

5

Vitamins, Minerals, and Water

INSIDE THIS CHAPTER

- Vitamins, Minerals, and Health
- Functions of Selected Vitamins and Minerals
- Retaining Vitamins and Minerals When Cooking
- Supplementation of Vitamins and Minerals
- Water in the Diet



CHAPTER LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Distinguish between water-soluble and fat-soluble vitamins.
- Describe the functions, sources, and recommended intake amounts of vitamins and minerals in the body.
- Identify causes and implications of nutritional deficiencies.
- Identify the recommended sodium intake and the implications of high-sodium diets.
- Identify ways to retain the vitamin and mineral content of food when cooking.
- Determine when it is appropriate to take supplemental vitamins and minerals.
- Describe the recommended intake amounts and functions of water in the body.

KEY TERMS

| | | |
|--|-----------------------------------|----------------------------------|
| antioxidant, p. 108 | fat-soluble vitamin, p. 100 | nonheme iron, p. 113 |
| beta-carotene, p. 108 | free radical, p. 108 | precursor, p. 108 |
| bioavailability, p. 103 | hard water, p. 118 | retinol, p. 108 |
| coenzyme, p. 103 | heme iron, p. 113 | soft water, p. 118 |
| cruciferous vegetable, p. 114 | hemoglobin, p. 113 | trace mineral, p. 103 |
| dehydrating, p. 117 | iron-deficiency anemia, p. 113 | vegan, p. 115 |
| Dietary Approaches to Stop Hypertension (DASH) eating plan, p. 112 | major mineral, p. 103 | water-soluble vitamin, p. 100 |
| | micronutrient, p. 100 | |

CASE STUDY

Sarah is the manager of a college foodservice operation that serves one thousand students living in two dormitories on campus. Although she checks in on the operation on a daily basis, one day she decided to have her assistant relieve her for most of the day while she conducted in-depth observations of each production area. She made the following notes:

- Deliveries left longer at the dock than necessary in warm weather.
- Box of fruit left in storeroom; no one knows when it was placed there.
- Line cook boiling vegetables in deep water instead of using steamer. Check to see if steamer is functioning correctly.
- Vegetables cooked too soon for service and held too long.
- In salad preparation area, produce soaking in water while staff are on break.

After her day of observation, Sarah decided to talk to the entire staff about nutrient retention at the next regular staff training.

1. What nutrition information should Sarah provide her staff?
2. Why should Sarah and her staff be more careful to preserve nutrients for their customers?

THINK ABOUT IT . . .

Vitamins and minerals are measured in thousandths of a gram and millionths of a gram. To imagine how small one-millionth of a gram is, note that one-quarter teaspoon of sugar weighs about one gram and does not even come close to having a million granules.

VITAMINS, MINERALS, AND HEALTH

Vitamins and minerals are important in the human diet because they promote growth and optimum health. Both vitamins and minerals are essential for body functioning. Because some food items contain more vitamins and minerals than others, consuming a variety of nutrient-dense food items from each of the five food groups is necessary to obtain the vitamins and minerals needed for good health. This chapter focuses on individual vitamins and minerals and their roles in the body.

Vitamins

Scientists began discovering vitamins in the early 20th century. They assigned letters and numbers to unknown properties in food and later named them vitamins. The Polish scientist Casimir Funk originally used the term *vitamines*, a combination of the Latin word *vita*, meaning “life,” and *amine*, for the type of organic chemical that scientists originally thought vitamins were. Vitamins are organic compounds, meaning they contain carbon and are made from plants or animals.

Vitamins are classified as either water soluble or fat soluble. **Water-soluble vitamins** are soluble (can dissolve) in water but not in fat, and generally they are not stored in the body. **Fat-soluble vitamins** are soluble in fat but not in water, and they can be stored in the body’s adipose (fat) tissue. Now scientists know that there are thirteen vitamins: four fat-

soluble vitamins and nine water-soluble vitamins (see *Exhibit 5.1*).

After identifying some vitamins, scientists conducted experiments to learn more about the new substances. This eventually led to the discovery of vitamins A and D, as well as the B-complex vitamins. Each vitamin’s designated letter is based on its original discovery and chemical names. Vitamins may have more than one active form and therefore be assigned different chemical names. See *Exhibit 5.2* for information about the function of each vitamin and the related deficiency diseases.

Vitamins are called **micronutrients** because the body needs only a small amount of each one, while carbohydrates, fats, and proteins are called macronutrients because the body needs large amounts of them. To visualize the differences among grams, milligrams, and micrograms,

Exhibit 5.1

VITAMINS BY CATEGORY

| Fat-soluble vitamins | Water-soluble vitamins |
|--|--|
| Vitamin A (retinol) | Thiamin B ₁ |
| Vitamin D (cholecalciferol) | Riboflavin B ₂ |
| Vitamin E (tocopherol) | Niacin B ₃ |
| Vitamin K (phylloquinone, menaquinone) | Pantothenic acid B ₅ |
| | Vitamin B ₆ (pyridoxine, pyridoxal, pyridoxamine) |
| | Biotin B ₇ |
| | Folate B ₉ or folic acid |
| | Vitamin B ₁₂ (cyanocobalamin) |
| | Vitamin C (ascorbic acid) |

Exhibit 5.2

VITAMINS: PRIMARY FUNCTIONS AND DEFICIENCIES

| Vitamin | Primary function | Deficiency |
|-------------------------------|--|--|
| Vitamin A | Normal vision and normal cell development in the body | Night blindness, dry eyes, softening of the cornea |
| Thiamin | A coenzyme for energy metabolism, nervous-system function | Beriberi |
| Riboflavin | A coenzyme in energy metabolism, normal vision | Ariboflavinosis |
| Niacin | A coenzyme in energy metabolism | Pellagra |
| Pantothenic acid | Part of a coenzyme used in energy metabolism | Convulsions or anemia |
| Vitamin B₆ | Part of a coenzyme used in amino-acid metabolism, helps make red blood cells, assists in the conversion of the amino acid tryptophan to the vitamin niacin | Anemia, nerve damage, seizures, skin problems, sores in the mouth |
| Biotin | Part of a coenzyme used in energy metabolism, used in cell growth, helps maintain a steady blood-sugar level, strengthens hair and nails | Changes in mental state, dry skin, fine and brittle hair, fungal infections, hair loss or total alopecia, muscular pain, skin rash, seborrheic dermatitis |
| Folate or folic acid | Part of a coenzyme used in the synthesis of new cells | Behavioral disorders, diarrhea, loss of appetite, sore tongue, headaches, heart palpitations, infant neural tube defects, irritability, low birth weight babies, megaloblastic anemia, premature babies, weakness, weight loss |
| Vitamin B₁₂ | Part of a coenzyme used in the synthesis of new cells | Megaloblastic anemia, nerve-cell death, numbness or tingling of the extremities, pernicious anemia |
| Vitamin C | Antioxidant, collagen formation in the skin, helps immunity | Scurvy |
| Vitamin D | Maintains the normal levels of calcium and phosphorus in the blood | Osteomalacia, osteoporosis, rickets |
| Vitamin E | Antioxidant | Neurological disorders leading to poor transmission of nerve impulses, muscle weakness, and degeneration of the retina |
| Vitamin K | Blood clotting | Bleeding diathesis (causing problems with blood coagulation) |

