Nutrition:

Food for Health

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CHAPTER OUTLINE

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Case Study

Kaitlyn knew the potato chips in the dorm vending machine weren't a good choice—but aside from candy, they were her only option. Kaitlyn had been in classes and at work until late in the evening. When she finally sat down to study, she realized that she had missed dinner. She needed to eat something to keep her going until she finished the first chapter of her nutrition textbook, but her residence offered few food choices late at night. So she opted for the chips and fruit punch from the vending machine—they seemed to be the healthiest choices available.

As a first-year university student who has never been away from home, Kaitlyn has gained a few pounds and is beginning to be concerned about her weight. Her father recently had cardiac bypass surgery, and her mother takes medication for high blood pressure. Kaitlyn knows that because of this family history, her diet is a particularly important part of her future health. The residence cafeteria, although not great, does offer a variety of choices. The problem is that Kaitlyn doesn't know how to choose a healthy diet. She tries to keep some healthy snacks in her room, but her options are limited because she doesn't

have a refrigerator. Several of her friends drink high-caffeine energy drinks to stay awake and use supplements like ginkgo biloba to improve their memory. Kaitlyn is tempted to start taking them herself but remembers that her high school soccer coach told her that some supplements can be dangerous. To optimize her health, then, 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.

By reading the first chapter of her nutrition textbook, Kaitlyn will begin to understand how to achieve this goal, as will you as you read along with her.

1.1 Nutrition and the Canadian Diet

Canadian Content

LEARNING OBJECTIVES

- Describe the modern Canadian food supply.
- Describe the changes Canadians can make to their diet to improve their health.

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

nutrients Chemical 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. Sometimes, however, fast-paced lifestyles and food choices made available through modern technology contribute to a diet that contains too much or too little of some of the nutrients we need (**Figure 1.1**).

The Modern Canadian Food Supply

For much of human history, in order to get enough to eat, people needed to spend most of their day obtaining food ingredients and preparing meals. Even 100 years ago, the time spent for meal preparation was measured in hours—hours spent peeling, chopping, baking, roasting, stewing, and then cleaning. Today, a microwaveable dinner that includes meat, rice, vegetables, and dessert can be ready in five minutes.

Ilene MacDonald/Alamy Stock Photo

FIGURE 1.1 The availability of fast food has changed the Canadian diet, but at what price?

The modern Canadian food supply includes an endless assortment of eating options. Many of these choices are foods that have been part of the human diet for centuries—fresh fruits and vegetables, meats, and grains. But others are newer additions—frozen vegetables, canned soups, packaged meats, frozen prepared meals, and snack foods. Fifty years ago, people ate most of their meals at home, with their families, at a leisurely pace. Today the demands and pace of life in the 21st century, mean fewer people cook their own meals; instead they eat **processed foods** that can be microwaved in minutes rather than meals prepared from basic ingredients that need to be chopped, seasoned, and cooked. Snack foods such as potato chips, nachos, sugar-sweetened beverages, and other snack foods are readily available in fast food outlets, vending machines, school and workplace cafeterias, gasoline stations, etc. For example, on any given day, about one-quarter of Canadians eat food prepared in a fast-food restaurant.[1]

processed foods Foods that have been specially treated or changed from their natural state.

These changes in the Canadian food supply have made it easier to obtain a meal or snack but they have not improved our nutritional health (see Your Choice: Convenience Has Its Costs).

How Healthy Is the Canadian Diet?

The infographic (**Figure 1.2**) shows that the Canadian diet is not as nutritious as it could be and it is impacting the health of Canadians. A high proportion of children and adults are overweight or obese, due to the overconsumption of energy (kcalories or Calories). Canadians need to eat more vegetables and fruit, whole grains, and plant-based protein foods and

Your Choice

Convenience Has Its Costs

It's Monday morning, and you're exhausted. As you lie in bed, you decide that you'll stop for a muffin and coffee on your way to school to save a couple of minutes. You won't have to turn on your coffee pot, wait for the toaster, or clean up after you eat. But what is the cost of this convenience in terms of dollars and energy content? The examples given here show how much more expensive convenience foods are in dollar cost, and how much higher in energy content they are, compared to similar foods consumed at home. Scientists measure the energy content of food in kilocalories, which is exactly the same as the popular term "Calorie." Eating more kilocalories than we expend during daily activities will result in weight gain.

Consider that morning coffee and muffin. At home you might pour yourself an 8-ounce mug of coffee with whole milk and sugar, which would cost about 20 cents and provide about 50 kilocalories of energy along with a little protein and calcium. Toast or an English muffin with butter would add about 30 cents to the cost, along with 150 kilocalories and some B vitamins and iron. If instead you stop for a 16-ounce mocha and a healthy-looking bran muffin at the corner coffee shop, you will spend around $5.00 and ingest about 850 kilocalories, and not get many more nutrients than the toast and coffee at home would provide. The impact of stopping for coffee and a muffin once in a while when you are running late is minimal, but making it an everyday habit is expensive and can break your kilocalorie "budget" as well.

A homemade turkey sandwich for lunch, as an example, would cost about $2.00 and provide approximately 320 kilocalories. A 12-inch sub from the shop on the corner, in comparison, costs three or four times as much and may contain an additional

Luisa Begani

500 kilocalories—even more if you add a soft drink and cookie. Dropping $4.00 into the vending machine for an afternoon snack will get you a soft drink and a bag of chips, for a total of more than 300 kilocalories with few vitamins or minerals. Instead, a snack of fruit and baby carrots from home costs only about 50 cents and provides an assortment of essential nutrients for only about 100 kilocalories. Although the modern Canadian lifestyle tempts us with convenience, we need to consider the costs to both our wallets and our waistlines.

