CHAPTER 1



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Nutrition: Food for Health

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CHAPTER OUTLINE

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Case Study


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Kaitlyn peered into the mini fridge in her dorm room looking for something to eat. The only thing she had was some leftover pizza and a couple of cookies. Kaitlyn had been in classes and then at work until late in the evening, so when she finally sat down to study, she realized that she had completely forgotten to eat dinner. She needed to eat something to keep her going until she finished that chapter in her nutrition book, but her dorm offered few food choices late at night. After finishing the pizza, Kaitlyn headed down the hall to get a bag of potato chips and an energy drink from the vending machine. She knew that they weren't a good choice, but they were her only option.

As a college freshman away from home for the first time, Kaitlyn has gained a few pounds and is beginning to be concerned about her weight. Her father recently suffered heart problems, and her mother takes medication for high blood pressure. Kaitlyn knows that because of this family history her diet is particularly important for her future health. Though the dorm cafeteria offers a variety of choices, Kaitlyn never learned how to choose a healthy diet. She wants to keep healthy foods in her refrigerator, but never takes time to go to the store.

Several of Kaitlyn's friends have started taking supplements like Mega B to give them more energy and ginkgo biloba to improve their memories. She is tempted to start taking them, but she's not sure the claims about them are true. **To optimize her health, Kaitlyn needs to learn the basics of nutrition science and perfect the art of making nutritionally sound decisions and healthy food choices—a goal that is a little overwhelming at first.**

1.1 Nutrition, Food Choices, and the American Diet

LEARNING OBJECTIVES

- Identify factors that affect our food choices.
- Describe two ways in which our food and eating patterns have changed during the past 50 years.
- Name two foods or nutrients that Americans over- or underconsume.

nutrition A science that studies the interactions between living organisms and food.

nutrients Substances in foods that provide energy and structure and help regulate body processes.

Nutrition is a science that studies all the interactions that occur between living organisms and food. Food provides **nutrients** and energy, which are needed to keep us alive and healthy, to support growth and to allow reproduction. Which foods we choose determine the nutrients we get, which in turn affects how healthy we are. Many factors affect our food choices, and despite an abundant food supply Americans today don't always choose the right combination of foods to optimize nutritional health.

Why We Eat What We Eat

Our food choices are affected by more than our nutrient needs. We choose what we eat based on what is available to us, what we have learned to eat from our family and cultural traditions, what foods appeal to us for emotional reasons, and what our personal preferences are, whether based on what we enjoy or what we think we should eat.

food environment The physical, economic, and social factors that affect eating habits and patterns.

Availability The food available to an individual or a population is affected by the **food environment**, which includes factors such as access to grocery stores and restaurants, the products available in these stores and restaurants, food pricing, and food advertising (**Figure 1.1**). Economic status and health also affect what foods are available.



David McNew/Staff/Getty Images

FIGURE 1.1 Our food environment affects our food choices When fast food restaurants dominate the landscape, the availability, affordability, and familiarity of these foods result in increased consumption.

In developing parts of the world, dietary choices are often limited to foods produced locally. Nutrients that are lacking in local foods will be lacking in the population's diet. This is less of a factor in more-developed countries because the ability to store, transport, and process food allows year-round access to seasonal foods and foods grown and produced at distant locations.

Even if foods are available in the store, it doesn't mean that they are available to all individuals. Socioeconomic factors such as income level, living conditions, and education affect the types and amounts of foods to which people have access. Individuals with limited incomes can choose only the types and amounts of foods that they can afford. Individuals who don't own cars can purchase only what they can carry home. Those without refrigerators or stoves are limited in what foods can be prepared at home. And those who can't or don't have time to cook are limited to raw foods, prepared foods, and restaurant meals.

Health status also affects the availability of food. People who cannot carry heavy packages are limited in what they can purchase. People with food allergies, digestive problems, and dental disease are limited in the foods that are safe and comfortable for them to eat. People consuming special diets to manage disease conditions are limited to foods that meet their dietary prescriptions.

Social and Cultural Considerations

Food preferences and eating habits are learned as part of each individual's family, cultural, national, and social background (**Figure 1.2**). They are among the oldest and most entrenched features of every culture. In Japan rice is the focus of the meal, whereas in Italy, pasta is included with every meal. Curries characterize Indian cuisine, and we expect refried beans and tortillas when we go out for Mexican food.

Social, religious, and cultural traditions also affect what foods we choose. Each of us associates holidays such as Christmas, Easter, Passover, New Year's Day, and Kwanzaa with specific foods that are traditional in our family, religion, and culture. Seventh-Day Adventists espouse vegetarianism; Jews and Muslims do not eat pork; Sikhs and Hindus do not eat beef.

In addition to being part of our cultural heritage, food is the centerpiece of our everyday social interactions. We get together with friends for a meal or for a cup of coffee and dessert. The dinner table is often the focal point for communication within the family—a place where the experiences of the day are shared. Social events dictate our food choices in a number of ways. When invited to a friend's house for dinner, we may eat foods we don't like out of politeness to our hosts. We also sometimes alter our food choices because of peer pressure (**Figure 1.3**).



AFP/Getty Images

FIGURE 1.2 Culture dictates food acceptability If you grew up in Asia or Africa, you might consider grasshoppers, termites, or the silkworms in this Vietnamese market to be an acceptable food choice. Most Americans would not be willing to include insects as part of a meal.



Blend Images/Moxie Productions/Getty Images

FIGURE 1.3 Peer pressure affects food intake For an adolescent, having pizza after school may be an important part of being accepted by his or her peers.

Psychological and Emotional Factors

Food represents comfort, love, and security. Comfort foods such as hot tea and chicken soup help us to feel better when we are sick, sad, tired, or lonely. We use food as a reward when we are good—A's on a report card are celebrated with an ice cream cone. We sometimes take away food as punishment—a child who misbehaves is sent to bed without dessert. We celebrate milestones and reward life's accomplishments with food. Food may also be an expression and a moderator of mood and emotional states. When we are upset, some of us turn to chocolate or overeat in general, while others eat less or stop eating altogether.

Personal Preference

We eat what we like. Tradition, religion, and social values may dictate what foods we consider appropriate, but personal preferences for taste, smell, appearance, and texture affect which foods we actually consume. How would you feel about giving up your favorite foods? Probably not too good, and you are not alone. Even though most Americans understand that nutrition is important to their health, many do not choose a healthy diet because they don't want to give up their favorite foods and they don't want to eat foods they don't like.[1] Personal convictions also affect food choices; a vegetarian would not choose a meal that contains meat, and a person concerned about the environment may not buy foods packaged in nonrecyclable containers.

Individuals' perceptions about food and health also affect their food and nutrition choices. Some people may choose low-carbohydrate foods because they think these choices will help them lose weight. Others may limit red meat intake to reduce their risk of heart disease, or may purchase organically produced foods if they believe that reducing pesticide exposure will prevent illness.

food processing The practices used by the food industry to transform raw plant and animal materials, such as grains, produce, meat, and milk, into products for consumers. Nearly all our food has been processed in some way.

Food in 21st-Century America

For much of human history, people needed to spend most of their day obtaining food and preparing meals in order to get enough to eat. Even a generation ago, the time spent for meal preparation was measured in hours—hours spent peeling, chopping, baking, roasting, stewing, and then cleaning. Today, our homes are stocked with an endless assortment of foods available at a moment's notice. Many of these choices are foods that have been part of the human diet for centuries—fresh fruits and vegetables, milk, breads, and cereals. But others are newer additions created through **food processing**: frozen vegetables complete with sauce, dried soups and noodle bowls, pre-cooked packaged meats, frozen prepared meals, and an endless array of sweet and savory snack foods.

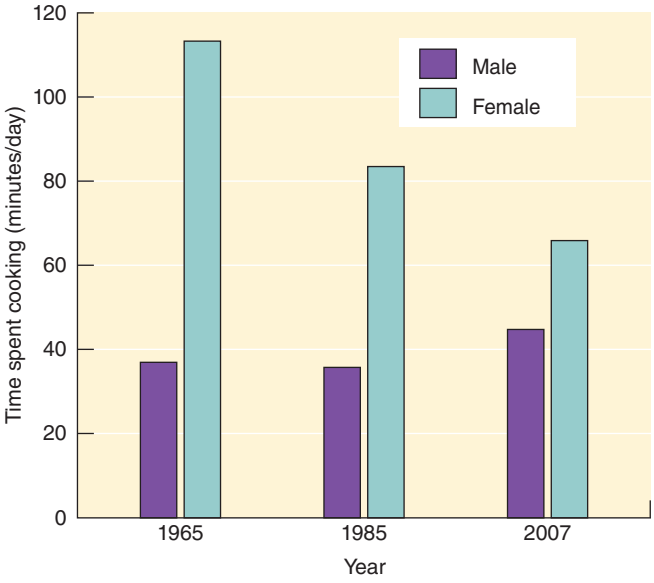
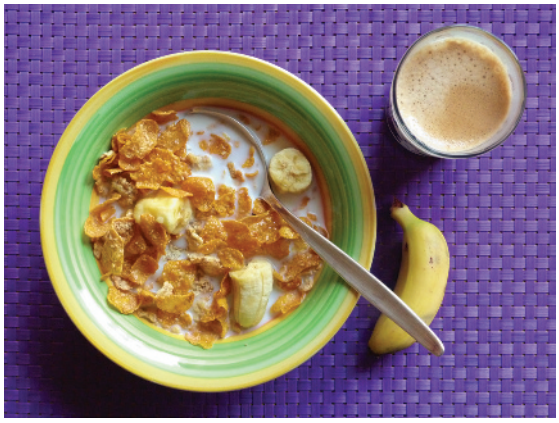


FIGURE 1.4 Time spent cooking Since the 1960s, the amount of time women spend cooking has decreased significantly. Due to other social changes, the amount of time men spend cooking has increased slightly.[2]

In addition to our food choices, our eating patterns have changed. Fifty years ago people ate most of their meals at home, with their families, at a leisurely pace. Today, more single-parent households and families with both parents working mean no one is home in the afternoon to prepare an evening meal. Dinner is a rush because busy after-school schedules impinge on family mealtimes. Fewer people today even know how to prepare a full meal, so shoppers of all ages are choosing to buy more convenient, processed foods that can be boiled or heated in the microwave rather than raw ingredients that need to be chopped, seasoned, and cooked (**Figure 1.4**).[2] These convenience foods have expanded our choices for meals at home and Americans are replacing more and more home-cooked meals with take-out food and meals eaten away from home. These meals tend to be higher in calories than foods prepared at home; almost a third of our calories currently come from meals eaten away from home.[3]

Breakfast at home
A cup of coffee with whole milk and sugar and a cup of whole grain cereal with low-fat milk and a half a banana would cost about $1.00 and provide about 350 kcalories.

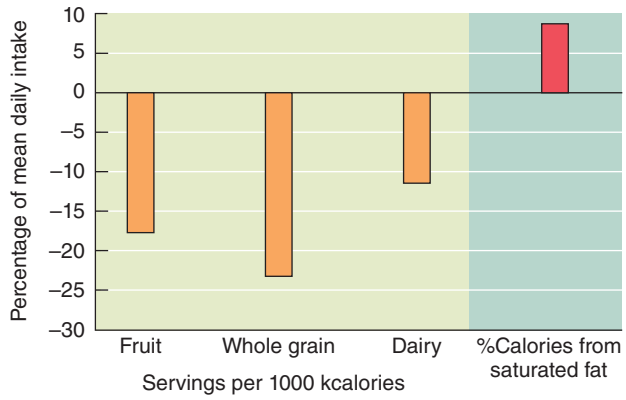


P. Langen/Getty Images

Breakfast out
A 16-ounce caramel mocha and a blueberry muffin at Dunkin' Donuts or the corner coffee bar would cost about $4 and provide about 770 kcalories.



P. Mittongtare/FoodPix/Getty Images



Dietary impact of eating breakfast away from home

On average, breakfast away from home decreases the number of servings of whole grains, fruit, and dairy consumed per 1000 kcalories and increases the percentage of calories from saturated fat.[4]

FIGURE 1.5 The costs of convenience If you stop for a muffin and coffee on your way to work or school, you can save a couple of minutes, but you may pay a higher price than you think in terms of both dollars and nutrient intake. The impact of stopping for coffee and a muffin once in a while when you are running late is minimal, but making this an everyday habit can break your dollar and calorie budget and affect the quality of your overall diet.

Think Critically

iProfile

Use iProfile to plan a 500-kcal lunch that you can prepare at home. How does the amount of food compare with 500 kcalories of food from a typical fast-food restaurant?

