: Muscle weakness, muscle damage, bone pain, dizziness |
| Chloride     | Fluid balance    | AI: Adults = 2.3 g/day (2,300 mg/day) | Table salt | Toxicity: None known  
Deficiency: Dangerous blood acid–base imbalances, irregular heartbeat |
| Calcium      | Primary component of bone  
Acid–base balance  
Transmission of nerve impulses  
Muscle contraction | AI: Adults aged 19 to 50 = 1,000 mg/day  
Adults aged > 50 = 1,200 mg/day  
UL = 2,500 mg/day | Milk/cheese/yogurt, sardines, collard greens and spinach, calcium-fortified juices | Toxicity: Mineral imbalances, shock, kidney failure, fatigue, mental confusion  
Deficiency: Osteoporosis, convulsions, heart failure |
| Magnesium    | Component of bone  
Muscle contraction  
Assists more than 300 enzyme systems | RDA: Men aged 19 to 30 = 400 mg/day  
Men aged > 30 = 420 mg/day  
Women aged 19 to 30 = 310 mg/day  
Women aged > 30 = 320 mg/day  
UL = 350 mg/day | Greens (spinach, kale, collard greens), whole grains, seeds, nuts, legumes (navy and black beans) | Toxicity: None known  
Deficiency: Low blood calcium, muscle spasms or seizures, nausea, weakness, increased risk of chronic diseases such as heart disease, hypertension, osteoporosis, and type 2 diabetes |
| Sulfur       | Component of certain B-vitamins and amino acids  
Acid–base balance  
Detoxification in liver | No DRI | Protein-rich foods | Toxicity: None known  
Deficiency: None known |

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake; DRI, Dietary Reference Intake.

**Trace Minerals**

Trace minerals are those we need to consume in amounts of less than 100 mg per day. They are found in the human body in amounts of less than 5 g (5,000 mg). Currently, the Dietary Reference Intake (DRI) Committee recognizes eight trace minerals as essential for human health: selenium, fluoride, iodine, chromium, manganese, iron, zinc, and copper. Table 4 identifies the primary functions, recommended intakes, food sources, and toxicity/deficiency symptoms of these minerals.

**Same Mineral, Different Forms**

Unlike most vitamins, which can be identified by either alphabetic designations or the more complicated chemical terms, minerals are known by one name only. Iron, calcium, sodium, and all other minerals are simply referred to by their chemical name. That said, minerals do often