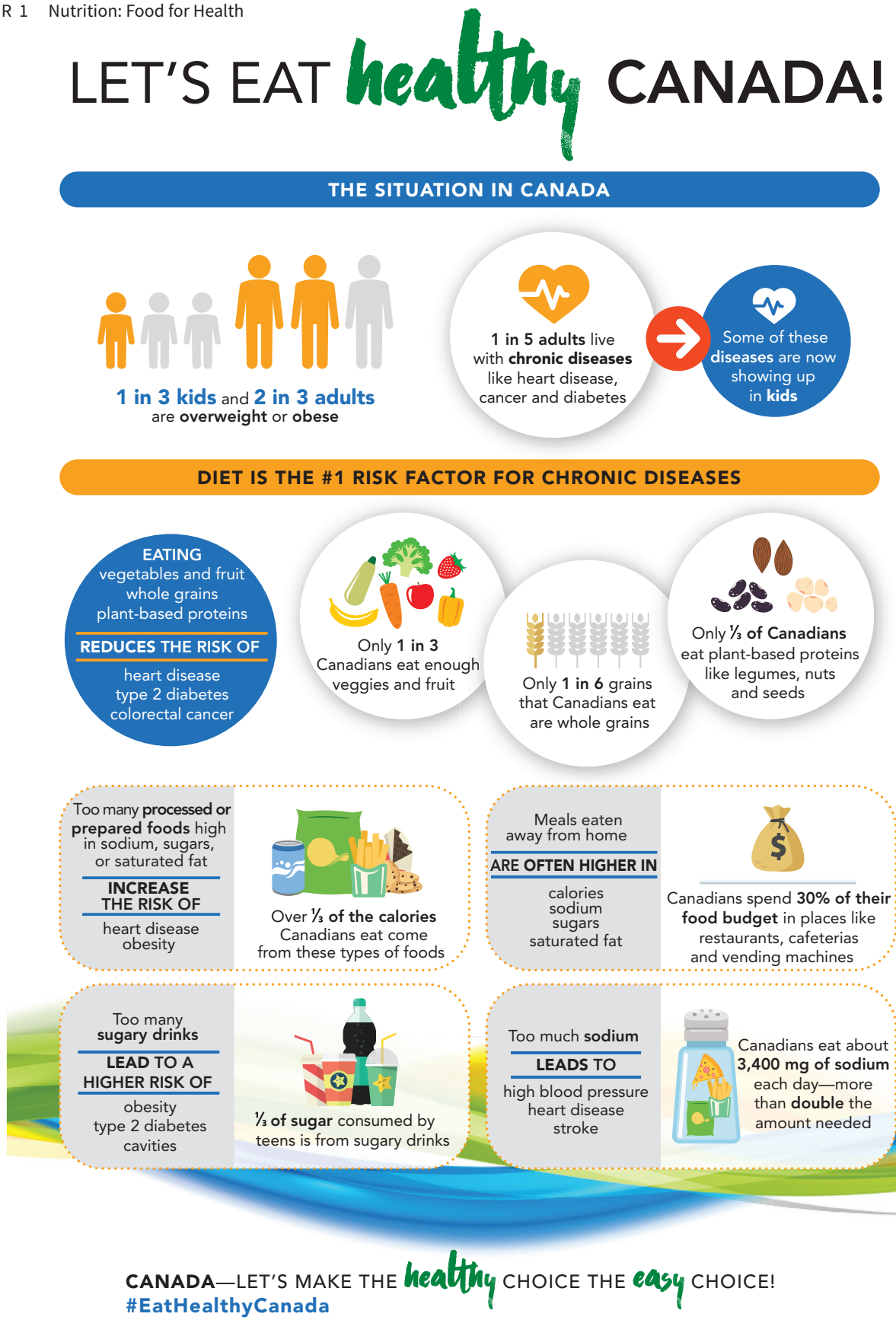

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FIGURE 1.2 **Characteristics of the Canadian diet.** Canadians should eat more vegetables and fruits, whole grains, and plant-based proteins and reduce the amount of saturated fat, salt, and sugar they consume.

Source: Statistics Canada. https://www150.statcan.gc.ca/n1/pub/82-003-x/2019001/article/00002-eng.htm. Accessed May 21, 2019. Public Domain.

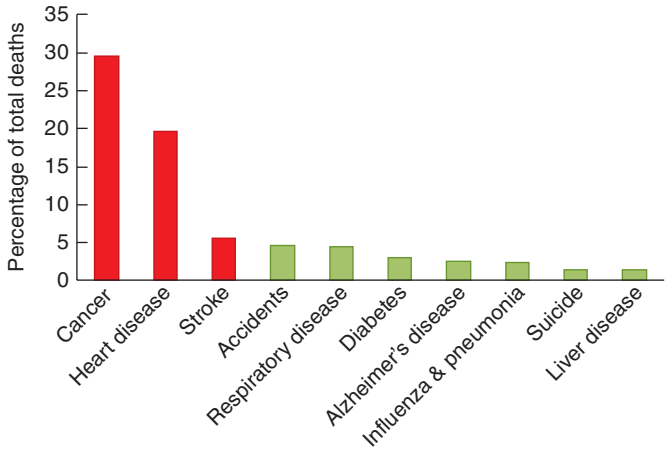


FIGURE 1.3 Leading causes of death. Of the 10 leading causes of death in Canada, the top three are nutrition-related.

Source: From Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310039401 Table 13-10-0394-01 Leading causes of death, total population, by age group, all ages, 2016. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310039401. Accessed May 22, 2019. Public Domain.

reduce the amount of processed foods they eat. Processed foods are usually high in saturated fat, sugar, and/or salt, which increase the risk of **chronic disease**. Chronic diseases are non-communicable diseases that develop slowly over a lifetime and need continuing medical attention to manage and control, such as heart disease, stroke, diabetes, and cancer. As indicated in **Figure 1.3** these chronic diseases are major causes of death among Canadians.

chronic disease Non-communicable diseases that develop slowly over a lifetime and need continuing medical attention to manage and control.

Canadian Health and Nutrition Surveys

Information about the health and food intake of Canadians is obtained from the **Canadian Community Health Survey** (CCHS), an annual survey, conducted by Canadian government agencies, that investigates various aspects of health and well-being in Canada, through a detailed questionnaire. In 2004 and 2015 the CCHS conducted focused surveys about the food intake of Canadians and the results of these two surveys are presented throughout this textbook. The two surveys are referred to as the 2004-CCHS-Nutrition[2] and the 2015-CCHS-Nutrition.[3]

Canadian Community Health Survey This is a comprehensive survey of health-related issues, including the eating habits of Canadians, that was begun in 2000 and continues to collect data annually. Results of this survey will be presented throughout this textbook.

Another survey called the Canadian Health Measures Survey (CHMS) conducted every two years, includes useful food and nutrition data, but differs from the CCHS as it includes laboratory measurements as well as questionnaires.[4]

Learning Nutrition

As you study nutrition, you will learn more about the relationship between diet, health, and disease and how to make wise food 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 determine which nutrition information to believe.

1.1 Concept Check

1. Define nutrition and nutrients.
2. What characteristics of the modern Canadian food supply may be detrimental to health?
3. Describe how fast foods can break your kilocalorie "budget".
4. Which foods should Canadian eat more of and which should they avoid?

1.2 Food Provides Nutrients

LEARNING OBJECTIVES

- List the six classes of nutrients.
- Describe the three general functions of nutrients.
- Describe the different types of malnutrition.
- Describe how diet–gene interaction affects our health.

Canadian Content To date, approximately 45 nutrients have been determined to be essential to human life. **Essential nutrients** must be supplied by the diet to support life; they either cannot be made by the body or cannot be made in sufficient 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 vitamin C deficiency. If vitamin C is not added back to the diet, the deficiency will eventually be fatal.

essential nutrients Nutrients that must be provided in the diet because the body either cannot make them or cannot make them in sufficient quantities to satisfy its needs.

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**. In Canada, vitamins and minerals can be added to a number of foods such as white flour, breakfast cereals, milk, orange juice, infant formula, and plant-based beverages such as soy, rice, and almond milk. The type and amount of nutrients that can be added are regulated and are intended to restore nutrient losses caused by processing or to prevent known inadequacies in the Canadian diet. **Natural health products** are another source of nutrients in the food supply. Natural health products are a category of products regulated by Health Canada which occupy a middle ground between foods and drugs. They include vitamins, minerals, amino acids, and fatty acid supplements, as well as other compounds (see definition). The 2015-CCHS-Nutrition estimates about 46% of Canadians use vitamin and mineral supplements.[5]

fortified foods Foods to which one or more nutrients have been added, typically to replace nutrient losses during processing or to prevent known inadequacies in the Canadian diet.

natural health products Natural health products are a category of products regulated by Health Canada that include vitamin and mineral supplements, amino acids, fatty acids, probiotics, herbal remedies, and homeopathic and other traditional medicines. They occupy a middle ground between food and drugs.

In addition to essential 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 typical 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. Certain fatty acids found in fish oils are examples of zoochemicals; they are not essential as they can be synthesized in the body, but additional dietary intake has been linked to health benefits such as reduced risk of death from cardiovascular disease (see Section 5.6 for more details).

phytochemicals Substances found in plant foods (*phyto* means plant) that are not essential nutrients but may have health-promoting properties.

zoochemicals Substances found in animal foods (*zoo* means animal) that are not essential nutrients but may have health-promoting properties.

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) (see Appendix E). Vitamins and minerals are classified as **micronutrients**, because they are needed in small

energy-yielding nutrients Nutrients that can be metabolized to provide energy in the body.

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

micronutrients Nutrients needed by the body in small amounts. These include vitamins and minerals.

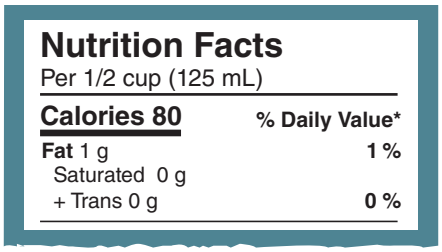


FIGURE 1.4 Kilocalories in the Nutrition Facts Table. The top portion of the table indicates that there are 80 kcalories per the stated 125 ml serving.

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). 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.

organic molecules Those containing carbon bonded to hydrogen.

inorganic molecules Those containing no carbon–hydrogen bonds.

The Energy-Yielding Nutrients

The energy provided by carbohydrates, lipids, and proteins is measured in **kilocalories** (abbreviated as kcalories or kcals) or in **kilojoules** (abbreviated as kjoules or kJs). The more common term, "calorie," is technically 1/1000 of a kilocalorie, but when it is spelled with a capital "C," it indicates kilocalories. For instance, the term "Calories" on food labels actually refers to kilocalories (**Figure 1.4**). However, in the popular press, the term "calorie" (small "c") is often used to express the kcalorie content of a food or diet.

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

kilojoule (kjoule, kJ) 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 one kilogram a distance of 1 metre under the force of gravity (4.18 kjoules = 1 kcalorie).