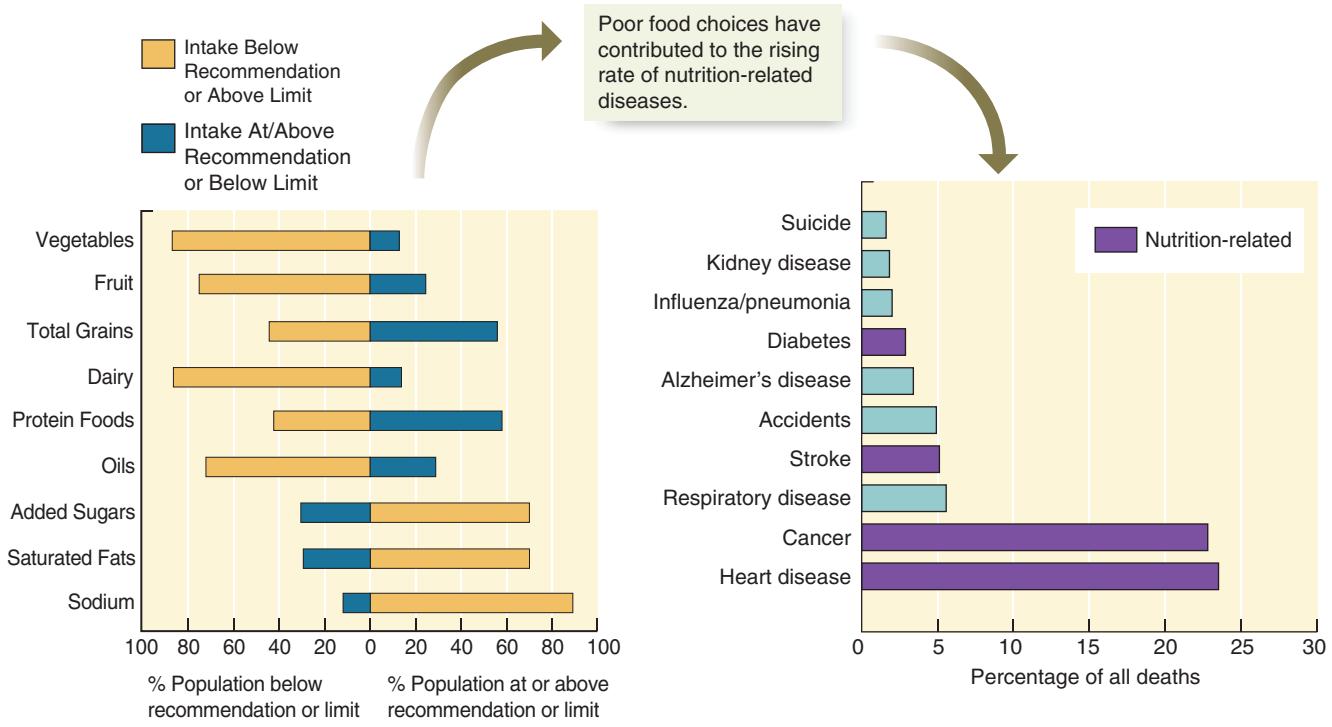
These changes in our food environment have made it easier and faster to obtain a meal or snack on the run, but the foods we choose are lower in whole grains, milk, fruits, and vegetables and higher in unhealthy saturated fat than the choices we make at home (**Figure 1.5**).[4] Over the past century, the major nutrition concerns in the United States have shifted from providing enough nutrients to meet people's needs to limiting overconsumption and reducing the incidence of chronic diseases related to excesses of energy and certain nutrients.

How Healthy Is the American Diet?

The American diet isn't as healthy as it could be. As it has become easier to obtain and prepare food, the amount of food we eat has increased. American adults eat more calories than they did 50 years ago primarily due to larger portion sizes, especially from fast foods, and an increase in the frequency of snacking and calories consumed from those snacks.[5,6] As a result, over two-thirds of American adults weigh more than they should.[7]

In addition to eating more calories than we need, we are not eating enough of the foods that make up a healthy diet. Recommendations suggest a diet based on whole grains, vegetables, and fruits, with smaller amounts of low-fat dairy products and lean meats and limited amounts of sweets and certain types of fats, such as saturated fat.[5] As a population, we don't eat enough whole grains, vegetables, fruits, seafood, or dairy products. We frequently choose French fries for a vegetable and consume few nutrient-rich dark green and deep yellow vegetables. Our diets are high in snack foods and desserts that supply us with more salt (sodium)

FIGURE 1.6 Our current diet increases our health risks



a. The current U.S. dietary pattern is not as healthy as it could be. The graph shows how the typical American diet compares with recommendations for various food groups and dietary components.

b. The graph shows the leading causes of death in the United States; those shown in purple are nutrition related.[9]

and sugar than is recommended (**Figure 1.6a**).[5] Instead of milk, we are choosing sweetened beverages, especially carbonated soft drinks and fruit drinks.[8] This dietary pattern, along with a lack of physical activity, increases the risk of developing chronic diseases such as diabetes, obesity, heart disease, and cancer, which are the most common, costly, and preventable of all health problems in the United States (**Figure 1.6b**).[9–11] Recommendations for reducing disease risk focus on changes in the foods we choose and the amount of exercise we get.[5,12]

A healthy diet does not need to exclude processed convenience foods, but it must involve wise choices. To choose a healthy diet that provides the right amounts of energy and each nutrient, we need to understand how our bodies obtain nutrients from food, which nutrients are essential, how much we need, and which foods provide healthy sources of nutrients. We also need to recognize which nutrition information to believe.

1.2 Food Provides Nutrients

LEARNING OBJECTIVES

- Define the term *essential nutrient* and list the six classes of nutrients.
- Describe the three general functions of nutrients.
- Discuss how nutrition can affect your health in the short term and in the long term.

essential nutrient A nutrient that must be provided in the diet because the body either cannot make it or cannot make it in sufficient quantities to satisfy its needs.

To date, approximately 45 nutrients have been determined to be essential to human life. **Essential nutrients** must be supplied in the diet to support life; they either cannot be made by the body or cannot be made in large enough quantities to meet needs. For example, our bodies cannot synthesize vitamin C, but we need it to stay healthy. If we do not consume vitamin C in the foods we eat, we will begin to show signs of a vitamin C deficiency. If vitamin C is not added back into the diet, the vitamin C deficiency will eventually be fatal.

Our intake of essential nutrients is determined by our food choices. Some foods are naturally high in nutrients, and some contain nutrients added during processing. Foods to which nutrients have been added are called **fortified foods**. Some fortified foods, such as milk with added vitamin A and **enriched grains**, have been a part of our food supply for decades. The government mandated the fortification of these foods to eliminate nutrient deficiencies in the population, and the amounts and types of nutrients added are specified. Other foods, such as orange juice with added calcium and flavored water with added vitamins and minerals, are not part of mandated fortification programs. These foods are fortified with nutrients to increase sales by meeting consumer demand for nutrient-rich foods. The amounts and types of nutrients added to these foods are at the discretion of the manufacturer. **Dietary supplements** are another source of nutrients in the American food supply. National surveys indicate that 71% of adults in the United States take dietary supplements, and vitamin and mineral supplements are the most popular category.[13]

In addition to nutrients, food contains substances that are needed by the body but are not essential in the diet. Lecithin, for example, is a substance found in egg yolks that is needed for nerve function. It is not considered an essential nutrient because it can be manufactured in the body in adequate amounts. The diet also contains substances that are not made by the body and are not necessary for life, but that have health-promoting properties. Those that come from plants are called **phytochemicals**; those that come from animal foods are called *zoochemicals*. For example, a phytochemical found in broccoli called sulforaphane is not essential in the diet but has effects in the body that may help reduce the risk of cancer.

fortified food Food to which one or more nutrients have been added.

enriched grains Grain products to which specific amounts of thiamin, riboflavin, niacin, and iron have been added. Since 1998 folic acid has also been added to enriched grains.

dietary supplement A product intended for ingestion in the diet that contains one or more of the following: vitamins, minerals, plant-derived substances, amino acids, and concentrates or extracts.

phytochemical A substance found in plant foods (*phyto-* means plant) that is not an essential nutrient but may have health-promoting properties.

energy-yielding nutrient A nutrient that can be metabolized to provide energy in the body.

macronutrient A nutrient needed by the body in large amounts. These include water and the energy-yielding nutrients: carbohydrates, lipids, and proteins.

micronutrient A nutrient needed by the body in small amounts. These include vitamins and minerals.

organic molecule A molecule that contains carbon bonded to hydrogen.

inorganic molecule A molecule that contains no carbon–hydrogen bonds.

kilocalorie (kcal, kcalorie) The unit of heat used to express the amount of energy provided by foods. It is the amount of heat required to raise the temperature of 1 kg of water 1 degree Celsius (1 kcal = 4.18 kJ).

kilojoule (kJ, kjoule) A unit of work that can be used to express energy intake and energy output. It is the amount of work required to move an object weighing 1 kg a distance of 1 meter under the force of gravity (1 kJ = 0.24 kcal).

legumes Plants in the pea or bean family that produce an elongated pod containing large starchy seeds. Green peas, kidney beans, and peanuts are legumes.

The Six Classes of Nutrients

Chemically, there are six classes of nutrients: carbohydrates, lipids, proteins, water, vitamins, and minerals. These classes can be grouped in a variety of ways—by whether they provide energy to the body, by how much is needed in the diet, and by their chemical structure. Carbohydrates, lipids, and proteins provide energy and thus are referred to as **energy-yielding nutrients**. Alcohol also provides energy but is not considered a nutrient because it is not needed to support life (see Focus on Alcohol). Along with water, the energy-yielding nutrients constitute the major portion of most foods and are required in relatively large amounts by the body. Therefore, they are referred to as **macronutrients** (*macro-* means large). Their requirements are measured in kilograms (kg) or grams (g). Vitamins and minerals are classified as **micronutrients** because they are needed in small amounts in the diet (*micro-* means small). The amounts required are expressed in milligrams (1 mg = 1/1000 g) or micrograms (1 μg = 1/1,000,000 g) (see Appendices A and I). Structurally, carbohydrates, proteins, lipids, and vitamins are **organic molecules**, so they are referred to as *organic nutrients*. Minerals and water are **inorganic molecules**, so they are referred to as *inorganic nutrients*.

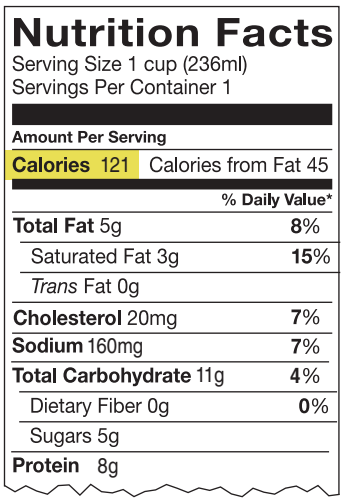
The Energy-Yielding Nutrients

The energy provided by carbohydrates, lipids (fats), and proteins is measured in **kilocalories** (abbreviated kcal or kcalories) or in **kilojoules** (abbreviated kJ or kjoules). The more common term, calorie (lowercase *c*), is technically 1/1000 of a kilocalorie, but when spelled with a capital *C*, Calorie means a kilocalorie (**Figure 1.7**). In the popular press, calorie (small *c*) is often used to express the kilocalorie content of a food or diet.

Carbohydrates provide a readily available source of energy to the body. They contain 4 kcal/g (see Figure 1.7). Carbohydrates include sugars such as those in table sugar, fruit, and milk, and starches such as those in vegetables, **legumes**, and grains. Sugars are the simplest form of carbohydrate, and starches are more complex carbohydrates made of many sugars linked together. Most fiber is also carbohydrate. Fiber cannot be digested and therefore provides very little energy. However, it is important for gastrointestinal health. Fiber is found in vegetables, fruits, legumes, and whole grains.

Lipids, commonly called fats and oils, provide 9 kcal/g. They are a concentrated source of energy in food and a lightweight storage form of energy in the body. Several types of lipids are important in nutrition. Triglycerides are the type that is most abundant in foods and in the body. The fat on the outside of a steak, the butter and oil that is added to food during cooking,

The grams of carbohydrate, fat, and protein determine the number of kcalories in a food.



Energy Provided by Macronutrients and Alcohol

	Kcalories/gram	Kjoules/gram
Carbohydrate	4	16.7
Protein	4	16.7
Fat	9	37.6
Alcohol	7	29.3

FIGURE 1.7 Calories in foods The term "Calories" listed near the top of the Nutrition Facts panel technically refers to the number of kilocalories in a serving of the food. A recent revision to the Nutrition Facts panel presents Calories more prominently (see Chapter 2). The Calories shown on food labels are equal to the total number of kilocalories provided by the grams of carbohydrate, fat, protein, and alcohol in a serving. The number of kilocalories in a serving of the food from the label shown here can be calculated as follows: (5 g fat × 9 kcal/g) + (11 g carbohydrate × 4 kcal/g) + (8 g protein × 4 kcal/g) = 121 kcal per serving.

and the layer of fat under a person's skin are all composed almost entirely of triglycerides. Triglycerides are made up of fatty acids. Different types of fatty acids have different health effects. Diets high in saturated fatty acids increase the risk of heart disease, whereas those high in unsaturated fatty acids may reduce these risks. Cholesterol is another type of lipid; high levels in the blood can increase heart disease risk (see Chapter 5).