trace minerals  
Minerals we need to consume in amounts less than 100 mg per day and of which the total amount present in the body is less than 5 g (or 5,000 mg).
<table>
<thead>
<tr>
<th>Mineral Name</th>
<th>Primary Functions</th>
<th>Recommended Intake*</th>
<th>Reliable Food Sources</th>
<th>Toxicity/Deficiency Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selenium</td>
<td>Required for carbohydrate and fat metabolism</td>
<td>RDA: Adults = 55 µg/day, UL = 400 µg/day</td>
<td>Nuts, shellfish, meat/fish/poultry, whole grains</td>
<td>Toxicity: Brittle hair and nails, skin rashes, nausea and vomiting, weakness, liver disease. Deficiency: Specific forms of heart disease and arthritis, impaired immune function, muscle pain and wasting, depression, hostility.</td>
</tr>
<tr>
<td>Fluoride</td>
<td>Development and maintenance of healthy teeth and bones</td>
<td>RDA: Men = 4 mg/day, Women = 3 mg/day for children aged 4 to 8, 10 mg/day for children aged &gt;8</td>
<td>Fish, seafood, legumes, whole grains, drinking water (variable)</td>
<td>Toxicity: Fluorosis of teeth and bones. Deficiency: Dental caries and bone density.</td>
</tr>
<tr>
<td>Iodine</td>
<td>Synthesis of thyroid hormones, Temperature regulation, Reproduction and growth</td>
<td>RDA: Adults = 150 µg/day, UL = 1,100 µg/day</td>
<td>Iodized salt, saltwater seafood</td>
<td>Toxicity: Goiter. Deficiency: Goiter, hypothyroidism, cretinism in infant of mother who is iodine deficient.</td>
</tr>
<tr>
<td>Chromium</td>
<td>Glucose transport, Metabolism of DNA and RNA, Immune function and growth</td>
<td>AI: Men aged 19 to 50 = 35 µg/day, Men aged &gt;50 = 30 µg/day, Women aged 19 to 50 = 25 µg/day, Women aged &gt;50 = 20 µg/day</td>
<td>Whole grains, brewers yeast,</td>
<td>Toxicity: None known. Deficiency: Elevated blood glucose and blood lipids, damage to brain and nervous system.</td>
</tr>
<tr>
<td>Manganese</td>
<td>Assists many enzyme systems, Synthesis of protein found in bone and cartilage</td>
<td>AI: Men = 2.3 mg/day, Women = 1.8 mg/day, UL = 11 mg/day for adults</td>
<td>Whole grains, nuts, leafy vegetables, tea</td>
<td>Toxicity: Impairment of neuromuscular system. Deficiency: Impaired growth and reproductive function, reduced bone density, impaired glucose and lipid metabolism, skin rash.</td>
</tr>
<tr>
<td>Iron</td>
<td>Component of hemoglobin in blood cells, Component of myoglobin in muscle cells, Assists many enzyme systems</td>
<td>RDA: Adult men = 8 mg/day, Men aged 19 to 50 = 18 mg/day, Women aged &gt;50 = 8 mg/day</td>
<td>Meat/fish/poultry (best-absorbed form of iron), fortified cereals, legumes, spinach</td>
<td>Toxicity: Nausea, vomiting, and diarrhea; dizziness, confusion; rapid heart beat, organ damage, death. Deficiency: Iron-deficiency microcytic (small red blood cells), hypochromic anemia.</td>
</tr>
<tr>
<td>Zinc</td>
<td>Assists more than 100 enzyme systems, Immune system function, Growth and sexual maturation, Gene regulation</td>
<td>RDA: Men = 11 mg/day, Women = 8 mg/day, UL = 40 mg/day</td>
<td>Meat/fish/poultry (best-absorbed form of zinc), fortified cereals, legumes</td>
<td>Toxicity: Nausea, vomiting, and diarrhea; headaches, depressed immune function, reduced absorption of copper. Deficiency: Growth retardation, delayed sexual maturation, eye and skin lesions, hair loss, increased incidence of illness and infection.</td>
</tr>
<tr>
<td>Copper</td>
<td>Assists many enzyme systems, Iron transport</td>
<td>RDA: Adults = 900 µg/day, UL = 10 mg/day</td>
<td>Shellfish, organ meats, nuts, legumes</td>
<td>Toxicity: Nausea, vomiting, and diarrhea; liver damage. Deficiency: Anemia, reduced levels of white blood cells, osteoporosis in infants and growing children.</td>
</tr>
</tbody>
</table>

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake.*
exist within different chemical compounds; for example, a supplement label might identify calcium as calcium lactate, calcium gluconate, or calcium citrate. As we will discuss shortly, these different chemical compounds, while all containing the same elemental mineral, may differ in their ability to be absorbed by the body.

**How Do Our Bodies Use Micronutrients?**

In Chapter 3, we investigated the truth behind the claim that “You are what you eat.” We found out that the body has to change food in order to use it. This is also true for foods containing vitamins and minerals, because the micronutrients found in foods and supplements are not always in a chemical form that can be used by our cells. This discussion will highlight some of the ways in which our bodies modify the food forms of vitamins and minerals in order to maximize their absorption and utilization.

**What We Eat Differs from What We Absorb**

The most healthful diet is of no value to our bodies unless the nutrients can be absorbed and transported to the cells that need them. Unlike carbohydrates, fats, and proteins, which are efficiently absorbed (85–99% of what is eaten makes it into the blood), some micronutrients are so poorly absorbed that only 3% to 10% of what is eaten ever arrives in the bloodstream.

The absorption of many vitamins and minerals depends on their chemical form. Dietary iron, for example, can be in the form of **heme iron** (found only in meats, fish, and poultry) or **non-heme iron** (found in plant and animal foods as well as iron-fortified foods and supplements). Healthy adults absorb about 25% of heme iron but as little as 3% to 5% of non-heme iron.

In addition, the presence of other factors within the same food influences mineral absorption. For example, approximately 30% to 45% of the calcium found in milk and dairy products is absorbed, but the calcium in spinach, Swiss chard, seeds, and nuts is absorbed at a much lower rate because factors in these foods bind the calcium and prevent its absorption. Non-heme iron, zinc, vitamin E, and vitamin B<sub>6</sub> are other micronutrients whose absorption can be reduced by various binding factors in foods.