Carbohydrates provide a readily available source of energy to the body. They contain four kcalories per gram (**Table 1.1**). Carbohydrates include sugars such as those in table sugar, fruit, and milk, and starches such as those in vegetables and grains. Sugars are the simplest form of carbohydrate, and starches are more complex carbohydrates made of many sugars linked together (**Figure 1.5**). Most fibre is also carbohydrate, and cannot be digested, and therefore provides very little energy. However, it is important for gastrointestinal health. Fibre is found in vegetables, fruits, **legumes**, and whole grains. Carbohydrates are discussed in detail in Chapter 4.

legumes The starchy seeds of plants belonging to the pea family; includes peas, peanuts, beans, soybeans, and lentils.

Lipids, commonly called fats and oils, provide nine kcalories per gram. They are a concentrated source of energy in food and a lightweight storage form of energy in the body. There are several types of lipids that 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, and the layer of fat under a person's skin are all comprised almost entirely of triglycerides. Triglycerides are made up of fatty acids (see Figure 1.5). 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 monounsaturated and polyunsaturated fatty acids may reduce risks. Cholesterol is another type of lipid; high levels in the blood can increase heart disease risk. Lipids are discussed in detail in Chapter 5.

Protein is needed for growth and maintenance of body structures and regulation of body processes. It can also be used to provide energy—four kcalories per gram. Meat, fish, poultry, milk, grains, vegetables, and legumes all provide protein. Like carbohydrate and lipid, protein is

TABLE 1.1 Energy Provided by Macronutrients and Alcohol

	Kcalories/Gram	Kjoules/Gram
Carbohydrate	4	16.7
Lipid	9	37.6
Protein	4	16.7
Alcohol	7	29.3

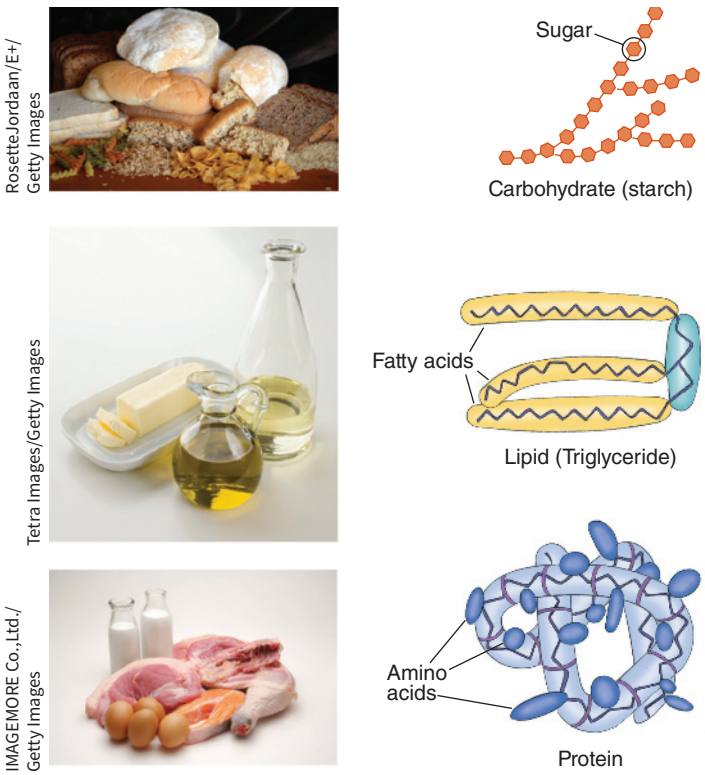


FIGURE 1.5 Carbohydrates, lipids, and proteins. Starches are a type of carbohydrate made of sugars linked together; most lipids, such as the triglyceride shown here, contain fatty acids; proteins are made of amino acids linked together.

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 (see Figure 1.5). 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. Proteins are discussed in detail in Chapter 6.

Water Water is a nutrient in a class by itself. It is a macronutrient that does not provide energy. Water makes up about 60% of the human body by weight and is required in kilogram amounts in the daily diet. Water serves many functions in the body, including acting as a lubricant, a transport fluid, and a regulator of body temperature. Water can be obtained from the beverages we drink and also from food, as many foods contain large amounts of water. About 60% of the weight of raw beef is water and fruits and vegetables can be anywhere from 70%-98% water.

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 unique structure and provides a unique function in the body. Many are involved in helping the body use the energy from carbohydrates, lipids, and proteins; others function in processes such as bone growth, vision, blood clotting, oxygen transport, and tissue growth and development. Vitamins are discussed in detail in Chapters 8 and 9.

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. Minerals are discussed in detail in chapters 10, 11, and 12.

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

Functions of Nutrients

Metabolism 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.

Providing 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 fat. These stores can provide energy when dietary sources are unavailable. Over the long term, if more energy is consumed than is needed, body stores get larger, and body weight increases. If less energy is consumed than is needed, the body will burn its stores to meet its energy needs, and body weight will decrease.

Forming Structures

Most of the weight of the human body is due to water, protein, and fat (**Figure 1.6**). These nutrients, along with the minerals, are needed to form and maintain the shape and structure of the body. Proteins form the ligaments and tendons that hold bones together and attach muscles to bones. Protein also forms the framework of bones and teeth that is hardened by mineral deposits, and the overall structure of muscles. At the cellular level, lipids and proteins make up the membranes that surround cells.

Regulating Body Processes

Together all of the reactions that occur in the body are referred to as **metabolism**. Metabolic processes must be regulated to maintain a stable environment inside the body, referred to as **homeostasis**. All six classes of nutrients have important regulatory roles (**Table 1.2**). The enzymes that catalyze the chemical reactions of metabolism are made up of proteins. These proteins combine with vitamins and minerals to speed up or slow down the reactions as needed to maintain homeostasis. Because water is the solvent for metabolism, most of these reactions occur in the watery component of the cells. Water also helps to regulate body temperature. When body temperature increases, water lost through sweat helps to cool the body.

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

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

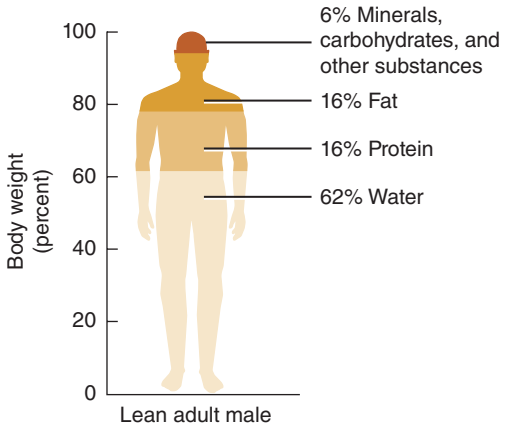


FIGURE 1.6 Composition of the human body. Water, protein, and fat are the most abundant nutrients in the human body.

TABLE 1.2 Examples of Nutrient Functions in the Body

Function	Nutrient	Example
Energy	Carbohydrate	Glucose is a carbohydrate that provides energy to body cells.
	Lipid	Fat is the most plentiful source of stored fuel 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.

Nutrition and Health

What we eat has an enormous impact on how much we weigh, how healthy we are now, and how likely we are to develop chronic diseases like heart disease and diabetes in the future. Consuming either too little or too much of one or more nutrients or energy can cause **malnutrition**. Malnutrition can affect our health today and can impact on our health 20, 30, or 40 years from now.

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

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

Dietary Deficiencies

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 1.7a**). Deficiencies of individual nutrients can also cause serious health problems. These health problems often reflect the body functions that rely on the

(a) (b)

Per-Anders Pettersson/Getty Images News/Getty Images

George Doyle/Stockbyte/Getty Images

FIGURE 1.7 Malnutrition includes both undernutrition (a) and overnutrition (b).

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 common in older adults because absorption often decreases with age, causes changes in mental status.

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 weeks, months, or even years to become apparent. The symptoms of the vitamin C deficiency disease scurvy do not occur until the diet has been deficient in vitamin C for weeks or months. Too little calcium in the teenage years causes no immediate symptoms but can cause bones to be weak and break too easily when people reach their fifties or sixties.

Dietary Excesses

Overnutrition, an excess of 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 over a few weeks or months can cause nerve damage. Most nutrient toxicities are due to excessive intakes of vitamin and mineral supplements. Foods generally do not contain high enough concentrations of nutrients to cause toxic reactions.