Protein is needed for growth and maintenance of body structures and to regulate and facilitate body processes. It can also be used to provide energy—4 kcal/g. Meat, fish, poultry, eggs, milk, grains, vegetables, and legumes all provide protein. Like carbohydrate and lipid, protein is not a single substance. There are thousands of different proteins in the human body and in the diet. All of these are made up of units called amino acids. Different combinations of amino acids are linked together to form different types of proteins. Some amino acids can be made by the body, and others are essential in the diet. The proteins in animal products better match our need for amino acids than do plant proteins, but both plant and animal proteins can provide all the amino acids we need.

Examples of food sources of carbohydrates, lipids, and proteins and the general structures of starch, triglycerides, and proteins and are shown in **Figure 1.8**.

Water

Unlike the other classes of nutrients, water is only a single substance. Water makes up about 60% of an adult's body weight. Because we can't store water, the water the body loses must constantly be replaced by water obtained from the diet. In the body, water acts as a lubricant, a transport fluid, and a regulator of body temperature, among other functions.

Micronutrients

Vitamins and minerals are needed in small amounts. Vitamins are organic molecules that do not provide energy but are needed to regulate body processes. Thirteen substances have been identified as vitamins. Each has a different structure and provides a unique function in the body. Many are involved in providing energy from carbohydrates, lipids, and proteins; others function in processes such as bone growth, vision, blood clotting, oxygen transport, and tissue growth and development.

Minerals are inorganic molecules. Like vitamins, they do not provide energy. Many have regulatory roles, and some are important structurally. They are needed for bone strength, the transport of oxygen, the transmission of nerve impulses, and numerous other functions. Requirements have been established for many of the minerals, but some are required in such small amounts that their role in maintaining health is still not fully understood.

FIGURE 1.8 Carbohydrates, lipids, and proteins



Jeffrey Coolidge/Getty Images, Inc.

a. Carbohydrates include sugars, starches, and fiber. Pasta, rice, and bread contain mostly starch; whole-grain bread, oatmeal, and popcorn are high in fiber; and cookies, cakes, and sweetened beverages are high in added sugar.



Charles D. Winters/Science Source

b. Most of the lipids we consume in our food are triglycerides; each contains three fatty acids. Plant sources of triglycerides in our diet include vegetable oils, avocados, olives, and nuts. Animal sources of triglycerides include cream, butter, meat, and whole milk; these animal foods also provide cholesterol.



Jeffrey Coolidge/Getty Images, Inc.

c. Proteins are made of amino acids linked together. The proteins we obtain from animal foods, such as meat, fish, and eggs, better match our amino acid needs than do most individual plant proteins, such as those found in grains, nuts, and beans. However, when plant sources of protein are combined, they can provide all the amino acids we need.

Vitamins and minerals are found in most foods. Fresh foods are a good natural source, and many processed foods are fortified with vitamins and minerals. Food processing and preparation can also cause vitamin losses because some vitamins are destroyed by exposure to light, heat, and oxygen. Minerals are more stable but can still be lost along with vitamins when food components are separated during processing and in the water used in cooking and processing.

What Nutrients Do

Together, the macronutrients and micronutrients provide energy, structure, and regulation, which are needed for growth, maintenance and repair, and reproduction. Each nutrient provides one or more of these functions, but all nutrients together are needed to maintain health (**Figure 1.9**).

Nutrients Provide Energy

Inside the body, biochemical reactions release the energy contained in carbohydrates, lipids, and proteins. Some of this energy is used to synthesize new compounds and maintain basic body functions, some is used to fuel physical activity, and some is lost as heat. When the energy in the carbohydrates, lipids, and proteins consumed in the diet is not needed immediately, it can be stored, primarily as body fat. These stores can provide energy when dietary sources are unavailable. Over the long term, if more energy is consumed than is needed, body fat stores enlarge and body weight increases. If less energy is consumed than is needed, the body will burn its fat stores to meet its energy needs and body weight will decrease.



Wendy Hope/Stockbyte/Getty Images, Inc.

When body temperature increases, sweat is produced, cooling the body as the water evaporates from the skin.

Function	Nutrient	Example
Energy	Carbohydrate	Glucose is a carbohydrate that provides energy to body cells.
	Lipid	Fat is the most plentiful source of stored energy in the body.
	Protein	Protein consumed in excess of protein needs will be used for energy.
Structure	Lipid	Lipids are the principal component of the membranes that surround each cell.
	Protein	Protein in connective tissue holds bones together and holds muscles to bones. Protein in muscles defines their shape.
	Minerals	Calcium and phosphorus are minerals that harden teeth and bones.
Regulation	Lipid	Estrogen is a lipid hormone that helps regulate the female reproductive cycle.
	Protein	Leptin is a protein that helps regulate the size of body fat stores.
	Carbohydrate	Sugar chains attached to proteins circulating in the blood signal whether the protein should remain in the blood or be removed by the liver.
	Water	Water in sweat helps cool the body to regulate body temperature.
	Vitamins	B vitamins regulate the use of macronutrients for energy.
	Minerals	Sodium is a mineral that helps regulate blood volume.

FIGURE 1.9 Nutrients provide energy, form structures, and regulate body processes

Nutrients Form Structures

With the exception of vitamins, all the classes of nutrients are involved in forming and maintaining the body's structure (**Figure 1.10**). Fat deposited under the skin contributes to our body shape, for instance, and proteins form the ligaments and tendons that hold our bones together and attach our muscles to our bones. Minerals harden bone. Proteins and water make up the structure of the muscles, which help define our body contours, and proteins and carbohydrates form the cartilage that cushions our joints. On a smaller scale, lipids, proteins, and water form the structure of individual cells. Lipids and proteins make up the membranes that surround each cell, and water and dissolved substances fill the cells and the spaces around them.

Nutrients Regulate Body Processes

All six classes of nutrients play important roles in regulating body processes (see Figure 1.9). To maintain life, body temperature, blood pressure, blood sugar level, and hundreds of other parameters must be kept relatively constant, a condition referred to as **homeostasis**. Maintaining homeostasis involves thousands of chemical reactions and physiological processes. Together all of the chemical reactions that occur in the body are referred to as **metabolism**. Proteins, vitamins, and minerals are regulatory nutrients that help control how quickly metabolic reactions take place throughout the body. Lipids and proteins are needed to make regulatory molecules that stimulate or inhibit various body processes.

homeostasis A physiological state in which a stable internal body environment is maintained.

metabolism The sum of all chemical reactions that take place in a living organism.

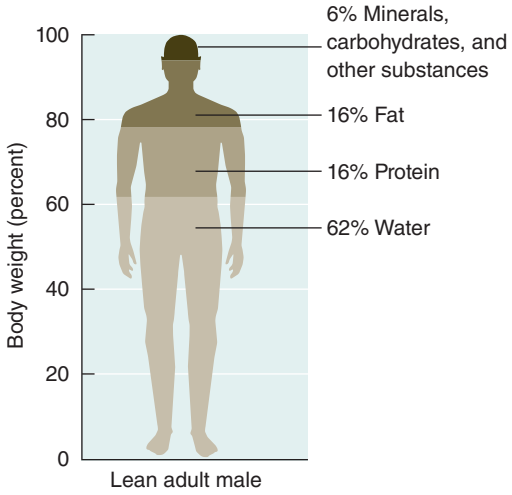


FIGURE 1.10 Composition of the human body Minerals, carbohydrate, fat, protein, and water all contribute to the shape and structure of our bodies.

1.3 Nutrition and Health

LEARNING OBJECTIVES

- Define *malnutrition*.
- Discuss how under- and overnutrition can affect your health in the short term and in the long term.
- Discuss how the genes you inherit affect the impact your diet has on your health.
- Define *nutrient density*.
- Explain the importance of variety, balance, and moderation in selecting a healthy diet.

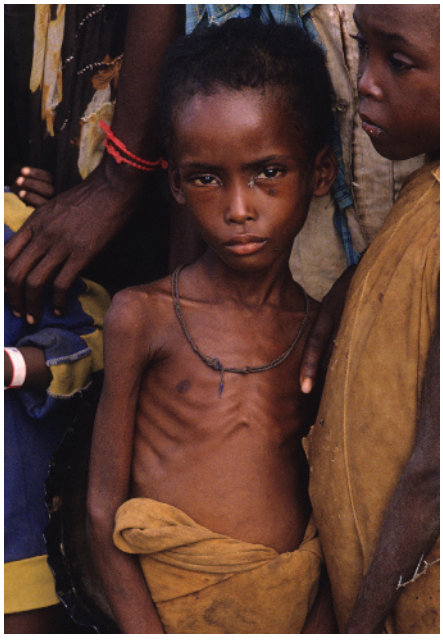
What we eat has an enormous impact on how healthy we are now and how likely we are to develop chronic diseases like heart disease, obesity, and diabetes in the future. Consuming either too little or too much of one or more nutrients or energy will cause **malnutrition**. Malnutrition can affect our health today and can impact our health 20, 30, or 40 years from now. Avoiding malnutrition and nutrition-related diseases requires choosing a dietary pattern that meets our nutrient and energy needs. The pattern that is optimal varies from person to person depending on the individual's genetic makeup.

malnutrition Any condition resulting from an energy or nutrient intake either above or below that which is optimal.

How Undernutrition Affects Health

Undernutrition is a form of malnutrition caused by a deficiency of energy or nutrients. It may be caused by a deficient intake, increased requirements, or an inability to absorb or use nutrients. Starvation, the most severe form of undernutrition, is a deficiency of energy that causes weight loss, poor growth, the inability to reproduce, and if severe enough, death (**Figure 1.11a**).

undernutrition Any condition resulting from an energy or nutrient intake below that which meets nutritional needs.



Wesley Bocxe/Photo Researchers, Inc.

a. The symptoms of starvation, the most obvious form of undernutrition, occur gradually over time when the energy provided by the diet is too low to meet the body's needs. Body tissues are broken down to provide the energy to support vital functions, resulting in loss of body fat and wasting of muscles.



© Dennis MacDonald/Age Fotostock America, Inc.

b. Obesity is a form of overnutrition that occurs when energy intake surpasses energy expenditure over a long period, causing the accumulation of an excessive amount of body fat. Today over a third of adults and an estimated 17% of U.S. children and adolescents ages 2 to 19 years have so much excess body fat that they are classified as obese.[7]

FIGURE 1.11 Starvation and obesity are both forms of malnutrition

Deficiencies of individual nutrients can also cause serious health problems. The symptoms of nutrient deficiencies often reflect the functions of the deficient nutrient. For example, vitamin A is necessary for vision; a deficiency of vitamin A can result in blindness. Vitamin B_{12} is needed for normal nerve function. A deficiency of this vitamin, which is more common in older adults because absorption often decreases with age, causes numbness, tingling, and other neurological symptoms.

Some nutrient deficiencies cause symptoms quickly. In only a matter of hours, an athlete exercising in hot weather may become dehydrated due to a deficiency of water. Drinking water relieves the headache, fatigue, and dizziness caused by dehydration almost as rapidly as these symptoms appeared. Other nutritional deficiencies may take much longer to become apparent. Symptoms of scurvy, a disease caused by a deficiency of vitamin C, appear after months of deficient intake; osteoporosis, a condition in which the bones become weak and break easily, occurs after years of consuming a calcium-deficient diet.

How Overnutrition Affects Health

overnutrition Poor nutritional status resulting from an energy or nutrient intake in excess of that which is optimal for health.

Overnutrition, an excess of energy or nutrients, is also a form of malnutrition. When excesses of specific nutrients are consumed, an adverse or toxic reaction may occur. For example, a single excessive dose of iron can cause liver failure, and too much vitamin B_6 can cause nerve damage. These nutrient toxicities usually result from taking large doses of vitamin or mineral supplements. Foods generally do not contain high enough concentrations of nutrients to be toxic.

The type of overnutrition that is most common in the United States today does not have immediate toxic effects but contributes to the development of chronic diseases in the long term. The typical U.S. diet, which provides more calories than are needed, has resulted in an epidemic of obesity in which more than 70% of adults are overweight or obese (**Figure 1.11b**).[7] Diets that are high in sodium contribute to high blood pressure; an excess intake of saturated fat contributes to heart disease; and a dietary pattern that is high in red meat and saturated fat and low in fruits, vegetables, and fiber may increase the risk of certain cancers.[5]

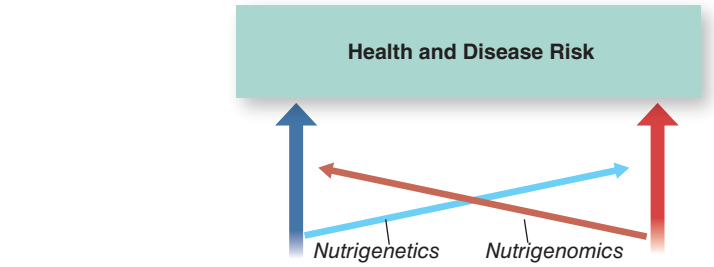
How Our Diets Interact with Our Genetic Makeup

genes Units of a larger molecule called DNA that are responsible for inherited traits.