The absorption of many vitamins and minerals is also influenced by other foods within the meal. For example, the fat-soluble vitamins are much better absorbed when the meal contains some dietary fat. Calcium absorption is increased by the presence of lactose, found in milk, and non-heme iron absorption can be doubled if the meal includes vitamin C–rich foods such as red peppers, oranges, or tomatoes. On the other hand, high-fiber foods such as whole grains and foods high in oxalic acid, such as tea, spinach, and rhubarb, can decrease the absorption of zinc and iron. It may seem an impossible task to correctly balance your food choices to optimize micronutrient absorption, but the best approach, as always, is to eat a variety of healthful foods every day.

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**heme iron** Iron that is part of hemoglobin and myoglobin; found only in animal-based foods such as meat, fish, and poultry.

**non-heme iron** The form of iron that is not a part of hemoglobin or myoglobin; found in animal- and plant-based foods.
What We Eat Differs from What Our Cells Use

Many vitamins undergo one or more chemical transformations after they are eaten and absorbed into our bodies. For example, before they can go to work for our bodies, the B-complex vitamins must combine with other substances. For thiamin and vitamin $B_6$, a phosphate group is added. Vitamin D is another example: Before cells can use it, the food form of vitamin D must have two hydroxyl (−OH) groups added to its structure. These transformations activate the vitamin; because the reactions don’t occur randomly, but only when the active vitamin is needed, they help the body maintain control over its metabolic pathways.

While the basic nature of minerals does not, of course, change, they can undergo minor modifications that change their atomic structure. Iron (Fe) may alternate between Fe$^{2+}$ (ferrous) and Fe$^{3+}$ (ferric); copper (Cu) may exist as Cu$^{1+}$ or Cu$^{2+}$. These are just two examples of how micronutrients can be modified from one form to another to help the body make the best use of dietary nutrients.

Controversies in Micronutrient Metabolism

The science of nutrition continues to evolve, and our current understanding of vitamins and minerals will no doubt change over the next several years or decades. While some people interpret the term *controversy* as negative, nutrition controversies are exciting developments, proof of new information, and a sign of continued growth in the field.

Are Supplements Healthful Sources of Micronutrients?

For millions of years, humans relied solely on natural foodstuffs as their source of nutrients. Only within the past 60 years or so has a second option become available: nutrient supplements, including those added to fortified foods. Are the micronutrients in supplements any better or worse than those in foods? Do our bodies use the nutrients from these two sources any differently? These are issues that nutrition scientists and consumers continue to discuss.

As previously noted, the availability or “usefulness” of micronutrients in foods depends in part on the food itself. The iron and calcium in spinach are poorly absorbed,
whereas the iron in beef and the calcium in milk are absorbed efficiently. Because of these and other differences in the availability of micronutrients from different sources, it is difficult to generalize about the usefulness of supplements. Nevertheless, we can say a few things about this issue:

- In general, it is much easier to develop a toxic overload of nutrients from supplements than it is from foods. It is very difficult, if not impossible, to develop a vitamin or mineral toxicity through diet (food) alone.
- Some micronutrients consumed as supplements appear to be harmful to the health of certain subgroups of consumers. For example, recent research has shown that use of high-potency supplements of vitamins A, C, and E may actually increase rates of death. Earlier, it had been shown that high-potency beta-carotene supplements increased death rates among male smokers. Alcoholics are more susceptible to the potentially toxic effects of vitamin A supplements and should avoid their use unless specifically prescribed by a healthcare provider. There is also some evidence that a high intake of vitamin A, including supplement use, increases risk of osteoporosis and hip fracture in older adults.
- Most minerals are better absorbed from animal food sources than they are from supplements. The one exception might be calcium citrate-malate, used in calcium-fortified juices. This form is used by the body as effectively as the calcium from milk or yogurt.
- Enriching a low-nutrient food with a few vitamins and/or minerals does not turn it into a healthful food. For example, soda that has been fortified with selected micronutrients is still basically soda.
- Eating a variety of healthful foods provides you with many more nutrients, phytochemicals, and other dietary factors than supplements alone. Nutritionists are not even sure they have identified all essential nutrients; it is possible that the list of essential micronutrients may, in the future, expand. Supplements provide only those nutrients that the manufacturer puts in; foods provide nutrients that have been identified as well as yet-unknown factors.
- Foods often provide a balance of micronutrients and other factors that work in concert with one another. The whole food is more healthful than its isolated individual nutrients, providing benefits not always seen with purified supplements or highly refined, highly enriched food products. As one science reporter recently suggested, “Eat food. Don’t eat anything your great-great-grandmother wouldn’t recognize as food.”
- A healthful diet, built from a wide variety of foods, offers social, emotional, and other benefits that are absent from supplements. Humans eat food, not nutrients.