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

The kinds of overnutrition that are most common in the Canada today do not have immediate toxic effects but contribute to the development of chronic diseases, such as heart disease, type 2 diabetes, and some types of cancer, in the long term. Diets providing more energy than needed have resulted in a Canadian population where 60% of adults are overweight or obese (**Figure 1.7b**).[6] Diets high in salt contribute to high blood pressure, those high in saturated fat play a role in heart disease, and those high in red meats and low in fruits and vegetables and fibre may increase the risk of colon cancer.[7]

Diet–Gene Interactions

Diet affects your health, but diet alone does not determine whether you will develop a particular disease. Each of us inherits a unique combination of **genes**. Genes are composed of DNA which contain the information that a cell needs to synthesize specific proteins. Some of these genes affect your risk of developing chronic diseases such as heart disease, cancer, high blood pressure, and diabetes, but their impact is affected by what you eat (**Figure 1.8**). Your genetic makeup determines the impact a certain nutrient will have on you. For example, some people inherit a combination of genes that results in a tendency to have high blood pressure, possibly because the proteins produced by these genes are less effective in excreting sodium. When these individuals consume large amounts of sodium, their blood pressure increases (discussed

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

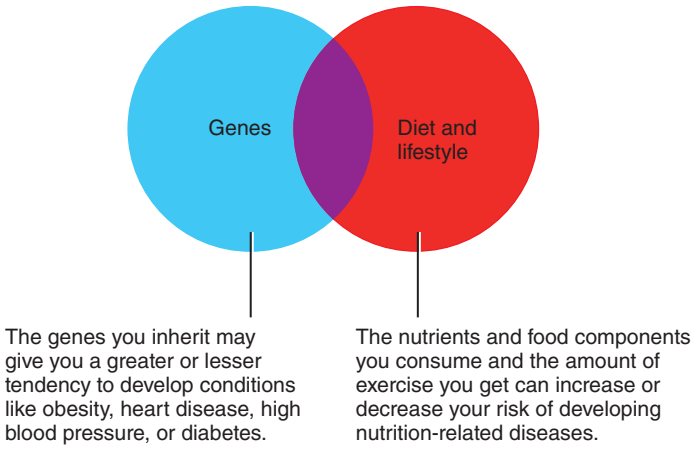


FIGURE 1.8 Diet and genes. Your actual risk of disease results from the interplay between the genes you inherit and the diet and lifestyle choices you make.

further in Section 10.3). Others inherit genes that allow them to consume a high-sodium diet without a rise in blood pressure, possibly because they are able to excrete sodium more readily than most people. Those whose genes dictate a rise in blood pressure with a high-sodium diet can reduce their blood pressure, and the complications associated with high blood pressure, by eating a diet that is low in sodium.

nutritional genomics or **nutrigenomics** The study of how diet affects our genes and how individual genetic variation can affect the impact of nutrients or other food components on health.

Our increasing understanding of human genetics has given rise to the discipline of **nutritional genomics** or **nutrigenomics**, which explores the interaction between genetic variation and nutrition.[8] This research has led to the development of the concept of "personalized nutrition," the idea that a diet based on the genes an individual has inherited can be used to prevent, moderate, or cure chronic disease. If a person, for example, carries a gene that causes vitamin C to be rapidly degraded in the body, then a personalized nutrition approach would recommend that this person consume higher than usual amounts of vitamin C to compensate for the greater than usual vitamin losses. Although today we do not know enough about gene–nutrient interactions to take a sample of your DNA and comprehensively advise you on your ideal diet, researchers continue to discover gene variants that influence health and our response to diet.

1.2 Concept Check

1. Define the term *essential nutrient* and list the six classes of nutrients.
2. Define fortified foods.
3. Define natural health products.
4. Describe the three general functions of nutrients.
5. Define malnutrition.
6. Define diet–gene interaction.

1.3 Food Choices for a Healthy Diet

LEARNING OBJECTIVES

- List factors other than nutrition that affect food choices.
- Describe how to choose a healthy diet.

Each of the food choices we make contributes to our diet as a whole. This diet must provide enough energy to fuel the body and all the essential nutrients and other food components—in the right proportions—to prevent deficiencies, promote health, and protect against chronic disease. No single food choice is good or bad in and of itself, but all of our choices combined make up a dietary pattern that is either healthy or not so healthy.

Factors That Affect Food Choices

AvailableLight/iStock/Getty Images Plus/Getty Images

FIGURE 1.9 What factors influence the foods you purchase at the supermarket?

There are hundreds of food choices to make and hundreds of reasons for making them (**Figure 1.9**). Even though the foods we eat provide the nutrients and energy necessary to maintain health, the foods we choose are not necessarily determined by the nutrients these foods contain. Our food choices and food intake are affected not only by nutrient needs but also by what is available to us, where we live, what is within our budget and compatible with our lifestyle, what we like, what is culturally acceptable, what our emotional and psychological needs are, what we think we should eat, and how we are influenced by media.

Availability The food available to an individual or a population is affected by geography, socioeconomics, and health status. Geography is important in developing parts of the world,

where 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 (**Figure 1.10**).

Even if foods are available in the store, it does not mean that they are available to all individuals. Socioeconomic factors such as income level, living conditions, and lifestyle as well as education affect the types and amounts of foods that are available. Individuals with limited incomes can choose only the types and amounts of foods that they can afford. Individuals who do not own cars can only purchase what they can carry home. Those without refrigerators or stoves are limited in what foods can be prepared at home. And those who cannot or do not have time to cook are limited to 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.

David R.Frazier/The Image Bank/Getty Images

FIGURE 1.10 The fresh produce you buy in your local store may come from across the street or across the ocean.

AFP/Stringer/Getty Images

FIGURE 1.11 A plate of silkworms, such as these being sold in a Vietnamese market, may not seem very appetizing to you, but insects are a part of the diet in many parts of the world.

Cultural and Family Background

Food preferences and eating habits are learned as part of each individual's family, cultural, national, and social background. 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 commonly consumed. Curries characterize Indian cuisine and we expect refried beans and tortillas when we go out for Mexican food. The foods we are exposed to as children influence what foods we buy and cook as adults. If your mother never served artichokes or Swiss chard, you may not consider eating them as an adult. If you grew up in Asia or Africa, you might consider grasshoppers or termites an acceptable food choice, but in Canada, insects are considered food contaminants (**Figure 1.11**). If you did not grow up in a culture that eats insects, you may be unwilling to try them now.

What would a birthday be without a cake, or Thanksgiving without a turkey? Each of us associates holidays such as Christmas, Passover, Chinese New Year, Diwali, and Eid with specific foods that are traditional in our family, religion, and culture. Seventh-Day Adventists are vegetarians; Jews and Muslims do not eat pork; Sikhs and Hindus do not eat beef. Even for those who choose not to observe religious dietary rules, habit may dictate many mealtime decisions. Jewish kosher laws prohibit the consumption of meat and milk in the same meal. Often Jews who, as adults, do not follow kosher law, may choose to avoid milk and meat products at a meal, simply because they never consumed this combination of foods as children.

Social Acceptability

In addition to being part of our cultural heritage, food is the centrepiece of many 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 do not like out of politeness to our hosts. We sometimes alter our food choices because of peer pressure. For example, an adolescent may feel that stopping for a cheeseburger or taco after school is an important part of being accepted by their peers.

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 favourite foods? Probably not too good, and you are not alone. Even though most people understand that nutrition is important to their health, taste is often more important in influencing food choice.[9] Personal convictions also affect food choices; a vegetarian would not choose a meal that contains meat, and an environmentalist may not buy foods packaged in non-recyclable containers.

Psychological and Emotional Factors

Food represents comfort, love, and security. We learn to associate food with these feelings as infants suckling while cradled in our

Image Source/Photodisc/Getty Images

FIGURE 1.12 What foods make you feel better when you are sad, tired, or lonely?

mothers' arms. As children and as adults, comfort foods such as hot tea and chicken soup help us to feel better when we are sick (**Figure 1.12**). We use food as a reward when we are good—an excellent report card is celebrated with an ice cream cone. We sometimes take away food as punishment—a child who misbehaves is sent to bed without dinner. We consider ourselves good when we eat healthy foods and bad when we order a decadent 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.