What we eat affects our health, but diet alone does not determine whether we will develop a particular disease. Each of us inherits a unique combination of **genes**. Some of these genes affect our risk of developing chronic diseases such as heart disease, cancer, high blood pressure, and diabetes, but their impact is affected by what we eat. Our genetic makeup determines the impact a certain nutrient will have on us. For example, some people inherit a combination of genes that makes their blood pressure more sensitive to the amount of sodium in their diet. When these individuals consume even an average amount of sodium, their blood pressure increases (as discussed further in Chapter 10). Others inherit genes that allow them to consume more sodium without a rise in blood pressure. Those who inherit "salt sensitivity" can reduce their blood pressure, and the complications associated with high blood pressure, by eating a diet that is low in sodium.

nutritional genomics The study of how our genes affect the impact of nutrients or other food components on health (nutrigenetics) and how nutrients affect the activity of our genes (nutrigenomics).

Our increasing understanding of human genetics has given rise to the discipline of **nutritional genomics**, which explores the interaction between human genes and nutrition and health.[14] It encompasses both the effect that the genes a person inherits have on how his or her diet affects health (nutrigenetics) and the effect the nutrients and other food components that he or she consumes has on gene activity (nutrigenomics) (**Figure 1.12**). Research in these areas has led to the development of the concept of "personalized nutrition." The goal of personalized nutrition is to prescribe a diet based on the genes an individual has inherited in order to prevent, moderate, or cure chronic disease. Although today we do not have the tools to take a sample of everyone's DNA and use it to tell them what to eat to optimize their health, we do know that certain dietary patterns can reduce the risk of many chronic diseases (see **Debate: Is There a "Best" Diet for You?)**





The genes you inherit affect your tendency to develop nutrition-related chronic diseases such as heart disease and diabetes.



The diet you consume affects your risk of developing nutrition-related chronic diseases.

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Alamy

FIGURE 1.12 Diet, genes, and health Both the genes you inherit and your diet and lifestyle choices directly affect your health and disease risk. There is also interplay between these such that your genes, through nutrigenetics, influence how your diet affects your health, and your diet, through nutrigenomics, affects how your genes impact your health.

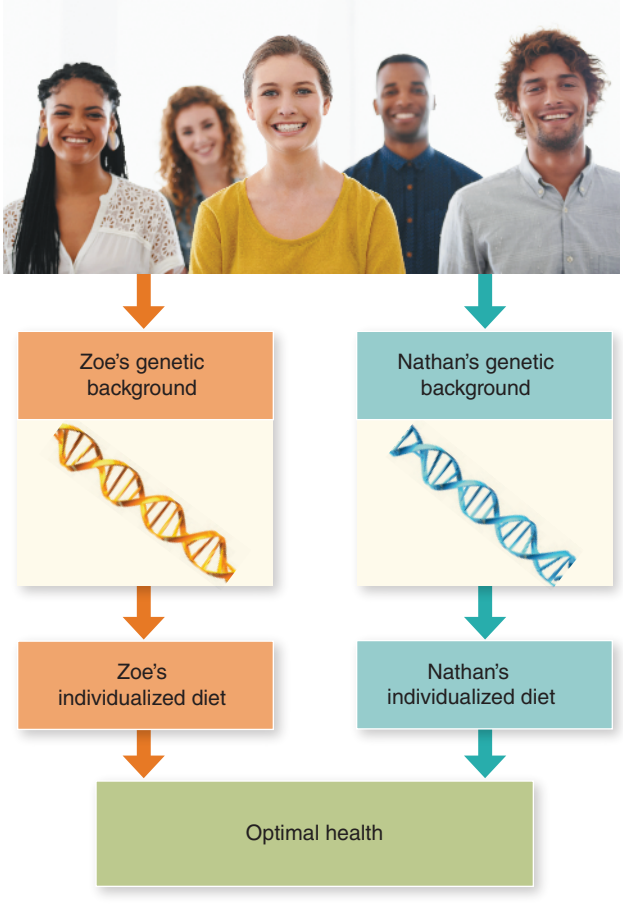
Debate

Is There a "Best" Diet for You?

What is the best diet for you? That depends on who you are, your current health status, and your health risks. Much of this is determined by your genetic background. Do your parents have diabetes or heart disease? If the answer is yes, you are at risk. Is everyone in your family overweight? If they are, you may be headed there too. The science of nutritional genomics suggests that you can reduce your risk of disease by tailoring your diet to your individual genetic makeup (see figure).[15] It predicts that someday you may go to the doctor's office, have your genes analyzed, and then have specific foods and dietary supplements prescribed to optimize your health. Are such genetically customized foods and diets the next big advance in public health, or are we better off sticking to general dietary recommendations that can be applied to everyone?

Current nutrition guidelines are designed to improve and maintain the health of almost all healthy people in the population. Yet we know that different people respond differently to the same diet, so dietary advice that is good for the majority of people may not be optimal for each individual. Modern medicine is already practicing nutritional genomics at a very basic level; dietitians design special diets based on patients' existing medical conditions. People with elevated blood lipid levels are instructed to reduce their intake of saturated fat and increase their fiber intake, those with high blood pressure are shown how to reduce their salt intake, and people with diabetes are taught how to manage blood sugar levels by modifying their carbohydrate intake.

Proponents of nutritional genomics suggest that reviewing an individual's genetic analysis will permit the development of more personalized dietary recommendations and these will prevent or improve



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outcomes for a variety of chronic diseases.[16] These diets could be customized to take into consideration individual genetic variations in disease as well as life stage, dietary preferences, and other aspects of health status.[17] Some propose that if followed, these personalized recommendations may supplement and even replace prescription drugs.

Would the benefit of these individualized diet plans justify the expense of the genetic analyses? Some argue that this approach is unlikely to improve individual or public health.[18] Many people fail to follow current population-wide nutrition guidelines for a healthy diet, not because they lack the knowledge, money, or motivation to do so, but simply because they choose not to. Therefore, it is unlikely that they will follow personalized guidelines any better or that genetic test results will motivate them to eat a healthier diet.[19,20] The priority for public health should not be to fine-tune diet prescriptions but to find out what will make people change their diets and live healthier lives.

Other concerns with nutritional genomics are the ethics of widespread genetic testing and the possibility that commercial interests will drive nutritional genomics rather than any benefits to public health.[20] People who strictly follow their diet prescriptions will certainly benefit, but the big beneficiaries of personalized diet prescriptions will be biotech companies, which would profit from the genetic testing needed to establish disease profiles, and the food industry, which would benefit from the creation and sale of foods designed to treat disease.[18] There is also concern that personalized nutrition will be very costly, perhaps reserved for those with money and education.[17]

In the future, will we select breakfast cereals and dietary supplements based on our genes? Will these choices, which target the prevention of some potential chronic diseases, increase the risk of others? Will following personalized dietary prescriptions make us healthier than just choosing an overall healthy diet? In choosing foods based on nutritional genomics, will we lose track of the pleasure we get from food and the cultural and social roles that food plays in our lives?

Think Critically

If genetic testing determines that you are at low risk for heart disease, does this mean that you can ignore the public health recommendation to limit saturated fat intake? Why or why not?

How to Choose a Healthy Diet

Each of the food choices we make contributes to our diet as a whole (see **How to Choose: Healthy Meals Away from Home**). No single food choice is good or bad in and of itself, but

How to Choose

Healthy Meals Away from Home

Fast food

- Skip the breaded and fried chicken and choose broiled instead.
- Choose a plain burger rather than one with extra sauce and cheese.
- Split an order of fries with a friend or choose a salad instead.
- Top your pizza with vegetables rather than meat and skip the extra cheese.

Standard American fare

- Avoid buffets and all-you-can-eat specials.
- Order a baked potato instead of French fries.
- Avoid thick buttery, creamy, and cheesy sauces.
- Trim the fat from meat and remove the skin from poultry.
- Order your protein grilled, broiled, flame-cooked, steamed, poached, roasted, or baked.
- Order your salad dressing on the side—then you can choose how much you add.

Ethnic choices

- Chinese: Choose items with large portions of vegetables and skip the fried wontons, dumplings, and egg rolls.
- Italian: Have a red sauce instead of high-fat alfredo sauce on your pasta.
- Mexican: Go easy on chips and order fajitas instead of the fried items such as chile rellenos, chorizo, chimichangas, or flautas.
- Indian: Choose dishes with lentils and vegetables and avoid ghee (clarified butter) and cream sauces such as korma. Choose tikka and tandoori and kabob preparations and avoid crispy dishes.
- Middle Eastern: Have hummus with pita, yogurt sauce (tzatziki sauce), eggplant, and other vegetable dishes, and avoid fatty gyros, fried falafel, and baklava.

all of our choices combined make up a dietary pattern that is either healthy or not so healthy. A healthy diet is one that provides the right amount of energy to keep weight in the desirable range; the proper types and balance of carbohydrates, proteins, and fats; plenty of water; and sufficient but not excessive amounts of essential vitamins and minerals. A healthy diet is rich in nutrient-dense foods such as whole grains, fruits, vegetables, lean meats, seafood, nuts and seeds, and low-fat dairy products.

Nutrient density is a measure of the nutrients a food provides compared with its energy content. Nutrient-dense foods contain more nutrients per calorie than do foods with a lower nutrient density. For example, a glass of low-fat milk is a more nutrient-dense choice than a soft drink or a glass of sugar-sweetened iced tea (**Figure 1.13a**). If a large proportion of your diet is made up of foods that are low in nutrient density, such as candy, soft drinks, snack foods, and baked goods, you could have a hard time meeting your nutrient needs without exceeding your calorie needs. By choosing nutrient-dense foods, you can meet all your nutrient needs and have calories left over for occasional treats that are lower in nutrients and higher in calories (**Figure 1.13b**).

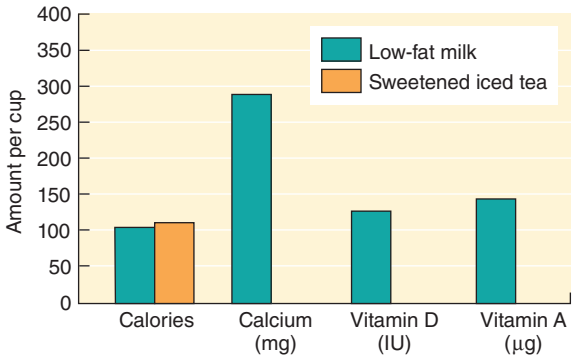
nutrient density An evaluation of the nutrient content of a food in comparison to the calories it provides.

A healthy diet is based on variety, balance, and moderation. Using these principles, you can develop a personal strategy for making better choices and maintain your health for the long term.

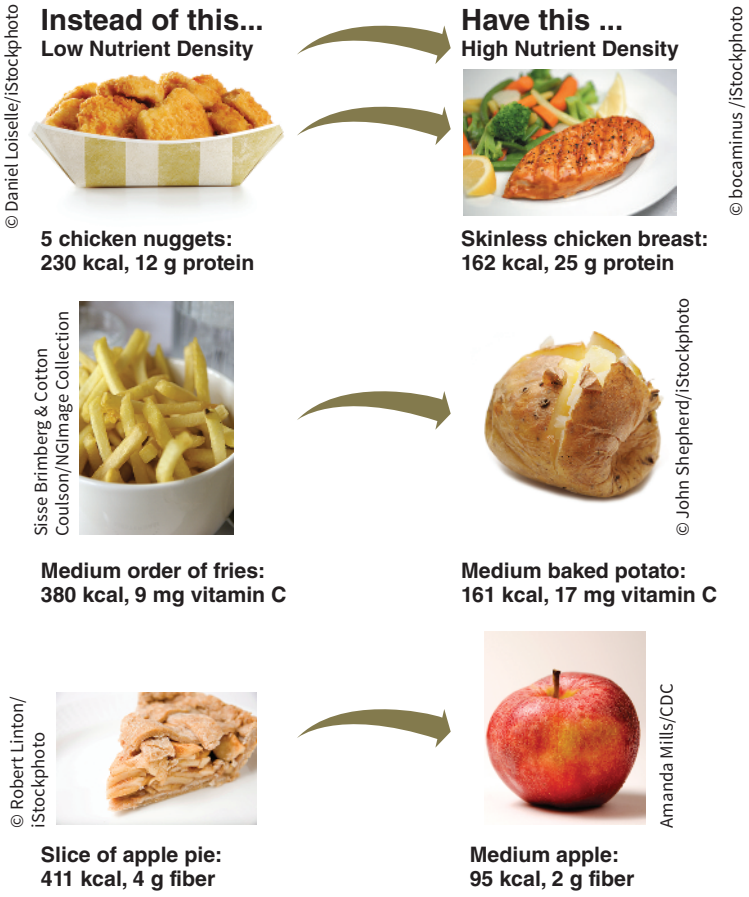
Eat a Variety of Foods

No one food can provide all the nutrients the body needs for optimal health. Eating a variety of foods, however, helps ensure an adequate nutrient

FIGURE 1.13 **Nutrient-dense diets provide more nutrients per calorie**



a. Nutrient density is important in choosing a healthy diet. For example, low-fat milk is higher in nutrient density than sweetened iced tea. Although it provides about the same number of calories per cup as the tea, it also provides calcium, vitamin D, vitamin A, and other nutrients, including protein.



b. Typically, less processed foods are higher in nutrient density. For example, a roasted chicken breast is more nutrient dense than chicken nuggets; a baked potato is more nutrient dense than French fries; and an apple is more nutrient dense than apple pie.