Exhibit 5.3



A varied diet helps people obtain all of the vitamins and minerals needed for optimal health.

think of the size of a meal that provides enough macronutrients versus the size of a vitamin tablet with 100 percent of the Daily Value (DV) for most vitamins. Vitamins are essential for life and must be obtained from food because the human body makes insufficient amounts of them, or none at all (see Exhibits 5.3 and 5.4). Unlike carbohydrates, fats, and proteins,

Exhibit 5.4

FOOD SOURCES OF VITAMINS

| Vitamin | Vegetarian sources | Animal sources |
|-------------------------------|--|--|
| Vitamin A | Dark orange and green vegetables, sweet potatoes, mangos | Fortified milk or dairy products, liver, eggs |
| Thiamin | Whole grains, enriched products, fortified products, nuts, legumes | Pork |
| Riboflavin | Whole grains or enriched grains | Milk and milk products |
| Niacin | Whole grains, enriched products, nuts | Milk, eggs, meat, poultry, fish |
| Pantothenic acid | Most | Most |
| Vitamin B₆ | Green vegetables, green leafy vegetables, fruit, whole grains | Meat, fish, poultry |
| Biotin | Most; people make small amounts in the intestines | Most |
| Folate | Green leafy vegetables, legumes, seeds, enriched products | Liver |
| Vitamin B₁₂ | None naturally; may be fortified in cereals | All |
| Vitamin C | Citrus fruit, peppers, strawberries, tomatoes, potatoes | None |
| Vitamin D | None, but made with the help of sunlight | Fortified milk, fatty fish, some fish-liver oils, eggs |
| Vitamin E | Green leafy vegetables, mayonnaise made with vegetable oil, nuts, peanut butter, sunflower seeds, sea buckthorn berries, seeds, vegetable oils (palm, sunflower, canola, corn, soybean, and olive), wheat germ, whole grains | Fish, only small amounts in some, not a good source |
| Vitamin K | Green, leafy cabbage-type vegetables, collards, spinach, also made by bacteria in the intestine | Minimal amounts in liver and eggs |

vitamins and minerals contain neither energy nor calories. Instead, vitamins facilitate the operation of other nutrients. Some vitamins act as **coenzymes** because they are activators of other enzymes—body chemicals that catalyze, or speed up, a specific chemical reaction. Think of a coenzyme as a puzzle piece that completes the puzzle; it is specific to and combines with the target enzyme to enable certain important reactions to take place in the body.

Minerals

Minerals are chemical elements found in soil or ground water. We obtain them from both animal and vegetable food. Like vitamins, minerals are essential to a healthy body. For example, calcium is needed to build bones, to maintain bone health, to maintain blood pressure, and to aid muscle contraction. Sodium, potassium, and chloride are needed because they function as electrolytes and maintain fluid balance.

Minerals are divided into two main categories, major or trace, depending on the amount required by the body. Calcium, phosphorus, potassium, sulfur, sodium, chloride, and magnesium are considered the **major minerals**, of which the body needs one hundred milligrams or more per day. In contrast, the body needs **trace minerals** in very small amounts. For example, iron is needed in milligrams, while copper, chromium, and iodine are needed in micrograms. (See *Exhibit 5.5* for a complete list.)

With regard to the maintenance of the body, mineral activity is as important as vitamin activity. Minerals can compete for absorption in the small intestine. When this happens, there is a possibility of an imbalance.

This competition can also affect a mineral’s bioavailability if a person takes too much of one, such as when taking supplements. **Bioavailability** is the degree to which the nutrients that people consume can be absorbed and become available for use by the body. Although many people do not get the daily recommended intakes of minerals, serious mineral deficiencies are usually caused by underlying medical conditions. *Exhibit 5.6* on the next page shows the functions and deficiencies of minerals in the body.

Minerals can be present in food but not necessarily available for absorption. Some food has chemicals that prevent the absorption of minerals. Two common examples are the oxalates in spinach that bind with the calcium and

Exhibit 5.5

MINERALS BY CATEGORY

| Major minerals | Trace minerals |
|----------------|----------------|
| Calcium | Chromium |
| Chloride | Copper |
| Magnesium | Fluoride |
| Phosphorus | Iodine |
| Potassium | Iron |
| Sodium | Manganese |
| Sulfur | Molybdenum |
| | Selenium |
| | Zinc |