In certain populations, micronutrient supplements can play an important role in promoting good health. These include pregnant women, children with poor eating habits, and people with certain illnesses. The relative benefits of supplements versus whole foods are discussed further in the Nutrition Debate in Chapter 10 (pages 393–397).

Can Micronutrients Really Prevent or Treat Disease?

Nutritionists and other healthcare professionals clearly accept the role that dietary fat plays in the prevention and treatment of coronary heart disease. The relationship between total carbohydrate intake and the management of diabetes is also firmly established. Less clear, however, are the links between individual vitamins and minerals and certain chronic diseases. A number of research studies have suggested, but not proven, links between the following vitamins and disease states. In each case, adequate intake of the nutrient has been associated with lower disease risk.

- Vitamin C and cataracts
- Vitamin D and colon cancer
- Vitamin E and complications of diabetes
- Vitamin K and osteoporosis
- Calcium and high blood pressure (hypertension)
- Chromium and type 2 diabetes in older adults
- Magnesium and muscle wasting (sarcopenia) in older adults
- Selenium and certain types of cancer
As consumers, it is important to critically evaluate any claim that might be made regarding the protective or disease-preventing ability of a specific vitamin or mineral. Supplements that provide megadoses of micronutrients are potentially harmful, and vitamin/mineral therapies should never replace more traditional, proven methods of disease treatment. Current, reputable information can provide updates as the research into micronutrients continues.

**Do More Essential Micronutrients Exist?**

Nutrition researchers continue to explore the potential of a variety of substances to qualify as essential micronutrients. Vitamin-like factors such as carnitine and trace minerals such as boron, nickel, and silicon seem to have beneficial roles in human health, yet additional information is needed in order to fully define their metabolic roles. Until more research is done, we cannot classify such substances as essential micronutrients.

Another subject of controversy is the question, “What is the appropriate intake of each micronutrient?” Contemporary research suggests that the answer to this question is to be found in each individual’s genetic profile. As you learned in the Nutrition Debate in Chapter 1, the science of *nutrigenomics* blends the study of human nutrition with that of genetics. It is becoming clear that some individuals, for example, require much higher intakes of folate in order to achieve optimal health. Researchers have identified a specific genetic variation in a subset of the population that increases their need for dietary folate. Future studies may identify other examples of how a person’s genetic profile influences his or her individual need for vitamins and minerals.

As explained in Chapter 1, the DRI Committees rely on Adequate Intake (AI) guidelines to suggest appropriate nutrient intake levels when research has not clearly defined an Estimated Average Requirement (EAR). As the science of nutrition continues to evolve, the next 50 years will be an exciting time for micronutrient research. Who knows? Within a few decades, we all might have personalized micronutrient prescriptions matched to our gender, age, and DNA!
Web Links

www.fda.gov
U.S. Food and Drug Administration
Select “Food” and then “Dietary Supplements” on the menu for information on how to evaluate dietary supplements.

www.ars.usda.gov/ba/bhnrc/ndl
Nutrient Data Laboratory Home Page
Click on “Search” and then type “Nutrients Lists” to find information on food sources of selected vitamins and minerals.

www.nal.usda.gov/fnic
The Food and Nutrition Information Center
Click on “Dietary Supplements” to obtain information on vitamin and mineral supplements.

Office of Dietary Supplements
This site provides summaries of current research results and helpful information about use of dietary supplements.

http://lpi.oregonstate.edu
Linus Pauling Institute of Oregon State University
This site provides up-to-date information on vitamins and minerals that promote health and lower disease risk. You can search for individual nutrients (for example, vitamin C) as well as types of nutrients (for example, antioxidants).

References