Think Critically

The slice of apple pie has twice as much fiber as the apple, so why is the apple considered the more nutrient-dense choice?

intake. Variety means choosing foods from different food groups—vegetables, grains, fruits, dairy products, and high-protein foods. Some of these groups are good sources of carbohydrate, fiber, and vitamins; others are rich in minerals and phytochemicals. All are important.

Variety also means choosing different foods from within each food group. For instance, if you choose three servings of vegetables a day and they are all carrots, it is unlikely that you will meet your nutrient needs. Carrots provide fiber and vitamin A but are a poor source of vitamin C. If instead you have carrots, peppers, and broccoli, you will be getting vitamin C along with more vitamin A, vitamin K, fiber, and phytochemicals than carrots alone would provide. Likewise, if you always choose red meat as a protein source, you will be missing out on the fiber in beans and the healthy fats in nuts and fish. Variety comes from choosing different foods not only each day but also each week and each season. If you had apples and grapes today, have blueberries and cantaloupe tomorrow. If you can't find tasty tomatoes in December, replace them with a winter vegetable like squash.

Choosing a varied diet is also important because of the interactions between different foods and nutrients. These interactions may be positive, enhancing nutrient utilization, or negative, inhibiting nutrient use. For example, consuming iron with orange juice enhances iron absorption, while consuming iron with milk may reduce its absorption. In a varied diet these interactions balance out. In addition, some foods may contain natural toxins or residues of pesticides, fertilizers, and other toxic substances (see Chapter 17). Choosing a variety of foods avoids an excess of any one of these substances. For example, tuna may contain traces of mercury, but as long as you don't eat tuna too often, you are unlikely to consume a toxic amount.

Balance Your Choices Choosing a healthy diet is a balancing act. Healthy eating doesn't mean giving up your favorite foods. There is no such thing as a good food or a bad food—only healthy diets and unhealthy diets. Any food can be part of a healthy diet as long as overall intake over the course of days, weeks, and months provides enough of all of the nutrients needed without excesses of any. When you choose a food, like white rice, that is lacking in fiber, balance this choice with one, like oatmeal, that provides lots of fiber. When you choose a food that is high in fat, like cheese, then balance that choice with a low-fat one, like a piece of fruit. Balancing your choices allows foods that would not usually be considered healthy choices to be included in a healthy dietary pattern. For example, baked goods, snack foods, and sodas should be balanced with nutrient-dense choices such as salads, fresh fruit, and low-fat dairy products. If your favorite meal is a burger, French fries, and a milkshake, enjoy it but balance it with asparagus, brown rice, and baked chicken at the next meal.

Balance involves mixing and matching foods in proportions that allow you to get enough of the nutrients you need and not too much of ones that might harm your health. A balanced diet provides plenty of whole grains, fruits, and vegetables. It contains enough but not too much of each of the vitamins and minerals, as well as protein, carbohydrate, fat, and water. It also balances the energy taken in with the energy used in daily activities so body weight stays in the healthy range (**Figure 1.14**).

Everything in Moderation Moderation means everything is okay, as long as you don't overdo it. Moderation means not consuming too much energy, too much fat, too much sugar, too much salt, or too much alcohol, whether you are eating at home or away from home (see How to Choose: Healthy Meals Away from Home). It means watching your portion sizes. Have you ever sat down in front of the TV with a bag of chips, and before you knew it half the bag was gone? If you have, then you know how easy it is to let portion sizes get out of control. Choosing moderately will help you maintain a healthy weight and help prevent some of the chronic diseases like heart disease and cancer that are on the rise in the U.S. population. The fact that more Americans are obese than ever before demonstrates that we have not been practicing moderation when it comes to energy intake. Moderation will make it easier to balance your diet and will allow you to enjoy a greater variety of foods.



FIGURE 1.14 Balance calories in with calories out To keep your weight stable, you need to burn the same number of calories as you consume. Extra calories you consume during the day can be balanced by increasing the calories you burn in physical activity.

1.4 The Science Behind Nutrition

LEARNING OBJECTIVES

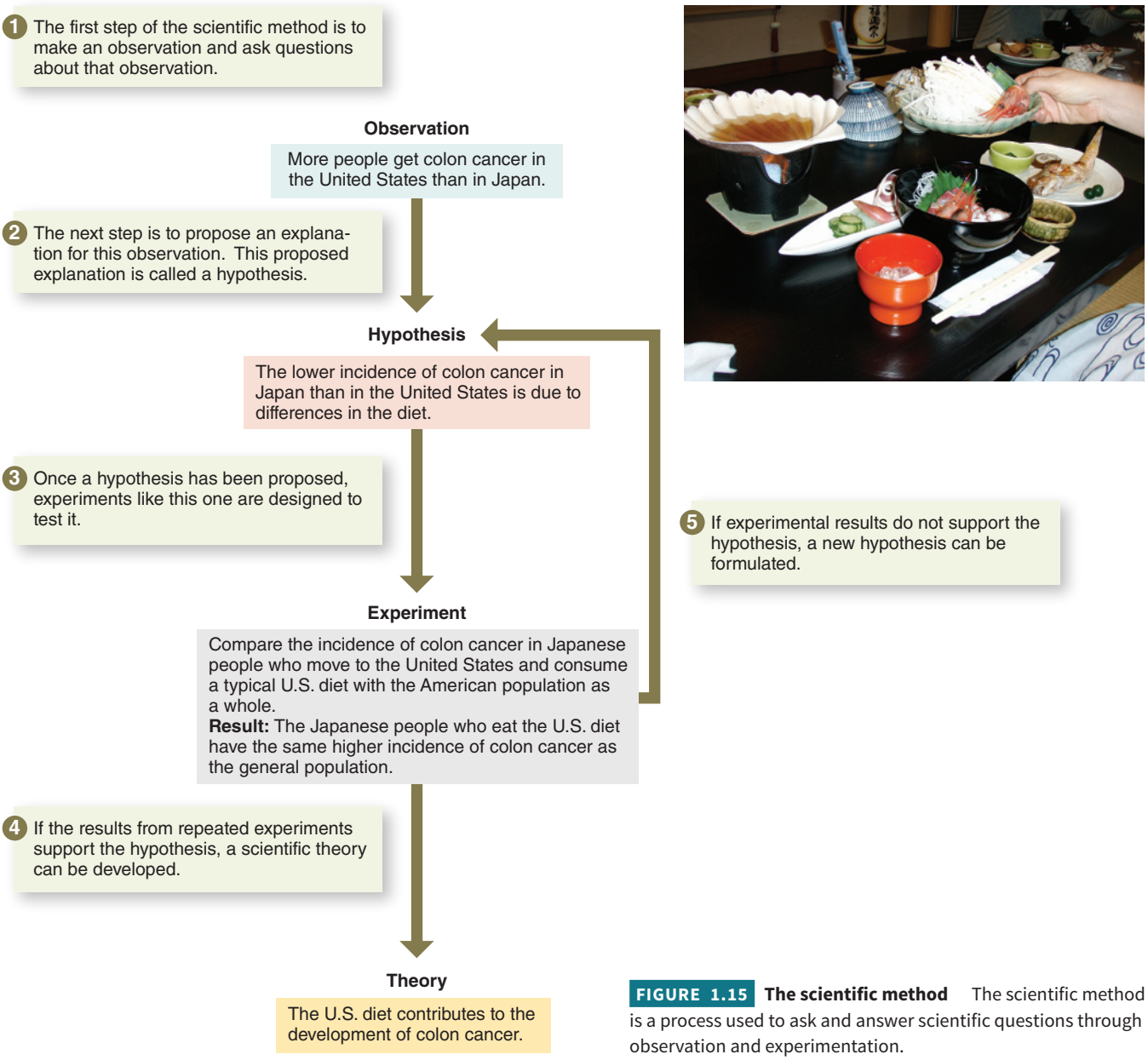
- List the steps of the scientific method.
- Compare the type of information obtained from epidemiology to that obtained from human intervention or laboratory studies.
- Discuss why animals and cells are used to study human nutrition.
- Discuss how the ethics of human and animal studies are monitored.

Nutrition, like all science, continues to develop as new discoveries provide clues to the right combination of nutrients needed for optimal health. As knowledge and technology advance, new nutrition principles are developed. Sometimes established beliefs and concepts must give way to new ideas, and recommendations change. Today more and more consumers are seeking information about nutrition and how to improve their diets.[1] But many people find it difficult to tell what information is accurate and what is exaggerated. Developing an understanding of the process of science and how it is used to study the relationship between nutrition and health can help consumers make wise nutrition decisions, whether they involve what to have for breakfast or whether a headline about vitamin E supplements is true.

The Scientific Method

Advances in nutrition are made using the **scientific method** (**Figure 1.15**). The scientific method offers a systematic, unbiased approach to evaluating the relationships among food, nutrients,

scientific method The general approach of science that is used to explain observations about the world around us.



Lori Smolin

FIGURE 1.15 The scientific method The scientific method is a process used to ask and answer scientific questions through observation and experimentation.

hypothesis An educated guess made to explain an observation or to answer a question.

theory An explanation based on scientific study and reasoning.

and health. The first step of the scientific method is to make an observation and ask questions about the observation. The next step is to propose a **hypothesis**, or explanation for the observation. Once a hypothesis has been proposed, experiments can be designed to test it. The experiments must provide objective results that can be measured and repeated. If the experimental results do not prove the hypothesis to be wrong, a **theory**, or a scientific explanation based on experimentation, can be established. Scientific theories are accepted only as long as they cannot be disproved and continue to be supported by all new evidence that accumulates. Even a theory that has been accepted by the scientific community for years can be proved wrong.

How Scientists Study Nutrition

Nutrition research studies are done to determine nutrient requirements, to learn more about the metabolism of nutrients, and to understand the role of nutrition in health and disease. Perfect

tools do not exist for addressing all these questions. However, there are many types of research studies that can be useful in understanding the relationships between humans and their nutrient intake.

Observational Studies

Some of our nutrition knowledge has been obtained by observing relationships between diet and health in different populations throughout the world. This study of diet, health, and disease patterns is called **epidemiology**. Epidemiology does not determine cause and effect relationships—it just identifies patterns (**Figure 1.16**). For instance, by comparing diets in different countries with the incidence of cancer, scientists were able to identify an association, or **correlation**, between diets high in fruits and vegetables and a lower incidence of cancer. Some epidemiological studies collect data from a cross section of the population at one point in time, whereas others collect data from the same individuals over a long period of time (see **Science Applied: How Epidemiology Led to Dietary Recommendations for Heart Disease**).

Case-control studies are a type of epidemiological study that compares individuals with a particular condition to similar individuals without the condition. For example, a case-control study of colon cancer might include a comparison of the dietary intake of a 45-year-old African American man with colon cancer to a man of the same age and ethnic background who is free of the disease. If a pattern, such as a higher fat intake among the cancer patients, is found in comparing cases

epidemiology The study of the interrelationships between health and disease and other factors in the environment or lifestyle of different populations.

correlation Two or more factors occurring together.

case-control study A type of observational study that compares individuals with a particular condition under study with individuals of the same age, gender, and background who do not have the condition.