Exhibit 5.6

MINERALS: PRIMARY FUNCTIONS AND DEFICIENCIES

| Mineral | Primary function | Deficiency |
|-------------------|--|---|
| Calcium | Bone health, maintenance of normal blood pressure, muscle contraction | Hypocalcemia, low blood calcium usually caused by other medical conditions, osteoporosis can result from chronic calcium and vitamin D deficiency |
| Chloride | Maintains fluid and electrolyte balance | Hypochloremia, usually caused by repeated vomiting in combination with low intakes |
| Chromium | Aids in carbohydrate metabolism | Impaired glucose tolerance, increased blood cholesterol and triglycerides |
| Copper | Part of various enzymes, used for electron transport | Deficiency is uncommon with exception of malnutrition |
| Fluoride | Bone and tooth health | Increased cavity formation |
| Iodine | Component of thyroid gland, a form of the hormone thyroxine regulates metabolic rate | Goiter (large growth on the thyroid gland), reproductive damage, hypothyroidism |
| Iron | Part of hemoglobin | Low iron stores, iron-deficiency anemia, can affect cognition and immune function in children |
| Magnesium | Part of bones and teeth, protein creation, muscle activity, activator of metabolism of macronutrients | Hypomagnesemia, low blood magnesium, occurs when other major minerals are deficient. Occurs with kidney disease and with alcoholism |
| Manganese | Cofactor for enzymes that facilitate metabolic processes and prevent damage by free radicals | Deficiency not seen in humans eating normal diets |
| Molybdenum | Purine degradation, formation of uric acid, enzyme reactions | Deficiency not seen in humans eating normal diets |
| Phosphorus | Part of bones and teeth | Hypophosphatemia, low blood phosphorus, occurs with underlying disease conditions |
| Potassium | Maintains fluid and electrolyte balance | Hypokalemia, low blood potassium, usually caused by vomiting and diarrhea, or use of diuretics (promotes urine formation), eventually irregular heartbeat |
| Selenium | Antioxidant, which protects substances from being oxidized and thus decreases the adverse effects of free radicals | Muscle pain, muscle weakness, and cardiomyopathy (structural change in the heart such as enlargement of the heart) |
| Sodium | Maintains fluid and electrolyte balance | Hyponatremia, low blood sodium, usually a result of vomiting, diarrhea, diuretics (promotes urine formation), or profuse sweating |
| Sulfur | Part of certain vitamins, part of sulfur-containing amino acids, determines shape of protein molecules | Deficiency not seen in humans |
| Zinc | Taste perception, coenzyme | Deficiency can result in delayed wound healing, impaired appetite, and diarrhea |

the phytic acid of grains that can bind calcium and other minerals, preventing them from being absorbed. Some types of food encourage the absorption of minerals. For instance, when taken with plant proteins, vitamin C increases the absorption of iron. See *Exhibit 5.7* for a listing of good food sources for minerals.

Exhibit 5.7

FOOD SOURCES OF MINERALS

| Mineral | Food sources |
|-------------------|---|
| Calcium | Broccoli, Chinese cabbage, corn tortillas, dairy products, fortified fruit juice, greens, kale, legumes, milk, salmon, sardines, soy milk |
| Chloride | Baking soda, baking powder, bread, cheese, eggs, meat, milk, processed food, seafood, table salt, vegetables |
| Chromium | Brewer's yeast, cheeses, fish, liver, meat, nuts, poultry, whole grains |
| Copper | Cocoa, legumes, organ meat, nuts, seafood, seeds, wheat bran, whole-grain products |
| Fluorine | Fluoridated water, legumes, marine fish, organ meat, nuts, seeds, whole grains |
| Iodine | Iodized salt, seafood, vegetables, small amounts in milk |
| Iron | Cereals/breads, egg yolks, fish, fruit, greens, legumes, liver, meat, nuts, poultry, enriched or whole grains |
| Magnesium | Alfalfa, almonds, apples, brown rice, cocoa, figs, greens, lemons, legumes, meat, peaches, nuts, seafood, sesame seeds, soybeans, sunflower seeds, vegetables, whole grains |
| Manganese | Fruit, nuts, whole grains |
| Molybdenum | Bread, cereal, grains, nuts |
| Phosphorus | Cereals, eggs, fish, meat, milk, peas, poultry, whole grains |
| Potassium | Bananas, citrus fruit, legumes, meat, melons, milk, potatoes, tomatoes, vegetables, whole grains |
| Selenium | Dairy products, fish, organ meat, poultry, seafood, vegetables, whole grains |
| Sodium | Table salt, milk, processed food, spinach |
| Zinc | Enriched cereals, red meat, seafood, whole grains |

THINK ABOUT IT . . .

The amount of a given vitamin or mineral may vary but does not dictate its importance to the body. Why might this be?

DAILY INTAKE OF VITAMINS AND MINERALS

Individuals need to ingest the recommended vitamins and minerals each day in addition to carbohydrate, protein, lipid, and water. See *Exhibits 5.8 and 5.9* for the recommended daily amounts of vitamins and minerals and the Tolerable Upper Intake Levels. Without adequate food intake, children and adults develop deficiency diseases. People with nutritional deficiencies may experience weight loss, slowed growth, iron-deficiency anemia, or weakened immune function.

Exhibit 5.8

DIETARY REFERENCE INTAKES FOR VITAMINS

| | Dietary Reference Intakes for Vitamins per Day | | | | | | |
|-------------------------------------|--|-------------------|-----------------|--------------------|---------------------|-------------------|------------------------------|
| | Male 9–18 yrs | Male 19–70 yrs | Male >70 yrs | Female 9–18 yrs | Female 19–70 yrs | Female >70 yrs | Male and female 19–70 yrs |
| | RDA/AI | RDA/AI | RDA/AI | RDA/AI | RDA/AI | RDA/AI | UL |
| Vitamin A (mcg) | 600–900 | 900 | 900 | 600–900 | 700 | 700 | 3,000 |
| Thiamin (mg) | 0.9–1.2 | 1.2 | 1.2 | 0.9–1.1 | 1.1 | 1.1 | ND |
| Riboflavin (mg) | 0.9–1.3 | 1.3 | 1.3 | 0.9–1.0 | 1.1 | 1.1 | ND |
| Niacin (mg) | 12–16 | 16 | 16 | 12–14 | 14 | 14 | 35 |
| Pantothenic acid (mg) | 4–5 | 5 | 5 | 4–5 | 5 | 5 | ND |
| Vitamin B₆ (mg) | 1.0–1.3 | 1.3–1.7 | 1.7 | 1.0–1.2 | 1.3–1.5 | 1.5 | 100 |
| Biotin (mcg) | 20–25 | 30 | 30 | 2–25 | 30 | 30 | ND |
| Folate (mcg) | 300–400 | 400 | 400 | 300–400 | 400 | 400 | 1,000 |
| Vitamin B₁₂ (mcg) | 1.8–2.4 | 2.4 | 2.4 | 1.8–2.4 | 2.4 | 2.4 | ND |
| Vitamin C (mg) | 45–75 | 90 | 90 | 45–65 | 75 | 75 | 2,000 |
| Vitamin D (mcg) | 15 | 15 | 20 | 15 | 15 | 20 | 100 |
| Vitamin E (mg) | 11–15 | 15 | 15 | 11–15 | 15 | 15 | 1,000 |
| Vitamin K (mcg) | 60–75 | 120 | 120 | 60–75 | 90 | 90 | ND |

Adapted from Dietary Reference Intakes (DRIs), Recommended Dietary Allowances (RDA), and Adequate Intakes (AI)—Food and Nutrition Board, Institute of Medicine, National Academy of Sciences.