Health Concerns An individual's perceptions of what makes a healthy diet affect their food and nutrition choices. For example, someone may choose low-carbohydrate foods if they believe that these choices will help them lose weight. They may limit red meat intake to reduce their risk of heart disease, or they may purchase organically produced foods if they believe that reducing pesticide exposure will prevent illness. A recent survey of Canadians found that at least 50% were making changes to improve the quality of their diet by reducing intakes of salt, sugar, and fat and by increasing their consumption of vegetables and whole grains.[10]

Media Food choices are often influenced by the messages someone receives from the media. Food advertisers try to promote a particular food product hoping to influence food purchases and preferences. Magazines, newspapers, books, television, and the Internet make a vast amount of information on food, nutrition, and health available to the individual. Sometimes this information is accurate and useful; other times it is inaccurate and confusing. (See Sorting Out Nutrition Information: Section 1.6.)

Choosing a Healthy Diet

A healthy diet has a number of positive characteristics including adequacy of nutrients and energy and high nutrient density. It contains a variety of foods, that are balanced and moderate, with respect to energy content.

adequacy A state in which there is a sufficient amount of a nutrient or nutrients in the diet to maintain health.

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

Adequacy and Nutrient Density A healthy or adequate diet is one that provides the right amount of energy to keep weight in the desirable range; the proper types and amounts of carbohydrates, proteins, and fats; plenty of water; and sufficient but not excessive amounts of essential vitamins and minerals. To ensure **adequacy**, a diet must be rich in nutrient-dense foods. **Nutrient density** is a measure of the nutrients a food provides compared to its energy content. Nutrient-dense foods contain substantial amounts of nutrients per kcalorie. For example, broccoli is more nutrient-dense than french fries (**Figure 1.13**). The broccoli is a good source of calcium, vitamin C, vitamin A, and folate and only contributes about

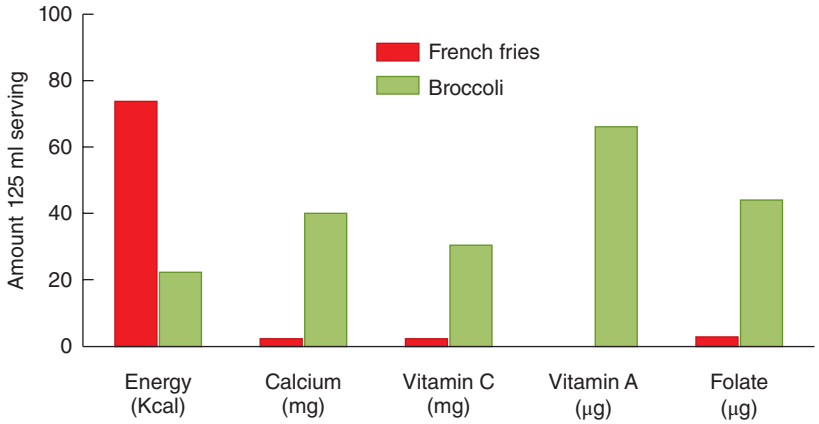


FIGURE 1.13 **Nutrient density.** Choosing broccoli instead of french fries will provide fewer kcalories and more calcium, vitamin C, vitamin A, and folate.

TABLE 1.3 Choices to Boost Nutrient Density

Lower Nutrient Density Choice Instead of this . . .	Higher Nutrient Density Choice Have this . . .
Soft drink	Low-fat milk
Chocolate candies	Fruit and nut trail mix
Apple pie	Fresh apple
Potato chips and sour cream dip	Baked tortilla chips and salsa
Triple fudge brownie	Oatmeal raisin cookie
Fried chicken	Roasted chicken without skin
French fries	Oven-baked potato wedges

20 kcalories per 125 ml (1/2 cup). The french fries provide little vitamin A and much smaller amounts of vitamin C, calcium, and folate and contribute about 80 kcalories per 125 ml. The french fries also provide less fibre and more fat than the broccoli. This does not mean you should never have french fries, but it does mean that if many of your choices throughout the day are foods that are low in nutrient density, such as soft drinks, snack foods, and baked goods, it will be hard to meet your nutrient needs. On the other hand, if you know how to choose nutrient-dense foods, you can meet all your nutrient needs and have kcalories left over for occasional treats that are low in nutrients and high in kcalories (**Table 1.3**). An adequate diet is based on variety, balance, moderation, and calorie control. 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 intake. Variety means including grains, vegetables, fruits, milk and alternatives, and meat and alternatives in the diet. Some of these foods are rich in protein and minerals, others in vitamins and phytochemicals. All are important. Variety also means choosing many 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 fibre 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, fibre, and phytochemicals than carrots alone would provide. Likewise, if you always choose red meat from the high-protein choices, you will be missing out on the fibre in beans and the healthy fats in nuts and fish. Variety comes not only from choosing different foods each day, but also each week, and each season. If you had apples and grapes today, have blueberries and cantaloupe tomorrow. If tomatoes do not look appetizing in the winter, replace them with a winter vegetable like squash.

Choosing a varied diet is also important because there are 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, residues of pesticides and fertilizers, or other contaminants. Choosing a variety of foods avoids an excess of any one of these substances.

Balance Your Choices

Balance involves mixing and matching foods in proportions that allow you to get enough of the nutrients you need and not too much of the ones that might harm your health. A balanced diet provides plenty of whole grains, vegetables, and fruits. 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 up in daily activities so body weight stays in the healthy range (**Figure 1.14**).

If you have a Big Mac for lunch instead of a smaller plain burger, you will have to increase your energy expenditure by 300 Calories.

Andy Washnik

PictureNet Corporation/ DigitalVision/Getty Images

You could do this by playing golf for about an hour, carrying your own clubs.

If you have a grande mocha frappuccino instead of a regular iced coffee, you will have to increase your energy expenditure by 370 Calories.

Andy Washnik

Kate Thompson/National Geographic Image Collection

You could do this by jogging for about 30 minutes.

FIGURE 1.14 Balance kcalories in with kcalories out. Extra kcalories you consume during the day must be balanced by increasing the kcalories you burn in physical activity to avoid weight gain.

Everything in Moderation

Moderation means everything is okay, as long as you do not overdo it. If you like burgers or potato chips, they can be included in your diet, but you have to watch the size of your portions and how frequently you consume these foods. As indicated in Figure 1.14, choosing larger portion sizes or high-kcalorie foods can result in excess kcalories. If these kcalories are not expended through physical activity, they can result in weight gain. 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. Moderation means not consuming too much energy, too much fat, too much sugar, too much salt, or too much alcohol. Choosing moderately will help you maintain a healthy weight and help prevent chronic diseases like heart disease, cancer, and type 2 diabetes that compromise the quality of life of many Canadians. The fact that more Canadians 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.

portion distortion The increase in portion sizes for typical restaurant and snack foods, observed over the last 40 years.

One factor that may make moderation difficult is a phenomenon called **portion distortion**.[11] Researchers have found that over the last 40 years, portion sizes in restaurants and the sizes of single-portion snack foods have increased. For example, in the 1960s, cola drinks were sold in 250-ml-sized bottles (110 calories for a sugar-containing drink), while today's single portion bottle contains almost 600 ml and 260 kcalories. Similarly, hamburgers, muffins, and bagels have increased in size. Many more examples can be found at Portion Distortion, a website created by the U.S. Dept of Health as part of its Obesity Education Initiative (find it by searching NHLBI portion distortion using any search engine). In recent years, the food industry has introduced smaller portion sizes into the marketplace, such as the 100-kcalorie snacks or soft-drink cans, a phenomenon called subpackaging (**Figure 1.15**). Research suggests that these smaller portions can be beneficial in controlling overeating.[12]

Ensuring Kcalorie Control

Kcalorie control refers to the specific aspects of balance and moderation that are related to energy intake. Ensuring that energy intake from foods balances energy expended in daily activities will ensure kcalorie control, as will moderation in food choices so that too much energy is not consumed.

Luisa Begani

FIGURE 1.15 Subpackaging. Smaller 100 kcalories single portions of food products may help to prevent overeating.

1.3 Concept Check

1. Apart from nutrition, what factors can affect food choices?
2. Define nutrient density.
3. Explain the importance of variety, balance, moderation, and kcalorie control in selecting a healthy diet.

1.4 Understanding Science Helps Us Understand Nutrition

LEARNING OBJECTIVES

- List the steps of the scientific method.
- Describe the features of a good experiment.

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. But they may find this frustrating because the experts seem to change their minds so often. One day, consumers are told margarine is better for them than butter; the next day, a report says that it is just as bad. 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 determining whether a headline about vitamin E supplements is true.