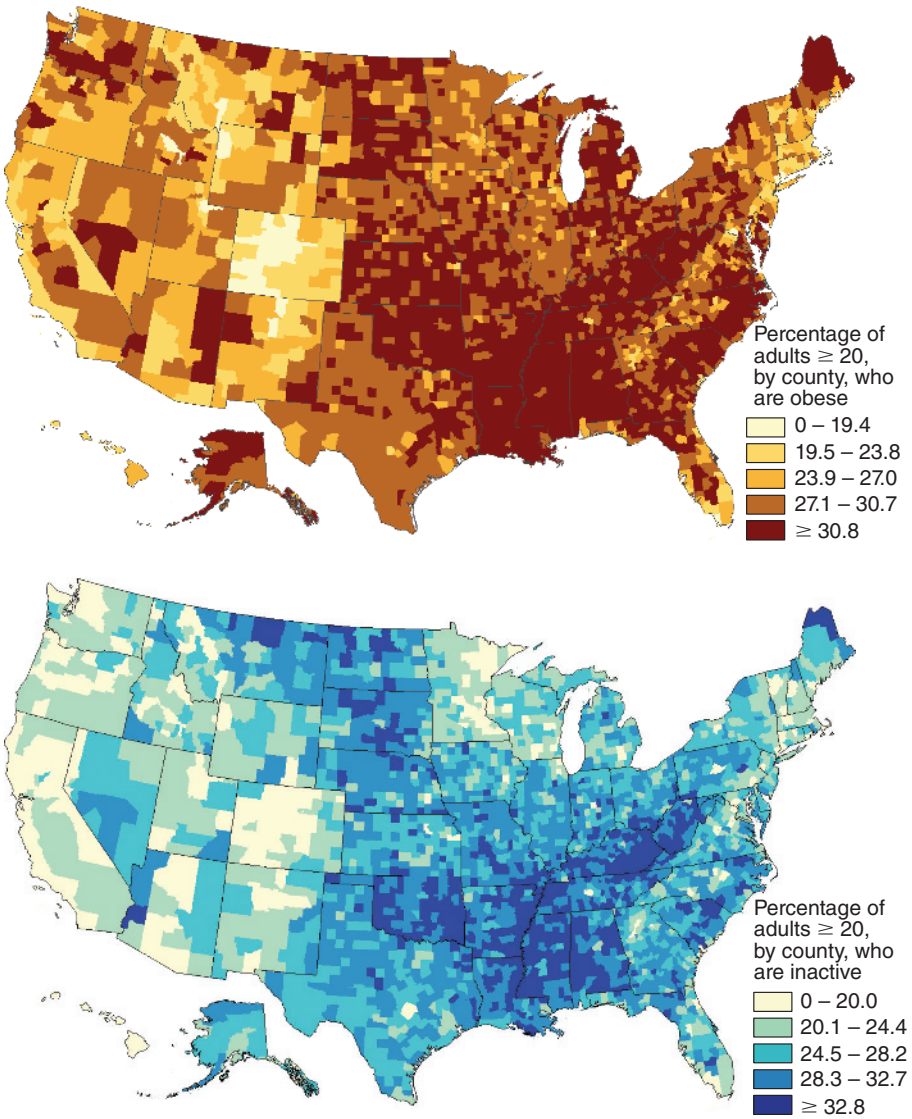


FIGURE 1.16 Does inactivity cause obesity? These maps were created using epidemiological data. They show that the prevalence of obesity (top map) roughly mirrors the prevalence of inactivity (bottom map) in counties across the United States.

Analyze the Data

Does the data from these maps mean that inactivity is the cause of obesity? Will everyone who is inactive be obese?

Science Applied

How Epidemiology Led to Dietary Recommendations for Heart Disease

As early as the 1930s, scientists and physicians noticed that the incidence of heart disease was different in different countries and varied with social class and occupation.[21] In the 1940s, Professor Ancel Keys observed that well-fed American businessmen had high rates of heart disease, while the rate of heart disease had decreased in postwar Europe where food supplies were low. This led Keys to hypothesize that diet affected the risk of heart disease and to launch a series of epidemiological studies that changed the way we manage heart disease.

The Science

To test the diet and heart disease hypothesis, Keys began a study that collected annual physiological and lifestyle data on 500 healthy businessmen in Minnesota. He knew that over time some would develop heart disease and others would not. He hoped that comparing the data from afflicted men with that from healthy men would identify which characteristics were related to the development of the disease.[22] Key's study was what we call a prospective study: one that follows people over time and relates outcomes, such as the development of heart disease, to other factors such as body weight, blood cholesterol, or diet. The aim was to identify how those who developed heart disease differed from those who escaped it.

The Minnesota businessmen study provided Keys with the groundwork for a much larger epidemiological study called the Seven Countries Study, which was designed to compare characteristics among populations across a wide spectrum of diet and lifestyle. Between 1958 and 1964 the Seven Countries Study enrolled 12,763 men, ages 40 to 59 years, from 16 different regions within seven countries on three continents. The study evaluated health status, dietary intake, body weight, blood pressure, blood cholesterol level, and other health-related parameters at regular intervals. Patterns began to emerge. In northern European countries, the diet was high in dairy products; in the United States, it was high in meat; in southern Europe, it was high in vegetables, legumes, fish, and wine; and in Japan, it was high in cereals, soy products, and fish.[23] After 10 years, 1512 of the study participants were dead—413 of them from coronary heart disease[24]—but mortality differed strikingly with location. The island of Crete had only one coronary death out of 686 men studied, whereas eastern Finland had 78 coronary deaths among 817 participants.[25]

The coronary death rate was correlated with the average percentage of calories from saturated fat. In places such as Japan and the Greek islands, where the diet was low in saturated fat, blood cholesterol levels were lower, as was the risk of dying from heart disease.



Pixtal/SuperStock

The vegetables, fruit, fish, and olive oil shown here are plentiful in the diet of countries around the Mediterranean Sea—where the Seven Countries Study found the incidence of coronary heart disease to be low. This dietary pattern, now known as the "Mediterranean diet," is one of the dietary patterns currently recommended for reducing the risk of heart disease.

In countries such as Finland and the United States, where the diet was higher in saturated fat, blood cholesterol levels were higher, as was the incidence of heart disease. The results showed that blood cholesterol was strongly correlated with coronary heart disease deaths both for populations and for individuals. Some of the difference in the incidence of heart disease between countries was not explained by risk factors, but within a population risk factors such as diet, blood cholesterol, blood pressure, and cigarette smoking did predict risk.

The Application

The Seven Countries Study and other epidemiological investigations have established the major risk factors for heart disease. These findings have helped develop individual dietary and lifestyle recommendations to treat people at high risk for heart disease as well as population-wide guidelines to promote public health. Heart disease is still the leading cause of death in the United States, but since 1950, age-adjusted death rates from cardiovascular disease have declined 60%. This is considered one of the most important public health achievements of the 20th century. The decline is due in part to fewer people smoking, better health care, and the use of antihypertensive and cholesterol-lowering drugs, but changes in diet based on the results of the Seven Countries Study and other epidemiological studies have also had an impact.[26]

human intervention study or **clinical trial** A study of a population in which there is an experimental manipulation of some members of the population; observations and measurements are made to determine the effects of this manipulation.

to controls, a hypothesis can be proposed. Hypotheses based on case-control studies and other types of epidemiology must then be tested by controlled intervention and laboratory studies.

Human Intervention Studies The observations and hypotheses that arise from epidemiology can be tested using **human intervention studies**, often referred to as **clinical trials**. This type of experiment actively intervenes in the lives of a population and examines the effect of this intervention (see **Critical Thinking: Early Science**). Nutrition intervention studies generally explore

Critical Thinking

Early Science

When explorers began making long sea voyages in the 1400s, it was observed that after about 12 weeks at sea the sailors began getting the symptoms of the disease scurvy. We know today that scurvy is due to a deficiency of vitamin C, but at the time Scottish physician James Lind was looking for a cure for the disease, vitamins had not even been discovered. Lind hypothesized that scurvy was caused by lack of acid in the body.

In 1747, Lind set up an experiment involving 12 sailors suffering from scurvy. He divided them into six groups. They were all fed the same diet that today we know was lacking in vitamin C, also known as ascorbic acid. He supplemented each group with a different substance. Most were acids, such as vinegar, dilute sulfuric acid, and cider. One group received lemons and oranges, which are high in ascorbic acid.

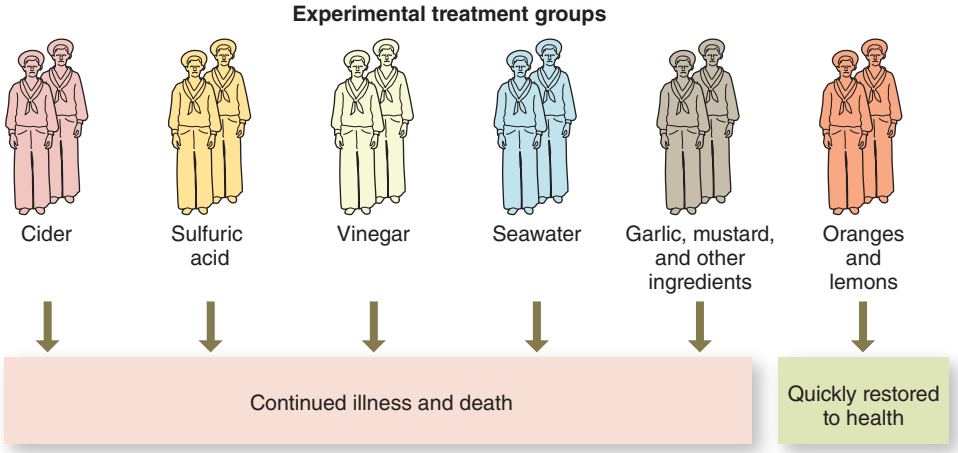


Foodcollection/Getty Images

1. What kind of study is this? Is the study well controlled?

Answer:

After only a week the health of the group eating lemons and oranges was much improved, while sailors in the other groups remained ill and many died.



2. Did the experimental results support Lind's hypothesis? Why or why not?

Answer:

Based on the study results, one might hypothesize that scurvy is due to an absence of fruit in the diet.

3. Design a study to test the hypothesis that scurvy is caused by a lack of any type of fruit.

Answer:

iProfile Use iProfile to find vegetables that are good sources of vitamin C.

the effects of altering people's diets. For example, if it is determined by epidemiology that populations eating a diet low in saturated fat have a lower incidence of heart disease, an intervention trial may be designed with an **experimental group** that consumes a diet lower in saturated fat than is typical in the population and a **control group** that consumes the typical diet. The groups can be monitored to see if the dietary intervention affects the incidence of heart disease over the long term.

experimental group In a scientific experiment, the group of participants who undergo the treatment being tested.

control group In a scientific experiment, the group of participants used as a basis of comparison. They are similar to the participants in the experimental group but do not receive the treatment being tested.

Laboratory Studies Laboratory studies are conducted in research facilities such as hospitals and universities. They are used to learn more about how nutrients function and to evaluate

the relationships among nutrient intake, levels of nutrients in the body, and health. They may study nutrient requirements and functions in whole organisms—either humans or animals—or they may focus on nutrient functions at the cellular, biochemical, or molecular level.

depletion–repletion study A study that feeds a diet devoid of a nutrient until signs of deficiency appear and then adds the nutrient back to the diet to a level at which symptoms disappear.

How Whole Organisms Are Used to Study Nutrition Many nutrition studies are done by feeding a specific diet to a person or animal and monitoring the physiological effects of that diet. **Depletion–repletion studies** are a classic method for studying the functions of nutrients and estimating the requirement for a particular nutrient. This type of study involves depleting a nutrient by feeding experimental subjects a diet devoid of that nutrient. After a period of time, if the nutrient is essential, symptoms of a deficiency will develop. The symptoms provide information on how the nutrient functions in the body. The nutrient is then added back to the diet, or repleted, until the symptoms are reversed. The requirement for that nutrient is the amount needed to reverse or prevent the deficiency symptoms. An example of a depletion–repletion study might be to feed animals a diet devoid of vitamin A for several weeks and examine the deficiency symptoms that appear. Then, if vitamin A is incrementally added back to the diet, the amount that prevents deficiency symptoms can be identified.

balance study A study that compares the total amount of a nutrient that enters the body with the total amount that leaves the body.

Another method for determining nutrient functions and requirements is to compare the intake of a nutrient with its excretion. This type of study is known as a **balance study**. If more of a nutrient is consumed than is excreted, balance is positive and it is assumed that the nutrient is being used or stored by the body. If more of the nutrient is excreted than is consumed, balance is negative, indicating that some is being lost from the body. When the amount consumed equals the amount lost, the body is neither gaining nor losing that nutrient and is said to be in a steady state or in balance. By varying the amount of a nutrient consumed and then measuring the amount excreted, it is possible to determine the minimum amount of that nutrient needed to replace body losses. This type of study can be used to determine protein requirements because protein is not stored in the body. It is not useful for determining the requirements for nutrients such as fat and iron that are stored when an excess is available (**Figure 1.17**).

Why Animals Are Used to Study Human Nutrition Ideally, studies of human nutrition would be done in humans. However, because studying humans is costly, time consuming, inconvenient for subjects, and in some cases impossible for ethical reasons, many studies are done using experimental animals.

An ideal animal model is one with metabolic and digestive processes similar to those of humans. For example, cows are rarely used in human nutrition research because they digest their food in four stomach-like chambers as opposed to a single stomach. Pigs, on the other hand, are a good model because they digest food in a manner similar to that of humans. In addition to digestion and metabolism, factors such as cost and time must be considered. Pigs and other large animals are expensive to use, and they take a long time to develop nutrient deficiencies. Smaller laboratory animals, such as rats and mice, are therefore the most common experimental animals. They are inexpensive, have short life spans, reproduce quickly, and show the effects of nutritional changes rapidly. Their food intake can be easily controlled, and their excretions can be measured accurately using special cages. Even when researchers use small animals, the species of animal must be carefully chosen (**Figure 1.18**). For example, rats are more resistant to heart disease than are humans, so they are not a good model for studying the effect of diet on heart disease. Rabbits, on the other hand, do develop heart disease and can be used to study diet–heart disease relationships. Even the best animal model is not the same as a human, and care must be taken when extrapolating the results to the human population. For example, a study that uses rats to show that a calcium supplement increases bone density can hypothesize, but not conclude, that the supplement will have the same effect in humans.