Key:
 UL - Tolerable Upper Intake Levels
 ND - Not Determined

Exhibit 5.9

DIETARY REFERENCE INTAKES FOR MINERALS

| | Dietary Reference Intakes for Minerals per Day | | | | | | |
|-------------------------|--|-------------------|-----------------|--------------------|---------------------|-------------------|------------------------------|
| | Male 9–18 yrs | Male 19–70 yrs | Male >70 yrs | Female 9–18 yrs | Female 19–70 yrs | Female >70 yrs | Male and female 19–70 yrs |
| | RDA/AI | RDA/AI | RDA/AI | RDA/AI | RDA/AI | RDA/AI | UL |
| Major minerals | | | | | | | |
| Calcium (mg) | 1,300 | 1,000 | 1,200 | 1,300 | 1,000–1,200 | 1,200 | 2,000–2,500 |
| Chloride (mg) | 2,300 | 2,000–2,300 | 1,800 | 2,300 | 2,000–2,300 | 1,800 | 3,600 |
| Magnesium (mg) | 240–410 | 400–420 | 420 | 240–360 | 310–320 | 320 | 350 |
| Phosphorus (mg) | 1,250 | 700 | 700 | 1,250 | 700 | 700 | 4,000 |
| Potassium (mg) | 4,500–4,700 | 4,700 | 4,700 | 4,500–4,700 | 4,700 | 4,700 | — |
| Sodium (mg) | 1,500 | 1,300–1,500 | 1,200 | 1,500 | 1,300–1,500 | 1,200 | 2,300 |
| Trace minerals | | | | | | | |
| Chromium (mcg) | 25–35 | 30–35 | 30 | 21–24 | 20–25 | 20 | ND |
| Copper (mcg) | 700–890 | 900 | 900 | 700–890 | 900 | 900 | 10,000 |
| Fluoride (mg) | 2–3 | 4 | 4 | 2–3 | 3 | 3 | 10 |
| Iodine (mcg) | 120–150 | 150 | 150 | 120–150 | 150 | 150 | 1,100 |
| Iron (mg) | 8–11 | 8 | 8 | 8–15 | 8–18 | 8 | 45 |
| Manganese (mg) | 1.9–2.2 | 2.3 | 2.3 | 1.6 | 1.8 | 1.8 | 11 |
| Molybdenum (mcg) | 34–43 | 45 | 45 | 34–43 | 45 | 45 | 2,000 |
| Selenium (mcg) | 40–55 | 55 | 55 | 40–55 | 55 | 55 | 400 |
| Zinc (mg) | 8–11 | 11 | 11 | 8–9 | 8 | 8 | 40 |

Adapted from Dietary Reference Intakes (DRIs), Recommended Dietary Allowances (RDA), and Adequate Intakes (AI)—Food and Nutrition Board, Institute of Medicine, National Academy of Sciences.

Key:

UL - Tolerable Upper Intake Levels

ND - Not Determined

There is neither an RDA/AI nor a UL set for sulfur because sulfur needs are met when enough protein is consumed.

Exhibit 5.10



FUNCTIONS OF SELECTED VITAMINS AND MINERALS

In order for restaurant and foodservice personnel to make informed decisions about recipes, portions, and menu choices, they must understand not only the importance of essential vitamins and minerals but also the functions of these substances in the body. It also will be helpful if they understand the food sources of the vitamins and minerals and the importance of retaining these nutrients in the food they prepare and serve to their customers (*Exhibit 5.10*).

Fat-Soluble Vitamins

Vitamins A, D, E, and K are fat-soluble vitamins. As a group, these vitamins are dependent on fat for absorption and utilization in the body. In order to circulate to the cells, vitamins A, D, E, and K use lipoproteins as their route of transportation in the body. They can be stored readily in liver and adipose tissue. Although they were discovered in the 20th century, these vitamins are still studied for their abilities to affect our health.

VITAMIN A

Vitamin A has multiple roles in the body. It is important in good vision, general growth and development, reproduction, bone health, and immune function. The main function of vitamin A is to promote good vision through the health of the retina, the light sensitive portion of the eye, and the cornea, the clear layer covering of the eye. That is why the active form of vitamin A is called **retinol**.

Its role in growth and development includes determining the specific function of cells, or cell differentiation. An example of this is the development of the mucous-forming cells and the cells that form the skin. Vitamin A is also essential for bone growth. A deficiency of vitamin A leads to poor bone growth, while a toxicity can cause bone fractures.

Vitamin A is a fat-soluble vitamin found in its active form in animal-based food such as liver, milk, and other dairy products. It is also found in plant sources as **beta-carotene**. Beta-carotene is an inactive form of the vitamin or **precursor** and is activated by the body. It is obtained from a variety of plant sources such as carrots, sweet potatoes, and other types of fruit and vegetables that are red, orange, or dark green in color. It gives carrots and sweet potatoes their orange color.

Beta-carotene is an **antioxidant** chemical that fights the excessive oxidation of molecules in the human body. Antioxidants serve an important function in the body. They protect cells from damage due to **free radicals**, or unpaired

electrons, formed during the metabolic activity of the body. If left unchecked, free radicals can harm the cellular membranes and cause damage that leads to inflammation and disease.

A deficiency of vitamin A may lead to several deficiency diseases, including night blindness, or the inability to see clearly at night. Fortunately, this disease can be easily treated. Two more serious conditions that may arise from a deficiency of vitamin A are xerophthalmia, or dry eyes, and keratomalacia, or softening of the cornea, both of which could lead to permanent blindness. On the other hand, excessive amounts of vitamin A, which usually come from vitamin supplements, are toxic. Studies suggest that consuming too much vitamin A can lead to severe headaches, nausea, skin irritation, bone pain, bone fractures, and death.

VITAMIN D

A second fat-soluble vitamin required by the body is vitamin D. There are very few food sources of vitamin D. It can be found naturally in fatty fishes such as salmon and sardines. To ensure that it is available in the diet, milk and some breakfast cereals have been fortified with it (*Exhibit 5.11*). Its main function in the body is to regulate the blood's calcium levels to maintain bone health. Our bodies can make vitamin D from a compound that lies under the skin. Sunlight activates the natural production of vitamin D. When sunlight hits the skin, this compound is converted into a vitamin D precursor that is absorbed into the blood and activated in the kidney and liver.