The Scientific Method

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

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

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

theory An explanation based on scientific study and reasoning.

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. The results of one experiment are generally not considered sufficient proof that a hypothesis is correct. If, however, the hypothesis is confirmed in a number of studies, that is, if the results are reproduced, then the hypothesis is considered strong enough for a **theory**, or a scientific explanation, to 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.

The discovery of the relationship between nutrition and pellagra, a disease now known to be caused by a deficiency of the vitamin niacin, is an example of how the scientific method has been used to study nutrition (**Figure 1.16**). In the early 1900s, pellagra was a common disease in the southeastern United States, where corn was a major component of the diet, particularly among the poor. Scientists observed that in institutions such as hospitals, orphanages, and prisons, residents suffered from pellagra, but the staff did not. If pellagra were an infectious disease, both populations would be affected. The hypothesis proposed was that pellagra was due to a dietary deficiency. To test this hypothesis, nutritious foods such as fresh meats and vegetables were added to the residents' diet. The symptoms of pellagra disappeared, supporting the hypothesis that pellagra is due to a deficiency of something in the diet. This experiment and others, shown in the flow chart in Figure 1.16, led to the theory that pellagra is caused by a dietary deficiency. This theory, which still holds today. was strengthened by the discovery of the vitamin niacin, and the observation that corn, as it was used in the southeastern US at the turn of the last century, was found to be a poor source of niacin (see Chapter 8: Science Applied: Pellagra: Infectious Disease or Dietary Deficiency?).

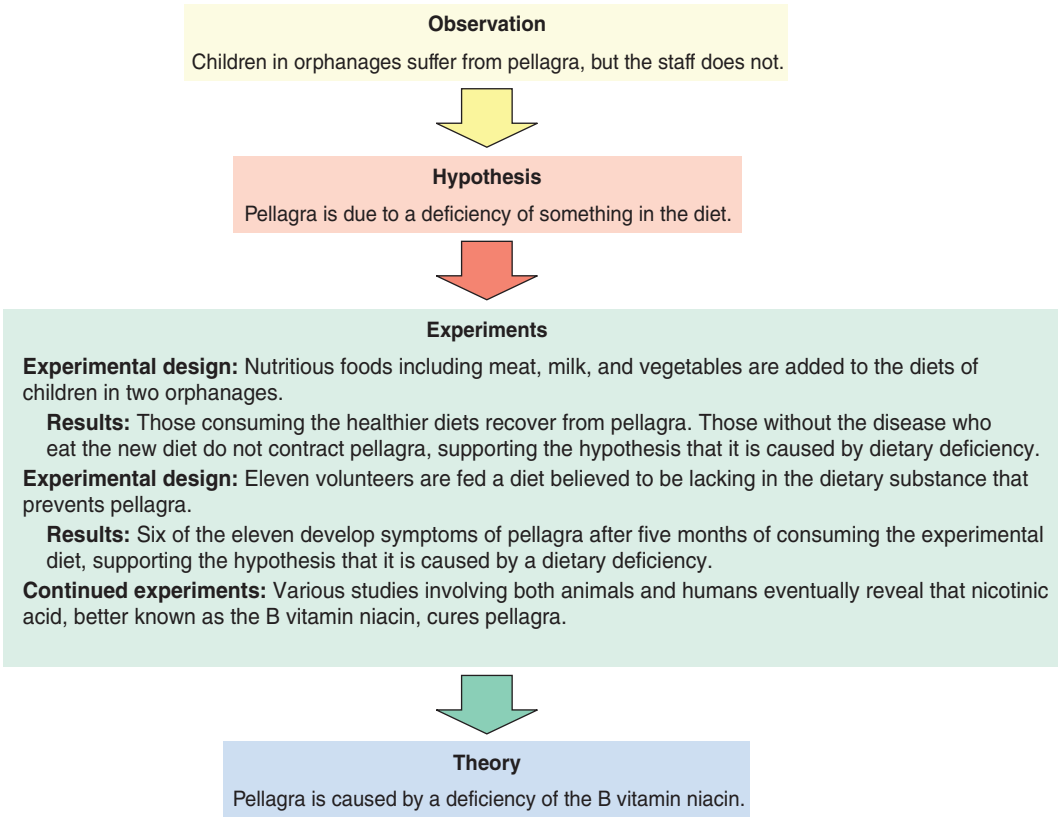


FIGURE 1.16 The scientific method. The scientific method is a process used to ask and answer scientific questions through observation and experimentation.

What Makes a Good Experiment?

For the scientific method to generate reliable theories, the experiments done to test hypotheses must generate reliable results and be interpreted accurately. Features of a well-designed nutrition experiment include (a) quantifiable data, (b) an appropriate experimental population, (c) appropriate number of subjects, (d) suitable study duration, (e) statistical analysis of results, and (f) publication after a peer-review process.

Quantifiable Data

Scientific experiments are designed to provide quantifiable data. This means that the data can be measured in a way that provides numerical results and uses methods that can be repeated by others. Measurements typically included in nutrition studies are sex, age, dietary intake (using methods discussed in Section 2.6), weight, blood pressure, levels of nutrients in the blood or urine, other biological indicators of future disease development, or the actual presence of disease. These indicators of future disease development are often called **biomarkers**. For example, the risk of getting **cardiovascular disease** is related to the levels of cholesterol in the blood. People who eventually develop cardiovascular disease tend to have higher levels of cholesterol in their blood for some time before they get the disease than people who do not develop cardiovascular disease. Therefore, cholesterol levels would be considered a biomarker of cardiovascular disease. The advantage of using biomarkers is that they often respond quickly to a dietary treatment. For example, some diets can lower cholesterol levels in a few weeks, while cardiovascular disease may take decades to develop. But biomarkers, although useful because they respond rapidly, are not as conclusive as directly measuring disease outcome. For this reason, some experiments do measure the actual presence of disease. These studies often last many years. For example, a study might compare the number of heart attacks in a group of individuals given a vitamin supplement for 5 to 10 years to the number of heart attacks in a group that did not get the supplement.

biomarker A biological measurement that is an indicator of future disease development.

cardiovascular disease A disease that results from damage to blood vessels, such as the coronary arteries of the heart, which can cause heart attack, or the blood vessels of the brain, which can result in stroke.

Feelings or impressions are more difficult to assess than measurements of body weight and blood pressure, but not impossible. In order to be useful in science, feelings and opinions must be quantified using standardized questionnaires and compared, where possible, to a quantifiable biomarker. For example, if a person taking a supplement to build muscle reports that they feel stronger after taking it, this alone is considered anecdotal information that has little value on its own. However, if perceptions of strength are assessed with a questionnaire which has a quantitative component (e.g., asking people to rate their strength on a numerical scale) and changes in muscle mass are measured, these are objective measurements that can be quantified and repeated.

Appropriate Experimental Population

For an experiment to produce useful results, the right experimental population must be studied. For example, a food or supplement that claims to improve performance in trained athletes must be tested using trained athletes. Scientists who are interested in studying how diet might help prevent heart disease generally select older adults, in whom the development of heart disease is common. In this population, it is easy to determine if diet has increased or decreased the number of adults who develop heart disease. On the other hand, because young adults in their 20s and 30s get so little heart disease diet might not have a measurable effect. They would not be suitable subjects unless the study was intended to last 30–40 years.

Appropriate Number of Subjects

The number of subjects included in a study is also important. For most experiments, you want to confirm that the effect of a treatment was not due to chance. It is often difficult to draw firm conclusions from a study that has too few participants and conducting a study with more participants than is necessary wastes resources. Fortunately, using a statistical method, called **sample size calculation**, it is possible to determine how many subjects are needed to demonstrate an effect of a certain size, given that researchers know something about the variability of the measurement and how much error they are willing to tolerate. For example, if a study is measuring the effect of a diet on lowering serum cholesterol, researchers can calculate how many participants are needed to confirm that a 10% decrease in serum cholesterol is not due to chance. The 10% decrease is the size

sample size calculation A statistical methodology to determine the appropriate number of participants in a study, given a certain effect size, variability in measurement, and tolerance for error.

of the treatment effect and is determined by researchers, before the study begins, as a difference that would be useful in improving human health. (A more detailed discussion of sample size calculation is beyond the scope of this textbook; interested students can learn more from an introductory statistics course or textbook).