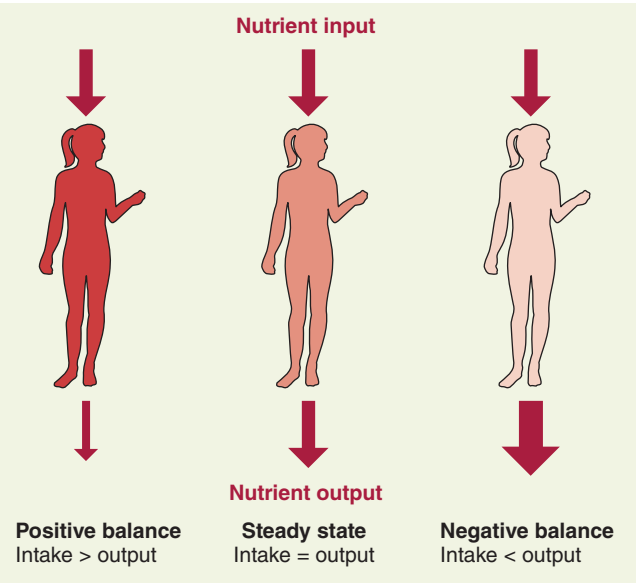
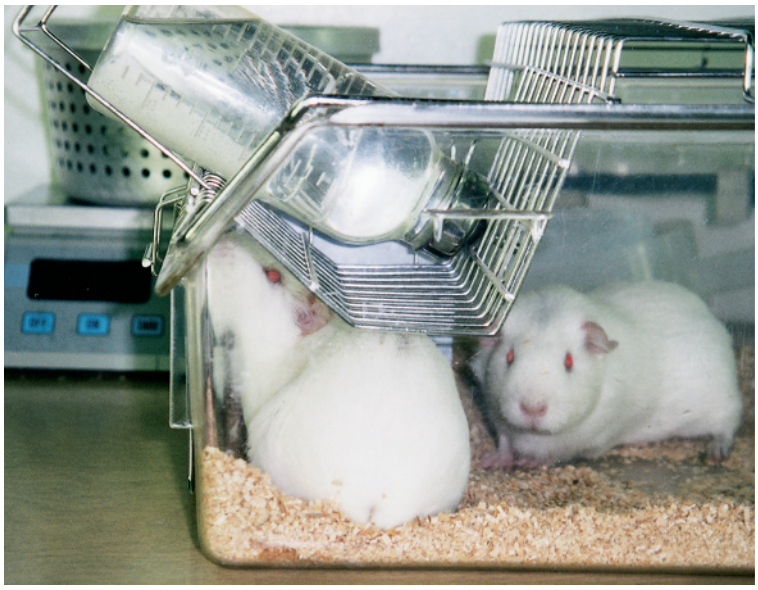


FIGURE 1.17 Balance studies Nutrient balance studies compare the amount of a nutrient that is consumed with the amount excreted to determine whether the amount of the nutrient in the body is increasing (positive balance), remaining constant (balance, or steady state), or decreasing (negative balance).

Studies Using Cells Another alternative to conducting studies in humans is to study cells either extracted from humans or animals or grown in the laboratory (**Figure 1.19**). Biochemistry can be used to study how nutrients are used to provide energy and how they regulate biochemical reactions in cells. Molecular biology can be used to study how genes regulate cell functions and how nutrients affect the action of certain genes. Knowledge gained from biochemical and molecular biological research can be used to study nutrition-related conditions that affect the entire organism.



Lori Smolin

FIGURE 1.18 Choosing animals to model human nutrition Guinea pigs are used to study vitamin C requirements and functions because the guinea pig is one of the few animals, other than humans, that cannot make vitamin C in its body.

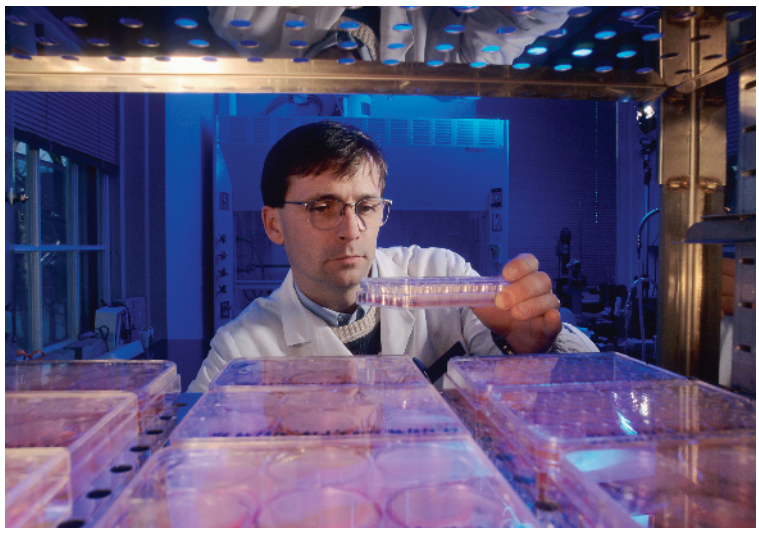
Ethical Concerns in Scientific Study

Ethical issues are often raised in the process of conducting nutrition research. Whenever possible, researchers use alternatives to human subjects or experimental animals. However, when questions cannot be answered using alternatives such as cells grown in culture or computer models, human and animal experimentation are necessary. To avoid harm and protect the rights of humans and animals used in experimental research, government guidelines have been developed.

Before a study involving human subjects can be conducted, it must be reviewed by a committee of scientists and nonscientists to ensure that the rights of the subjects are respected. The risk of physical, social, and psychological injury must be balanced against the potential benefit of the research. Before subjects participate in a study, oral and written explanations of the purpose of the research, the procedures used, and the possible risks and benefits are provided. Those who choose to participate must then sign a consent form stating exactly what they have agreed to do. Signing a consent doesn't mean subjects must complete the study if it turns out to be more than they bargained for—subjects can leave a study at any time. This informed consent process is part of the strict safety and ethical regulations that must be followed when research involves human subjects. These regulations protect subjects but limit the type of study that can be done on humans. For example, much of what we know today about the effects of starvation in humans was determined during World War II by conducting depletion–repletion studies using conscientious objectors as experimental subjects. These subjects were monitored physically and psychologically while they were starved and then re-fed. These individuals experienced some level of suffering during the trials and risked longer-lasting physical and psychological harm. It is unlikely that this study would be approved if researchers wanted to repeat it today.

As with experiments involving humans, the federal government mandates that panels of scientists review experiments that propose to use animals. These panels consider whether the need for animals is justified and whether all precautions will be taken to avoid pain and suffering. Animal housing and handling are strictly regulated, and a violation of these guidelines can result in closure of a research facility.

The development of the techniques of molecular biology has given rise to ethical issues regarding the manipulation of genes. Guidelines for manipulating genes have been developed and are discussed in the Focus on Biotechnology.



Keith Weller/Courtesy USDA

FIGURE 1.19 Cell culture The ability to grow cells in the laboratory allows scientists to study nutrients without using whole organisms.

Think Critically

What are the advantages and disadvantages of using cells grown in culture to study human nutrition?

1.5 Evaluating Nutrition Information

LEARNING OBJECTIVES

- Discuss why individual testimonies are not considered reliable sources of information.
- Name three points to consider when evaluating the reliability of nutritional information.
- Discuss the components of a well-designed study including experimental controls, control groups, and placebos.

We are bombarded with nutrition information. Some of what we hear is accurate and based on science and some of it is incorrect or exaggerated to sell products or make news headlines more enticing: Oat bran lowers cholesterol, antioxidants prevent cancer, low-carb diets promote weight loss, vitamin C cures the common cold, vitamin E slows aging. Sifting through this information and distinguishing the useful from the useless can be overwhelming. Just as scientists use the scientific method to expand their understanding of the world around us, each of us can use an understanding of how science is done to evaluate nutrition claims by asking the questions discussed below and summarized in **Table 1.1**.

Does It Make Sense?

The first question to ask yourself when evaluating nutrition information is this: Does the claim being made make sense? Some claims, we know, are too outrageous to be true or safe. For example, the hypothetical advertisement for StayWell states that this product will make illness a thing

TABLE 1.1 Sorting Out Nutrition Information

Does It Make Sense?

- **Is it too outrageous to believe?** If it is, disregard it.
- **Does it pose a risk?** If it doesn't sound safe, don't do it.

What's the Source?

- **Is it selling something?** Many claims are made to sell products rather than present unbiased nutrition information.
- **Is it someone's opinion or personal story?** Anecdotal information can be applied only to the person telling the story.
- **Who can you believe?** Recommendations made by the government, universities, and nonprofit organizations are based on science and designed to provide information to improve health.

Is It Based on Good Science?

- **Is the study well controlled?** Have experimental controls been used so that each variable studied can be compared with a known situation?
- **Were participants and researchers blinded to the treatment?** If the subjects or researchers know which group is receiving treatment, their beliefs and biases may alter the outcome of the study.
- **Was the information interpreted accurately?** Compare news reports and advertisements with the information in peer-reviewed studies. Has the importance of the study been exaggerated to sell a product or make a headline more appealing? If the study was done in animals, can the results be applied to humans?

Has It Stood the Test of Time?

- **Is the study the first to support a particular finding?** If it is, wait before changing your diet based on the results.
- **Has the finding been shown repeatedly in different studies over a period of years?** If it has, it will become the basis of reliable nutrition recommendations.

of the past (**Figure 1.20**). This is certainly appealing, but it is hard to believe, and common sense should tell you that it is too good to be true. The claim that StayWell will reduce cold symptoms, however, is not so outrageous. Common sense can also help determine whether health and nutrition information poses a risk. For example, a report that recommends you take supplements providing 1000% of the recommended amount of a vitamin or mineral should be viewed skeptically because high levels can be toxic and are not found in nature.

What's the Source?

If the claim seems reasonable, look to see where it came from. Was it a personal testimony, a government recommendation, or advice from a health professional? Is it in a news story or an advertising promotion? Is it on television, in a magazine, or on a Web page?

Is It Selling Something?

If a person or company will profit from the information presented, you should be wary. Information presented in newspapers and magazines and on television may be biased or exaggerated because it is designed to help sell magazines or boost ratings. Consider whether the claim is making a magazine cover or newspaper headline more appealing. Claims that are part of an advertisement for a food product or dietary supplement should be viewed skeptically because advertisements are designed to increase product sales and the company stands to profit from your belief in that claim. For example, in an advertisement for a vitamin E supplement, a company may claim that vitamin E increases longevity even if the research supporting this claim was done in rats, not humans; used higher amounts of vitamin E than are provided by the supplement; and caused only a very small change in life span. Information on the Internet is also likely to be biased toward a product if it comes from a site where you can buy the product (.com sites).



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FIGURE 1.20 What's behind the claims? This hypothetical supplement advertisement illustrates the types of nutrition claims that consumers must be prepared to evaluate.

Is It Someone's Opinion or Personal Story?

Personal testimonies or opinions, referred to as anecdotal evidence, are not a source of reliable information that can be applied to the general public (**Figure 1.21**). Reliable information comes from scientific experiments providing measurable data that can be quantified and repeated. Measurements of body weight and blood pressure are examples of parameters that can be quantified reliably. In contrast, the claims in Figure 1.20 that StayWell improves energy levels and overall sense of health and well-being are anecdotes based on the individual experiences of supplement users rather than


Before
Jose Luis Pelaez/Getty Images, Inc.


After
© Haveseen/iStockphoto

FIGURE 1.21 Anecdotal claims Weight-loss product advertisements often show before and after photos of people who have successfully lost weight using the product. These photos and personal stories of success are anecdotal evidence because they do not arise from controlled experiments that are evaluated scientifically. Therefore, it cannot be assumed that the product will produce the same results for you or anyone else.

on measured parameters. To be useful in science, feelings and opinions must be quantified using standardized questionnaires.

Who Can You Believe? There are a number of sources you can rely on for credible nutrition information. Government recommendations regarding healthy dietary practices are developed by committees of scientists who interpret the latest well-conducted research studies and use their conclusions to develop recommendations for the population as a whole. The government provides information about food safety and recommendations on food choices and the amounts of specific nutrients needed to promote health and avoid nutrient deficiencies and excesses. These recommendations are the basis for public health policies and programs. They are published in pamphlets and brochures and are available on websites designed for consumers. Government recommendations are also used to develop food labeling standards (see **Off the Label: Beware of Misleading Claims**).

Off the Label

Beware of Misleading Claims

Food labels are designed to provide information that can help you select a healthy diet, but manufacturers also use this information to help sell their products. Although labels are standardized and follow Food and Drug Administration (FDA) guidelines, some of the information can still be confusing and even misleading. You need to consider all the information on the label and remember that each food choice is only one part of your overall diet.