Rickets, which causes bowing of the legs or knocked knees, is a disease that occurs in children due to a deficiency of vitamin D. In adults, a deficiency causes osteomalacia, or a softening of the bones that can lead to bone deformities. Osteoporosis, a bone-thinning disorder that strikes people as they age, is caused by a deficiency of vitamin D and calcium.

Vitamin D deficiency is a particular concern for people who do not receive enough exposure to the sun. In addition, for those who are exposed to the sun, extensive use of sunscreen blocks the activation of vitamin D. Consuming good sources of vitamin D is essential to offset the lack of sun exposure, and it also helps those who must limit their time in the sun.

VITAMIN E

Vitamin E is known as an antioxidant vitamin. It has a role in protecting cellular membranes and preventing damage from free radicals. Deficiencies of vitamin E are rare in healthy adults but occur in cases where malabsorption is present. As with all vitamins, getting adequate amounts of vitamin E is important. However, high-dose supplements are not recommended as they may negatively affect heart health.

Exhibit 5.11



Sources of vitamin E can be found in both plant-based and animal-based food. The oils are good sources of it and so is wheat germ. Many cooking oils contain added alpha-tocopherol, the active form of vitamin E, to delay rancidity that is caused by oxidation.

VITAMIN K

There are two forms of vitamin K—the plant form phyloquinone and the form found in animal-based food and made by intestinal bacteria, menaquinone. Food sources of vitamin K include plants such as leafy green vegetables, broccoli, and cauliflower. Oils such as soybean, olive, and canola are also good sources.

The primary function of vitamin K is to enable blood to clot, but it also plays a role in the health of bones. The body can make vitamin K in the intestines. However, the body does not make sufficient amounts, so vitamin K also must be obtained from food sources. A deficiency of vitamin K is unlikely unless a person has malabsorption as in celiac disease or cystic fibrosis.

Some adults must take medicines called anticoagulants or blood thinners that prevent clots. Elderly patients often take this type of medication. They must limit their consumption of dietary sources of vitamin K or they will reverse the medicine's effects and form harmful blood clots. In a dining situation, they may request no green vegetables and no salad when eating out to avoid more dietary vitamin K.

Water-Soluble Vitamins

The water-soluble vitamins should be consumed every day because the body more easily excretes them. In metabolic reactions, these vitamins are very interdependent. If one vitamin is missing, the others will not be able to participate in certain reactions.

THIAMIN, RIBOFLAVIN, NIACIN

The major function of thiamin, riboflavin, and niacin is to serve as coenzymes in metabolic reactions. Thiamin is essential in the metabolism of glucose to other products used by the body. It was one of the first vitamins to be discovered and synthesized. Good sources of thiamin are wheat germ, pork, legumes, whole grains, and nuts. Deficiencies of thiamin can be seen in people with alcoholism. With increased alcoholic intake, thiamin is poorly absorbed and easily excreted by the body. In addition, poor dietary intake may accentuate the problem.

Riboflavin and niacin accept and donate electrons, making them essential to the metabolic activities of the body. Riboflavin is found in small quantities in all plant-based and animal-based food, and the best sources are milk and milk products. A deficiency of riboflavin can lead to inflammation of the

mouth, throat, and lips, along with the development of skin disorders. The body needs niacin in approximately two hundred enzyme reactions. It is found in meat, poultry, and fish as well as whole grains.

In the process of refining grains, these three B vitamins are removed. Some of the B vitamins are returned during the enrichment process. However, only reduced amounts of thiamin, riboflavin, niacin, folic acid, and the mineral iron are restored, leaving enriched bread with less of these nutrients than that found in whole-grain products.

VITAMIN B₆

The primary role of vitamin B₆ is to act as a coenzyme in amino-acid and protein metabolism. It also has a role in blood-cell synthesis, carbohydrate metabolism, and production of the chemicals that carry nerve impulses in the body. Vitamin B₆ is found in ready-to-eat cereals as well as meat, fish, and poultry. Severe deficiency of this vitamin is uncommon. Low dietary intakes can negatively affect the body's immune function. Toxic amounts from supplements can cause damage to the nervous system.

FOLATE

Folate is an important B vitamin required in the development of red and white blood cells. Folate deficiency results in megaloblastic anemia, which is associated with abnormally large red blood cells. Folic acid is used in supplements and enriched flour because folic acid is better absorbed than the natural folate found in food.

VITAMIN C

Sailors are sometimes referred to as limeys because they used to suck on lemons or limes to ingest vitamin C in order to avoid the illness later named scurvy. Hundreds of years ago, the lack of fresh fruit and certain vegetables in the diets of sailors caused this vitamin deficiency. Scurvy causes swollen gums, loose teeth, a rash that looks like red spots, and hair loss. The functions of vitamin C include acting as an antioxidant and assisting the body in the absorption of iron from plant sources.

Minerals and Blood-Pressure Regulation

Minerals play an important role in the regulation of blood pressure. It appears that deficiencies of the minerals potassium, calcium, and magnesium may contribute to the incidence of hypertension, or high blood pressure. Also, for people who have a genetic tendency toward high blood pressure, excessive sodium intake may increase the likelihood of developing this condition. Table salt is a combination of the minerals sodium and chloride. Salt has approximately twenty-three hundred milligrams of sodium in each teaspoon,

making it an important source of sodium in the diet. The National Institutes of Health publishes the **Dietary Approaches to Stop Hypertension (DASH) eating plan** as a heart-healthy guide. The DASH plan is a diet that is low in sodium but high in other minerals to help normalize blood pressure. It is available at www.nhlbi.nih.gov/health/public/heart/hbp/dash/new_dash.pdf.

Restaurants and foodservice operations should review their recipes to see if they are adding excessive amounts of salt or using products that are extremely high in sodium. Sodium is an essential nutrient, but public-health experts encourage Americans to reduce their intake to prevent hypertension. Under



some menu-labeling laws, some restaurants and foodservice establishments are required to provide nutrition information to the public upon request. This nutrient information must contain the amount of sodium in each standard menu item. It makes sense for managers and chefs to bring sodium levels down by substituting food items that are flavorful but low in sodium. Recommended sodium levels are lower than they have been in the past, and it will take time for both customers and chefs to adjust to less salt. *Exhibit 5.12* shows some low-sodium types of food that are rich in other nutrients.