Suitable Study Duration

It is important for scientists to design their study to last long enough to see an effect. For example, some biomarkers such as blood cholesterol levels can respond to diet very quickly and results can be seen in a few weeks or months. Diseases such as heart disease or cancer take decades to develop, so studies investigating disease outcomes often last many years. In the previous example, the young adults (in their 20s and 30s) would take 20–40 years to develop heart disease, and that is why they would not typically be used as subjects for a study on heart disease and diet, unless researchers are able to conduct a study of this duration. One such study, the Framingham Study, has examined the health of three generations; the first generation was enrolled in the study in 1948, the second in 1971, and the third in 2002.[13–15]

Statistical Analysis of Results

Statistical methods are essential for the analysis of the results. When different diets result in different levels of disease risk or other health-related **variables**, it is essential to determine, through statistical analysis, whether the observed difference is due to chance or represents a meaningful difference due to diet. For example, a study finds that a diet high in vegetables results in a lower risk of cardiovascular disease, compared to a diet low in vegetables. In most nutrition research studies, comparisons are commonly made between at least two groups, such as high and low vegetable intake, and statistical analysis answers the following question: If it is assumed that there is truly *no difference* between the two groups, what is the probability that the observed difference between groups is due to chance?

variable A factor or condition that is observed, manipulated, or measured in an experiment.

The calculated probability (P) is expressed as a decimal between 0 and 1, where $P = 0$ means there is no possibility that the observed difference between groups is due to chance and $P = 1$, which means it is certain that the observed difference is due to chance. In actual research, P is never 0 or 1, but a number in-between. If the probability that the difference is due to chance is low, meaning P is a very small number, then the difference is *statistically significant* or there is a *statistically significant difference* between groups such as high or low vegetable intake, with respect to cardiovascular disease risk. In the biomedical sciences, which includes nutrition, by convention, $P < 0.05$ is considered a low value and a difference with $P < 0.05$ is considered a statistically significant difference. So in the study of vegetable intake, if the probability is 0.01, (a value less than 0.05), then there is a statistically significant difference between high and low vegetable intake. This means that if there is *truly no difference* between the two groups, then the observed difference would occur in 1 study out of 100; it is a very uncommon event. Most researchers, when looking at an analysis like this, would make an alternative conclusion, which is to reject the assumption that there is no difference between the groups and instead conclude that the difference, in cardiovascular disease risk, is likely not due to chance, but reflects a meaningful effect of diet. It is very likely that high vegetable intake reduces the risk of cardiovascular disease. It is not a certainty, but it is much more likely than not.

So overall when assessing statistical analysis, one should first note which groups are being compared and determine whether $P < 0.05$. If P is less than 0.05 than it is likely (but not certain) that there is a meaningful difference between the groups, reflecting the effect of a specific dietary intake on a health-related variable. If P is equal to or greater than 0.05, then it suggests (but does not confirm with certainty) that there is no difference between the groups. **Table 1.4** illustrates these concepts with specific examples.

Publication of Results after Peer Review

The sharing of experimental results is essential to the progress of science, so after completing an experiment, scientists publish their results in a scientific journal. Scientific experimentation, however, is a very complex process and to ensure that only well-conducted and properly interpreted studies are published, these 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. This process is called **peer review**. Nutrition articles

peer review A process by which the quality of a science experiment is reviewed by experts. Experts must agree that the experiment is of good quality before it can be published.

TABLE 1.4 Understanding Statistical Significance

Study 1
Consider two groups of people who, on average, differ only in beverage intake: Group A (drinks water) Group B (drinks sugar-sweetened beverages)
For each group, change in body weight, as a result of treatment, over a period of time, was measured.
Average change in body weight: Group A: **0.1 kg** Group B: **6.0 kg**
Difference between Group A and Group B (Group B minus Group A): **5.9 kg**
Question: Assuming that there is no difference between Group A and Group B, what is the probability that a difference as large as 5.9 kg would be observed?
A statistical analysis is conducted. Additional information, such as the number of people in each group and the variation in weight change observed between people, would be part of the analysis.
Answer: *P* = 0.001, meaning that the probability of a difference as large as 5.9 kg is 0.001. Another way of saying this is that there is only 1 chance in 1,000 that the difference is due to chance, assuming there is no true difference between the groups. This is a statistically significant difference, indicating that drinking sugar-sweetened beverages (Group B) likely results in more weight gain than drinking water (Group A).
Study 2
Consider two groups that differ only in beverage intake: Group A (drinks water = 0 kcalories) Group B (drinks water containing an artificial sweetener = 0 kcalories)
For each group, change in body weight, as a result of treatment, over a period of time, was measured.
Average change in body weight: Group A: **0.10 kg** Group B: **0.13 kg**
Difference between Group A and Group B: **0.03 kg**
Question: Assuming that there is no difference between Group A and Group B, what is the probability that a difference as large as 0.03 kg would be observed?
A statistical analysis is conducted. Additional information, such as the number of people in each group and the variation in weight change observed between people, would be part of the analysis.
Answer: *P* = 0.4, meaning that the probability of a difference as large as 0.03 kg is 0.4. Another way of saying this is that there are 2 chances in 5 that the difference is due to chance, assuming there is no true difference between the groups. This is NOT a statistically significant difference, indicating that drinking an artificially-sweetened water (Group B) likely has the same effect as drinking water (Group A).

can be found in peer-reviewed journals such as the *American Journal of Clinical Nutrition*, the *Journal of Nutrition*, the *Journal of the American Dietetic Association*, the *New England Journal of Medicine*, and the *International Journal of Sport Nutrition*. Journals published by Canadian organizations include the *Canadian Journal of Dietetic Practice and Research* (published by Dietitians of Canada), *CMAJ* (Canadian Medical Association Journal) *Health Reports*, published by Statistics Canada, and *Biochemistry and Cell Biology* and *Applied Physiology, Nutrition, and Metabolism,* both published by the National Science and Engineering Research Council of Canada.

1.4 Concept Check

1. List the steps of the scientific method.
2. Describe the features of a good experiment.

1.5 Nutrition Research

LEARNING OBJECTIVES

- Differentiate between the different types of nutrition studies.
- Discuss how science monitors the ethics of human and animal studies.
- Describe the components of a research paper.

One of the main purposes of nutrition research is to study the impact of different nutrients, foods, or overall dietary patterns on human health and the occurrence of disease. In this section, we will discuss, in some detail, the two major categories of nutritional research studies, observational studies, particularly prospective cohort studies, and randomized controlled trials.

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

nutritional epidemiology The study of dietary exposures, such as the intake of a certain nutrient, food, or overall diet and outcomes, that are usually health-related such as the incidence of a disease.

observational study An epidemiological study that looks for associations between health and disease and environmental or lifestyle factors. There is no intervention or attempt to alter the behaviour or lifestyle of the study participants. Information about the subjects' lifestyle and health is collected and analyzed.

association Two or more factors occurring together. The association can be direct (positive) or inverse (negative). A direct or positive relationship is observed when increased nutrient intake increases disease risk; an inverse or negative relationship is observed when decreased nutrient intake increases disease risk. Associations do not prove causation.

causation A relationship between two factors where one factor causes the second factor to occur.

Types of Nutrition Studies

Observational Studies

The study of **epidemiology** looks at the relationship between an exposure and an outcome. Exposures are environmental factors that influence health-related outcomes. **Nutritional epidemiology** is the study of dietary exposures, such as the intake of a certain nutrient, food, or overall diet and outcomes, that are usually health-related such as the incidence of a disease. Most epidemiological studies are **observational studies**. In observational studies there is no attempt to intervene or alter the dietary intake of the study participants. Instead information about the dietary intake (the exposure) and the health (outcome) of study participants is collected and from these observations, patterns or associations are identified between diet and disease. Three relationships, as shown in **Figure 1.17**, are common (1) there is no association between the nutrient intake and the occurrence of the disease; (2) as nutrient intake increases, the disease declines, an inverse association; or (3) as nutrient intake increases, the disease increases, a direct association. Linear relationships are depicted but non-linear relationships are also possible. For instance, diets of individuals with different intakes of dietary fibre can be compared with the incidence of cancer. When scientists conducted such studies, they generally found that as the intake of dietary fibre increased, the risk of getting colon cancer decreased.[16] Another way of saying this is that scientists found an inverse **association**, between fibre and colon cancer. This does not prove that dietary fibre *causes* less cancer; that is, it does not prove **causation**, only that there is an association between the two variables.