Many food labels highlight information about the amounts of individual nutrients or ingredients. Food manufacturers use these to draw attention to the positive aspects of their products or distract you from the health negatives. For example, a breakfast cereal labeled "made with whole grain" sounds like a healthy choice, but it may contain only a small amount of whole grain and be loaded with added sugar. The claim that a snack is "made with real fruit" would cause most people to choose it over one that does not make this claim. Unfortunately, since the FDA does not dictate how much real fruit a product must contain to make this claim, these products may not contain very much fruit at all. A granola bar with a single dried cranberry could make this claim.

Manufacturers also use more general descriptors such as "natural," "fresh," and "healthy," to imply that a product is a better choice than a similar alternative. This is not necessarily the case. The FDA only restricts the use of the term "natural" on foods that contain added colors, artificial flavors, or synthetic substances. So, a food that has sugar or salt added to it can still claim to be "natural." The term "fresh" can be used on any raw food that has not been frozen, heat processed, or otherwise preserved. The term doesn't provide any information about the nutrient content of the food or how long it took the product to travel from the farm to the grocery store shelf. "Healthy" implies that a product is wholesome and nutritious. In fact, to use the term "healthy," a food must be low in fat and saturated fat, contain no more than 360 mg of sodium and 60 mg of cholesterol per serving, and be a good source of one or more important nutrients. Although all these qualities are indeed part of a healthy diet, foods that fit this definition are not necessarily the basis for a healthy diet. For instance, many fruit drinks fit the labeling definition of healthy. They are low in fat, saturated fat, cholesterol, and sodium, and they supply at least 10% of the recommended intake for vitamin C. But they are a good choice only in limited quantities because they are high in added sugars. Likewise, a food that doesn't meet the labeling definition of healthy is not necessarily a poor choice. Vegetable soup, for example, contains more sodium than the definition of healthy will allow, but if the rest of your diet is not high in sodium, the soup can be a healthy choice. The FDA is currently reviewing the use of the term "natural" on food labels and redefining the term "healthy" to be more consistent with current dietary recommendations.



Ken Karp

The claims made on food labels highlight one characteristic of the food. To get the whole picture, you need to read the rest of the label.

Healthy-sounding product names can also be misleading. Product names must comply with legal definitions, but they don't have to make sense to consumers. Unless you have memorized the U.S. Department of Agriculture (USDA) and FDA regulations, you have no way of knowing how much beef is needed for a product to be called a beef enchilada, for example, or how much chicken must be in chicken soup and how much fruit is in a fruit roll-up. "Lasagna with meat sauce" must be 6% meat, but "lasagna with meat and sauce" must be 12% meat.

Remember that no single nutrient makes a food good or bad for you. To understand the overall contribution that a food makes to your diet, you need to look beyond the healthy-sounding descriptors and the product name. Read the whole label, which must include the food's nutrient content and information on how it fits into the diet as a whole (see Chapter 2 and the *Off the Label* boxes throughout this book).

Nonprofit organizations such as the Academy of Nutrition and Dietetics, the American Medical Association, and the American Institute for Cancer Research are also good sources of nutrition information. The purpose of the information they provide to the public is to improve health. Reports that come from universities are supported by research and are also a reliable place to look for information. Many universities provide information that targets the general public, and university research studies are usually published in respected journals and are well scrutinized.

To help you evaluate the credibility of information in an article in print or posted on a website, check the author's credentials. Where does the author work? Does this person have a degree in nutrition or medicine? Although "nutritionists" and "nutrition counselors" may provide accurate information, these terms are not legally defined and are used by a wide range of people, from college professors with doctoral degrees from reputable universities to health-food-store clerks with no formal training.

One reliable source of nutrition information is a registered dietitian or registered dietitian nutritionist (RD/RDN). RD/RDNs are nutrition professionals who are certified to provide nutrition education and counseling. To obtain certification, an RD/RDN must earn a four-year college degree that includes coursework approved by the Academy of Nutrition and Dietetics, complete a supervised internship, and pass a national exam.

Is It Based on Good Science?

Most of the information we get is based on research studies. For some nutrition claims, not enough information is given to evaluate the validity of the studies on which they are based. Others, however, do provide the details of how a study was done. For example, the StayWell ad (see Figure 1.20) describes a university study that supposedly supports the advertiser's claims. If this type of information is available, ask yourself if the study was well controlled and if the results were interpreted accurately.

Is the Study Well Controlled?

Experimental controls are used to ensure that each factor or **variable** studied can be compared with a known situation. A control group acts as a standard of comparison for the treatment being tested. A control group is treated in the same way as the experimental groups except no experimental treatment is implemented. For example, the university study described in the StayWell ad compares the severity of cold symptoms and the cold recovery time of college students who took the StayWell supplement (experimental group) with the same parameters in a group of students of similar age, gender, health status, and dietary and exercise habits who did not take the supplement (control group).

variable A factor or condition that is changed in an experimental setting.

In the StayWell experiment, a **placebo** was used in order to make the control and experimental groups indistinguishable. A placebo is identical in appearance to the actual treatment but has no therapeutic value. Using a placebo prevents participants in the experiment from knowing whether or not they are receiving the actual supplement. When the subjects do not know which treatment they are receiving, the study is called a **single-blind study**. Using a placebo in a single-blind study helps to prevent the expectations of subjects from biasing the results. For example, if the students think they are taking a supplement that reduces cold symptoms, they may develop a positive outlook that makes their cold symptoms milder. Errors can also occur if investigators' expectations bias the results or the interpretation of the data. This type of error can be avoided by designing a **double-blind study** in which neither the subjects nor the investigators know who is in which group until after the results have been analyzed.

placebo A fake medicine or supplement that is indistinguishable in appearance from the real thing. It is used to disguise the control and experimental groups in an experiment.

single-blind study An experiment in which either the study participants or the researchers are unaware of which participants are in a control or an experimental group.

double-blind study An experiment in which neither the study participants nor the researchers know which participants are in a control or an experimental group.

Was the Information Interpreted Accurately?

In science, the interpretation of results is as important as the way studies are conducted. Even well-designed, carefully executed experiments can be a source of misinformation if the experimental results are interpreted incorrectly or if the implications of the results are exaggerated. For example, the headline in Figure 1.20 states that StayWell improves overall health. However, the study cited investigates

only cold symptoms; overall health is not addressed. Also, StayWell is tested using college students as experimental subjects, so an accurate interpretation of the results would not assume that StayWell would have the same effect in older adults or young children.

One way to ensure that experiments are correctly interpreted is to use a peer-review system. Most scientific journals require that prior to publication, two or three experts (who did not take part in the research that is being evaluated) agree that the experiment under review was well conducted and that the results were interpreted fairly. For example, reviewers will assess whether or not the study included enough subjects to demonstrate the effect of the experimental treatment. To claim a treatment has a particular effect, an experiment must show that the treatment being tested causes a result to occur more frequently than it would occur by chance. More subjects are needed to demonstrate an effect that frequently occurs by chance. For example, if many people only have mild symptoms when they get a cold, then an experiment to see if StayWell reduces cold symptoms would need to include many subjects to demonstrate an effect. However, if everyone got very ill with a cold, only a few subjects would be needed to show that StayWell reduces cold symptoms.

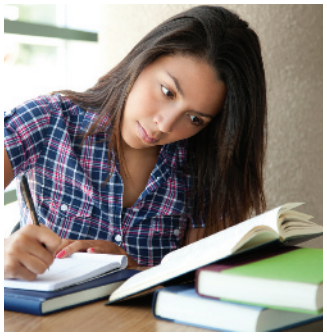
Peer-reviewed journals that publish nutrition-related articles include the *American Journal of Clinical Nutrition*, the *Journal of Nutrition*, the *Journal of the Academy of Nutrition and Dietetics*, the *New England Journal of Medicine*, and the *International Journal of Sport Nutrition and Exercise Metabolism*.

Has It Stood the Test of Time?

Often the results of a new scientific study are in the morning news the same day they are published in a peer-reviewed journal. Sometimes this information is correct, but a single study is never enough to develop a reliable theory. Results need to be reproducible before they can be used as the basis for nutrition decisions or used to make dietary recommendations. Headlines based on a single study should therefore be viewed skeptically. The information may be accurate, but there is no way to know because there has not been time to repeat the work and reaffirm the conclusions. If, for example, someone has found the secret to easy weight loss, the information will undoubtedly appear again if the finding is valid. If it is not, it will fade away with all the other weight-loss cures that have come and gone.



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Case Study Outcome

Kaitlyn found it hard to eat a healthy diet during the first semester of her freshman year. At home, her favorite meal of a burger and fries was an occasional treat. Having this available every night made it hard for her to vary her diet. She knew this meal wasn't a great everyday choice, but she didn't know how to choose a healthy diet. After reading this chapter, Kaitlyn knows that a healthy diet includes a variety of foods. She now aims to eat an assortment of choices from within each of the food groups. She also recognizes that eating a healthy diet involves using moderation, so she doesn't consume too much of any one food or food group. She chooses a variety of fresh vegetables from the salad bar and tries different hot entrees each night. She makes a point of getting to the store where she can buy yogurt and fruit to keep in her dorm refrigerator. Kaitlyn now knows how to balance less healthy choices, like study snacks, with healthier foods at other times of the day. She is gaining confidence in her ability to balance her food intake with her activity. In addition, her understanding of the scientific method and how to evaluate nutrition information has given her the tools she needs to make decisions about following fads and using dietary supplements. **Now, in the middle of her second semester, Kaitlyn is maintaining her weight and using the principles of variety, balance, and moderation to choose a nutrient-dense diet that minimizes her risks of developing heart disease and high blood pressure.**

Summary

1.1 Nutrition, Food Choices, and the American Diet

- Nutrition is a science that encompasses all the interactions that occur between living organisms and food. Nutrients are substances in foods that provide energy and structure and help regulate body processes.
- Food choices are affected by food environment, family and cultural traditions, emotional factors, and personal tastes and convictions. No one food choice is good or bad, and no one choice can make a diet healthy or unhealthy—each choice contributes to the diet as a whole.
- In 21st-century America, we spend less time preparing food and eating at home and rely more on processed convenience foods and food prepared away from home than we did 50 years ago.
- Americans eat more calories than they did 50 years ago, primarily due to larger portion sizes and more snacking. The typical American diet does not meet the recommendations for a healthy diet and contributes to the development of chronic diseases such as diabetes, obesity, and heart disease.

1.2 Food Provides Nutrients

- About 45 nutrients are essential to human life. Nutrients consumed come from those naturally present in foods, those added to fortified foods, and those contained in dietary supplements. In addition to nutrients, food provides phytochemicals and zoochemicals, nonessential substances that may provide health benefits.
- There are six classes of nutrients: carbohydrates, lipids, proteins, water, vitamins, and minerals. Carbohydrates, lipids, and proteins are energy-yielding nutrients. The energy they provide to the body is measured in kilocalories or kilojoules. Carbohydrates, lipids, protein, water, and minerals provide structure to the body, and all nutrient classes help regulate the biochemical reactions of metabolism to maintain homeostasis.
- Nutrients provide energy, structure, and regulation and are needed by the body for growth, maintenance and repair, and reproduction.

1.3 Nutrition and Health

- When energy or one or more nutrients are deficient or excessive in the diet, malnutrition may result. Malnutrition includes both undernutrition and overnutrition. Depending on the cause, the symptoms of malnutrition can occur in the short term or over the course of many weeks, months, or even years.
- Undernutrition is caused by a deficiency of energy or nutrients. Overnutrition may be caused by a toxic dose of a nutrient or the chronic overconsumption of energy or of nutrients that increases the risk of chronic disease.
- Our health is affected both by our diet and our genetic makeup. The genes a person inherits affect the impact their diet has on their health, and the nutrients and other food components they consume affect the activity of their genes.
- A healthy diet includes a variety of nutrient-dense foods from each food group as well as a variety of foods from within each group. It balances energy and nutrient intake with needs and moderates choices to keep intakes of energy, fat, sugar, sodium, and alcohol within reason.

1.4 The Science Behind Nutrition

- The science of nutrition uses the scientific method to determine the relationships between food and the nutrient needs and health of the body. The scientific method involves making observations of natural events, formulating hypotheses to explain these events, designing and performing experiments to test the hypotheses, and developing theories that explain the observed phenomena based on the experimental results.
- The science of nutrition uses many different types of experimental approaches to determine nutrient functions and requirements. Observational studies identify relationships between diet and health. Intervention trials can test hypotheses developed from epidemiology. Laboratory studies use biochemical and molecular methods to study whole organisms or cells.
- Ethical guidelines protect humans and animals involved in research studies but limit the types of experiments that can be done.

1.5 Evaluating Nutrition Information

- When judging nutrition claims, first consider whether the information makes sense and is safe and whether it comes from a reliable source, such as an educational institution, the government, or a nonprofit organization. Information that promotes a product or in any other way benefits the person or organization providing it should be viewed with skepticism. Individual testimonies cannot be trusted because they have not been tested by experimentation.
- To be valid, nutrition information should be based on experiments that use quantifiable measurements, the right type and number of experimental subjects, appropriate controls, and a careful interpretation of experimental results. Reliable information will be supported by more than a single research study.