According to the Dietary Guidelines for Americans 2010, individuals should lower their sodium intake to twenty-three hundred milligrams, or less than one teaspoon of salt per day. In addition, as mentioned in chapter 3, people who are more than 51 years of age, of African-American descent, or affected by hypertension, diabetes, or chronic kidney disease should not consume more than fifteen hundred milligrams or slightly less than 0.75 teaspoon of salt per day.

Mineral-Related Health Issues

Based on the functions of the different minerals previously described, it is clear that all minerals are important for health. Several particular health issues related to minerals merit further discussion.

MINERALS AND BONE HEALTH

As the body constantly builds up and breaks down bone, minerals work to maintain bone health. Calcium is well recognized for its role in healthy bones and teeth; it is also the most common mineral in the body. Phosphorus and magnesium are also present in the bones. Osteoporosis, which affects millions of Americans, is a disease that causes bones to become porous so that they fracture easily. When an elderly person seems to be getting shorter, osteoporosis is a possible cause.

Osteoporosis has several risk factors:

- **Gender:** Females are more likely to develop osteoporosis than are males.
- **Age:** The risk of osteoporosis increases with age.
- **Race:** Caucasian and Asian women are at a higher risk.
- **Family history:** A family history of osteoporosis increases risk.
- **Frame size:** People with smaller frames have a higher risk.
- **Medications:** Some medications can increase risk.

People can prevent osteoporosis by taking some simple actions. Do weight-bearing exercise such as jogging or walking, and decrease or eliminate smoking and the consumption of alcoholic beverages. Consume the recommended amounts of calcium and vitamin D. Any calcium supplements should contain vitamin D, as it enables calcium to pass through the intestinal wall and into the bloodstream.

MINERALS IN THE BLOOD

Iron, zinc, and copper are important minerals that form hemoglobin.

Hemoglobin is the active molecule in red blood cells; it is a protein in the body that carries oxygen through the blood. **Iron-deficiency anemia**, which is the most common nutritional deficiency in the world, occurs when there is a lack of iron in the diet or a problem with absorption of iron in the body, resulting in low levels of hemoglobin. The symptoms of iron-deficiency anemia include weakness, irritability, headaches, pale skin, and sensitivity to cold temperatures. Iron deficiency is more common in women and children than in men.

Iron comes in two forms in the diet: heme and nonheme. **Heme iron** is iron from animal sources, while **nonheme iron** comes from vegetarian sources. The body more easily absorbs heme iron than nonheme iron.

RETAINING VITAMINS AND MINERALS WHEN COOKING

Restaurant and foodservice managers should ensure that the cooking methods used at their establishments help retain the food's vitamins and minerals. If the water used to boil a green vegetable has turned green, there is a good chance that some vitamins were lost. Minimizing cooking time helps preserve vitamins and minerals, especially water-soluble vitamins. Steaming, shown in *Exhibit 5.13*, is the best process for preserving the vitamin content of vegetables; microwaving and stir-frying are other good methods. Even rinsing or soaking produce can result in lost vitamins, because the water-soluble vitamins are leached out.

Minerals and fat-soluble vitamins are not as fragile as water-soluble vitamins. However, restaurant and foodservice professionals should avoid soaking produce because it will leach out minerals like potassium. Also, storing food for extended periods of time, or simply exposing it to air or light, can destroy the vitamins. For example, light exposure destroys riboflavin, which is found in milk products.

Manager's Memo

Restaurant managers and foodservice professionals can increase the number of vitamins and minerals in the diets of their customers by increasing the amount of vegetables, fruit, and whole grains on the menu. Fruit and vegetables are very versatile in recipes and on menus as they can be used in appetizers, soups, sides, salads, and as part of the main course. They add high levels of micronutrients and provide color, texture, and taste without adding excessive calories when prepared without additional fats and added sugars. In addition, fruit, vegetables, and whole grains contain many phytochemicals. Whole grains are more commonly found as flour and meal. Providing breads with whole grains can change the nature of the bread basket. Items made with whole grains offer different tastes and textures while increasing minerals and fiber.

Exhibit 5.13

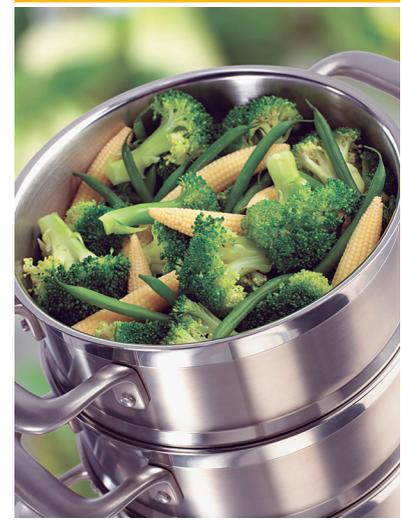


Exhibit 5.14

SOME FOOD ITEMS WITH KNOWN PHYTOCHEMICALS

Yellow and orange vegetables



Cruciferous vegetables (broccoli, cauliflower, and cabbage)



Citrus fruit



Onions



Garlic



Green tea



Wine



Soybeans



Leeks



Chives



SUPPLEMENTATION OF VITAMINS AND MINERALS

Although it is possible to obtain all necessary vitamins and minerals by following a healthy diet, Americans spend billions of dollars on vitamin and mineral supplements each year. There are some instances that require vitamin and mineral supplements; however, for healthy adults who are free of chronic disease, nothing more than a multivitamin is usually warranted.

Phytochemicals

It is best to obtain essential vitamins and minerals from food because food usually contains fiber and other substances such as phytochemicals. Although humans technically do not require phytochemicals in their diets, these substances may enhance the quality of life. Phytochemicals have a strong antioxidant effect and thus help protect the body from cancer and heart disease. Phytochemicals are found in food. For example, the isoflavones in soy are phytochemicals. When removed from food and offered in supplements, however, phytochemicals often show no positive effects. In fact, studies have shown some negative effects.

Cruciferous vegetables such as broccoli, cauliflower, and cabbage are rich in phytochemicals. *Exhibit 5.14* provides additional examples of food items that are known sources of various phytochemicals. Generally speaking, most fruits and vegetables contain at least one phytochemical.

Taking Vitamin and Mineral Supplements

Sometimes healthy people choose to take multivitamins as “insurance” to make sure they obtain all the vitamins and minerals they need each day. Supplements often occur in the form of a tablet, which usually contains synthetic forms of single or mixed vitamins and minerals. Vitamin tablets should be taken with a meal or snack to increase absorption. Otherwise the vitamins or minerals will likely be excreted in the urine and wasted.

There are times when the supplementation of vitamins and minerals is necessary. The major health conditions that call for vitamin supplementation, mineral supplementation, or both are discussed below. Although this is not a complete list, it provides an overview of the types of medical conditions that make supplementation necessary.

PREGNANCY AND BREAST-FEEDING

During pregnancy and breast-feeding, women need higher than normal amounts of some vitamins and minerals. For example, the B vitamin folate (or folic acid) is important for the prevention of neural-tube defects in infants. Spina bifida and cleft palate are examples of birth defects that result from inadequate folate intake during pregnancy.

Folic acid is added to prenatal vitamins for women whose intake is suboptimal and therefore puts the fetus at risk. The mineral iron is usually supplemented during pregnancy and breast-feeding as well. In addition, breast-feeding mothers may give their infant vitamin D supplements due to low supplies in breast milk.

IRON-DEFICIENCY ANEMIA

Individuals with iron-deficiency anemia lack sufficient iron in their blood. When a person is diagnosed with this disease, his or her physician may prescribe a daily iron tablet. Iron supplements should be taken only if prescribed by a physician, as excess iron can be harmful.

LOW-CALORIE DIETS AND CHRONIC DIETING

People who diet frequently or otherwise restrict their food consumption may also be restricting their vitamin and mineral intake. These people will benefit from a multivitamin that supplies the necessary vitamins and minerals that come from the food items they are not eating. Those who follow diets that eliminate an entire food group should also consider taking a multivitamin.

OSTEOPOROSIS

Calcium and vitamin D supplements are prescribed to people who have osteoporosis. They may also be prescribed to individuals who have a family history of osteoporosis in an effort to help prevent the disease.

VEGANS

Vegans are people who eliminate all animal products from their diet. They should supplement vitamin B₁₂ because it occurs only in animal products. Vegans might also need to supplement vitamin D, iron, and zinc. See chapter 9 for more information about vegan and other vegetarian diets.

THINK ABOUT IT . . .

Animal products provide vitamins and minerals. Vegans obtain some of these essentials via supplements. They also eat food that is high in the vitamins and minerals that are also found in animal products. What types of food should vegans add to their diets?

LACKING INTRINSIC FACTOR

Intrinsic factor is a protein needed for bodily absorption of vitamin B₁₂. In the aging process, a person may lose the ability to produce intrinsic factor and become deficient in vitamin B₁₂. Some types of abdominal surgery may also impact the body's ability to process this vitamin. In these instances, an individual should obtain a B₁₂ injection from a doctor for direct absorption into the bloodstream.

Potential for Toxicity

When people consume more calories than they need, the calories are stored as fat. In a similar way, more does not necessarily equal better when it comes to vitamins and minerals. In fact, excess amounts of vitamins and minerals can be toxic and thus detrimental to health. For example, vitamin A toxicity can cause a skin rash as well as hair loss, bone problems, birth defects, and even death.

It is difficult to get too many vitamins and minerals from whole unprocessed food. Fortified food can add to total vitamin and mineral intakes if eaten regularly. However, toxic amounts of vitamins and minerals are usually the result of the daily consumption of high-dose vitamin or mineral supplements. Usually, a toxic level of a vitamin or mineral is the result of supplementation in excess of 100 percent of the DV for that nutrient. This can happen either because the supplement contains more than 100 percent of the DV or because the supplement was taken more than once each day.

The best guide to follow when consuming vitamin and mineral supplements is the UL or Tolerable Upper Intake Level that is issued by the Food and Nutrition Board. This was discussed in chapter 3 and is shown in *Exhibits 5.8* and *5.9* earlier in this chapter. The UL values answer the question as to how much is too much with regard to vitamins and minerals. The UL is the highest level of daily nutrient intake that poses no risk of adverse health effects to almost all individuals. Some vitamins and minerals are beneficial up to a certain dosage, but at a higher level they are toxic and potentially harmful to the body. Because the fat-soluble vitamins are stored in adipose tissue, they are more likely to be toxic at excessive levels. Vitamin B₆, niacin, and vitamin C are potentially harmful water-soluble vitamins when consumed in excess. For example, high doses of vitamin C have been reported to help precipitate kidney stones. Keeping supplement intakes below the UL for each vitamin and mineral listed will decrease the risk of toxicity.

WATER IN THE DIET

Water is essential to the human body because it is involved in almost all of the chemical reactions that make the body work. The body needs a certain amount of water every day in order to function properly. Food and drink are the primary sources of water.

Water is the most abundant and important macronutrient in the body. It makes up about 60 percent of body weight. Water has many important roles in the body. It not only keeps people hydrated, or supplied with an ample amount of water, but also helps regulate body temperature, transports nutrients, makes up part of all cells, hydrates the skin, lubricates joints, and facilitates digestion, absorption, and excretion. Thirst is the mechanism that tells people they need water.

A lack of water in the body causes dehydration, or a deficiency of water in the body's cells and fluids. On the other hand, excess water can cause water intoxication, a condition in which there is too much water and not enough electrolytes in the body and which causes a shift in the amount of water in the cells. A rapid weight loss might be a sign of dehydration, whereas a rapid weight gain could indicate water intoxication. Both dehydration and water intoxication can be life threatening.

Water Requirements

According to U.S. dietary surveys, the daily Adequate Intake (AI) for water is 3.7 liters for men and 2.7 liters for women. These amounts account for water from all sources: food, beverages, and drinking water (*Exhibit 5.15*). Individual fluid needs vary according to physical-activity levels and prolonged exposure to high temperatures. More water is necessary for athletes during training and events because they need to reduce body temperature and make up fluid lost through sweating. Most people get enough water by letting thirst be their guide.

Restaurant and foodservice professionals should make liquids available at each meal. Drinking water can be included at the table with each individual place setting. Contrary to popular belief, beverages with caffeine are considered hydrating. Studies show that people who drink moderate amounts of coffee and tea do not get dehydrated. Beverages that contain alcohol, however, may actually increase a person's daily need for fluids because alcohol is **dehydrating**, meaning that it reduces the water available to the body by chemically causing fluid excretion. Additionally, alcohol contains calories but no other nutrients.

Exhibit 5.15



Hard and Soft Water

Hard water is water that contains large amounts of minerals such as calcium, magnesium, and sulfur. **Soft water** is water that contains minerals in smaller amounts. The distinction is mostly related to the interaction of soap with these minerals. Softened water is hard water that has had these minerals removed through a chemical process in a purification facility or water softener; it usually contains extra sodium or other minerals instead of the ones that make the water hard.

SUMMARY

1. Distinguish between water-soluble and fat-soluble vitamins.

Water-soluble vitamins dissolve in water but not in fat, and generally they are not stored in the body. Fat-soluble vitamins are soluble in fat but not in water, and they can be stored in the body's fat tissue.

2. Describe the functions, sources, and recommended intake amounts of vitamins and minerals in the body.

Both vitamins and minerals are essential to life, growth, and body maintenance. These substances either come from food or are produced within the body. The functions of specific vitamins and minerals are explained throughout the chapter.

Food should be the source of our nutrients. The fat-soluble vitamins have both plant and animal sources. For example, vitamin A comes from dairy products and the precursor beta-carotene comes from orange vegetables like squash and carrots. Many of the B vitamins, such as thiamin, riboflavin, and niacin, are found in enriched and whole-grain products. Vitamin B₁₂ is found only in animal products. Calcium is found in good amounts in milk. Potassium is found in both fruits and vegetables, with bananas and potatoes being good sources. For a full list, refer back to *Exhibits 5.4* and *5.7*.

The UL is the DRI value that will indicate if a person needs to reduce the amount of vitamins and minerals they are consuming. Consuming too many vitamins and minerals can be harmful to health. Whole food and fortified food can contribute to total vitamin and mineral consumption. Toxic amounts of each are usually the result of taking high-dose supplements every day.

3. Identify causes and implications of nutritional deficiencies.

Nutritional deficiencies occur when people ingest less than the recommended amounts of vitamins, minerals, or other nutrients. Iron-deficiency anemia and osteoporosis are examples of deficiencies of iron and calcium, respectively. Nutrient deficiencies can lead to stunted growth, weight loss, a weakened immune system, and disease.

4. Identify the recommended sodium intake and the implications of high-sodium diets.

The recommendation for sodium for healthy adults is twenty-three hundred milligrams per day. People who are over 51 years of age, of African-American descent, or affected by hypertension, diabetes, or chronic kidney disease should consume no more than fifteen hundred milligrams daily. High sodium intake increases the risk of developing hypertension, or high blood pressure.

5. Identify ways to retain the vitamin and mineral content of food when cooking.

The best way to retain vitamins and minerals is to cook food for a short time. Steaming, microwaving, and stir-frying are three good cooking methods to preserve vitamins and minerals. To prevent leaching of vitamins or minerals, do not soak vegetables. Instead, rinse them thoroughly and drain.

6. Determine when it is appropriate to take supplemental vitamins and minerals.

There are some circumstances in which an individual should take a vitamin or mineral supplement to get sufficient levels of a nutrient. Examples of these circumstances are pregnancy and breast-feeding, iron-deficiency anemia, vitamin B₁₂ deficiency, and osteoporosis.

7. Describe the recommended intake amounts and functions of water in the body.

Water keeps the body hydrated, regulates body temperature, transports nutrients, makes up part of all cells, hydrates the skin, lubricates joints, and facilitates digestion, absorption, and excretion. It also participates in the body's chemical reactions.

Dehydration causes a deficiency of water in the body's cells and fluids. Overhydration causes water intoxication, a condition in which there is too much water and not enough electrolytes in the body and which causes a shift in the amount of water in the cells. Both dehydration and water intoxication can be life threatening.

The AI for water each day is 3.7 liters for men and 2.7 liters for women. These figures include water from all sources: food, beverages, and drinking water. Individual fluid needs vary according to physical activity and exposure to high temperatures.



APPLICATION EXERCISES

Exercise 1

Select a meal from a restaurant and decide what portion sizes should be served for each item. Then navigate to the MyPlate Web site at www.choosemyplate.gov. Enter the items in the portions you have selected to determine how many vitamins and minerals a person will ingest with this particular meal. What percentages of the vitamin and mineral DRIs does the meal provide?

Exercise 2

Make a list of food items that you think could improve the number and amounts of vitamins and minerals on the menu at the restaurant you chose for Exercise 1. What would the new menu items cost the operation? What staff changes or other operational changes would need to be made in order to produce and serve the items? How do you think customers would react to your changes? How would these items sell?



REVIEW YOUR LEARNING

Select the best answer for each question.

- 1. What deficiency disease occurs in children who lack vitamin D?**

 - Xerophthalmia
 - Osteoporosis
 - Rickets
 - Scurvy
- 2. According to the Dietary Guidelines for Americans 2010, the maximum daily recommended sodium intake for a healthy adult is**

 - 1,000 milligrams.
 - 1,300 milligrams.
 - 2,000 milligrams.
 - 2,300 milligrams.
- 3. The primary function of the three B vitamins, thiamin, riboflavin, and niacin, is to**

 - serve as a coenzyme in energy metabolism.
 - act as an antioxidant to combat cell damage.
 - synthesize DNA inside the body's cells.
 - enable blood clotting in small wounds.
- 4. The primary function of vitamin C is to**

 - synthesize protein.
 - act as a coenzyme.
 - act as an antioxidant.
 - enable blood clotting.
- 5. What substance can bind calcium and make it unavailable for absorption?**

 - Purine
 - Tocopherol
 - Oxalate
 - Manganese
- 6. What is a good source of vitamin B₁₂?**

 - Corn
 - Rice
 - Tofu
 - Meat

7. Which mineral performs functions that include blood-pressure regulation, muscle contraction, and nerve transmission?
 - A. Calcium
 - B. Fluoride
 - C. Manganese
 - D. Phosphorus

8. The primary function of water in the body is to
 - A. synthesize collagen.
 - B. release free radicals.
 - C. maintain body temperature.
 - D. act as a coenzyme for energy metabolism.

9. What is one way to retain the vitamin and mineral content of food during cooking?
 - A. Extend cooking time.
 - B. Minimize cooking time.
 - C. Avoid microwaving food.
 - D. Soak vegetables before cooking.

10. What is the most common nutritional deficiency in the world?
 - A. Scurvy
 - B. Osteoporosis
 - C. Iron-deficiency anemia
 - D. Degeneration of the retina