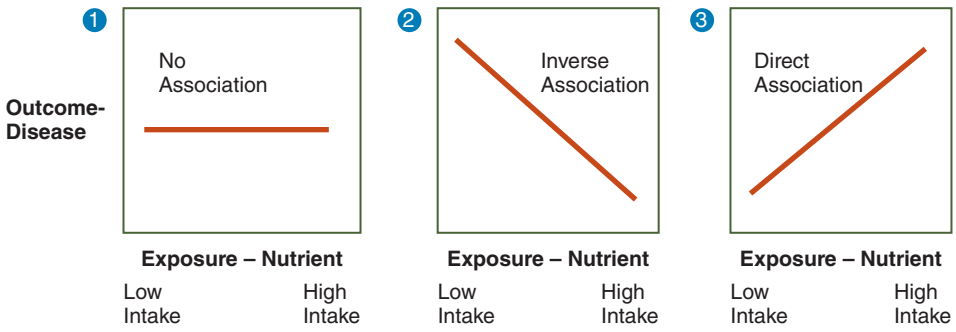


FIGURE 1.17 The relationships between exposure and outcome. Observational studies seek to determine whether there is an association between an exposure, such as nutrient intake, and an outcome, such as the incidence of a disease. Three relationships are common: (1) there is no association between the nutrient intake and the occurrence of the disease; (2) as nutrient intake increases, the disease declines, an inverse association, or (3) as nutrient intake increases, the disease increases, a direct association. Here linear relationships are depicted but non-linear relationships are also possible.

One of the limitations of observational studies is the presence of **confounding factors**, which are factors associated with both the dietary intake of interest and the disease. For example, in the cancer study, it may have been that the people who ate more dietary fibre were by chance younger than the people who did not eat dietary fibre. We know that cancer is less common in younger people, so perhaps the observed relationship between fibre and cancer is really due to differences in age. This would be an example of age being a confounding factor, as it is associated with both fibre intake and cancer incidence. Complex statistical methods can eliminate the effect of confounding factors; in research papers this is referred to as adjusting for confounding factors. Age is a very common confounding factor and virtually all observational studies are age-adjusted. Sex is another common confounding factor, so the results of men and women are often presented separately. Other confounding factors that are commonly adjusted for in research studies include socioeconomic status, educational level, physical activity levels, and other dietary factors besides the factor being studied. Statisticians try to identify and adjust for all confounding factors but it is not possible to completely eliminate their effect. So when scientists observe that a group of individuals with a high fibre intake have less cancer than a group with a low fibre intake they cannot be 100% certain that fibre intake is the only difference between the two groups. Other factors may be contributing to the observation, even after adjustment for confounding. This effect is referred to as **residual confounding** and arises because no adjustment is perfect and there may be unmeasured or unknown confounders still influencing results. That is why we describe the results as indicating an association but not proving causation, that is, not proving that a high fibre intake causes less cancer. On the other hand, one of the strengths of observational studies is that they almost always measure the effect of diet, directly on a disease outcome. This is generally preferable to measuring risk factors of disease. For example, high blood pressure is a risk factor for cardiovascular disease. While a dietary treatment, that is found to reduce blood pressure, would be viewed favourably, it is not equivalent to measuring an effect on cardiovascular disease directly.

confounding factor In scientific studies, a factor that is related to both the outcome being investigated (e.g., disease) and a factor that might influence outcome (e.g.dietary intake).

Residual confounding Confounding that remains in data because of incomplete adjustment due to factors present that are unknown, unmeasured, or imprecisely measured.

There are several types of observational studies; the most important is the **prospective cohort study** or more simply the **cohort study**. In a cohort study, the dietary intake of a healthy population is recorded and the health of this population is followed for a number of years, that is, it is prospective or moving forward in time. For example, researchers want to test the hypothesis that eating whole grains reduces the risk of cardiovascular disease. To test this hypothesis a large number of participants, typically in the tens or hundreds of thousands, are recruited into the study. The participants must be healthy and free of cardiovascular disease. It is important that the participants be free of disease at the start of the study, so that the exposure, intake of whole grains, occurs before the outcome, the development of disease, and therefore it is feasible for the exposure to have influenced the outcome.

prospective cohort study or **cohort study** An observational study in which dietary intake information is collected by researchers and the health of the study participants is observed, usually for several years. At the end of the study, scientists determine whether there are any associations between dietary intake and the incidence of disease.

The dietary intake of the participants is recorded at the beginning of the study, using questionnaires that are described in detail in Section 2.6, and may also be recorded multiple times over the course of the study, to account for changes in food intake, especially if it is a long-duration study. Cohort studies can often go on for decades. Information on potential confounding factors is also collected. The participants are followed for many years, with researchers checking in with participants regularly to collect information on their health status, and especially on the development of cardiovascular disease. In this way, the number of cases of cardiovascular disease over the course of the study are counted. The researchers then determine whether the participants with a low intake of whole grains experienced more cardiovascular disease than participants with a high intake. If this is the case, then the study supports the researchers' hypothesis.

The results of such studies are most commonly expressed as a ratio, called relative risk, (**Table 1.5a**) across different categories of dietary intake, relative to a reference group, which is typically the lowest food or nutrient intake. These relative risks are adjusted for confounding factors, so the impact of these factors on results are minimized and the relative risks reflect the impact of the dietary intake of interest. Depending on the study design and the type of data collected, other ratios such as a hazard ratio or an odds ratio can be reported, but they are essentially interpreted as described in Table 1.5a. Each relative risk, other than the reference group, is accompanied by a confidence interval, described in **Table 1.5b**, which can be used to determine whether a relative risk in one intake category is significantly different from the reference group.

TABLE 1.5a Understanding Relative Risk

To understand relative risk, consider this simplified example of a cohort study designed to test the hypothesis:

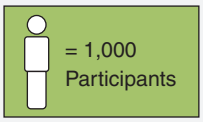
Nutrient X decreases the risk of getting disease A.

Twenty thousand (20,000) healthy participants, free of disease A, are recruited and dietary intake recorded.

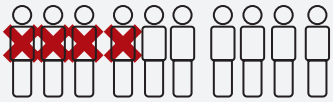
The health of participants is followed for 10 years and the development of disease A is recorded.

The participants are divided into 2 groups:

At the end of the experiment, 2,000 people in the high-intake group have disease A, while 4,000 in the low-intake group have disease A. The frequency of disease A in the low-intake group is 0.4 (i.e., 4,000/10,000), while in the high-intake group, it is 0.2 (i.e., 2,000/10,000).



Low nutrient intake



N = 10,000

Number with Disease A = 4,000

Frequency of Disease A = 0.4

Relative Risk:

$$\frac{\text{Frequency of Disease A (low intake)}}{\text{Frequency of Disease A (low intake)}} = \frac{0.4}{0.4} = 1$$

High nutrient intake

N = 10,000

Number with Disease A = 2,000

Frequency of Disease A = 0.2

Relative Risk:

$$\frac{\text{Frequency of Disease A (high intake)}}{\text{Frequency of Disease A (low intake)}} = \frac{0.2}{0.4} = 0.5$$

The ratio of the two frequencies is a measure of relative risk. When determining relative risk data, researchers select a reference group to which other groups are compared (i.e., the denominator in the relative risk calculation) and it is assigned a relative risk of 1. In this example, the reference group is the low-intake group. Therefore, compared to the low nutrient group, the high-nutrient group has a relative risk of 0.5. This means that compared to the low-intake group, the high-intake group has a 50% reduction of risk of getting disease A. This is summarized in the following table.

Nutrient Intake	Relative Risk
Low intake of nutrient	1
High intake of nutrient	0.5

A relative risk (RR) greater than 1 means an increased risk compared to the reference group, while as in the example here, a relative risk less than 1 means reduced risk. In addition to calculating the RR, additional analysis is typically conducted to determine whether the difference between groups is statistically significant. Statistically significance is determined by reporting a 95% confidence interval, for each relative risk other than the reference group (see Table 1.5b).

Assuming a statistically significant difference between the high and low intake, the results shown here support the hypothesis that high intakes of Nutrient X are associated with a reduced risk of disease A.

Another useful statistic, described in **Table 1.5c**, that is reported is *P* trend or *P* for trend. This indicates whether there is an overall increasing or decreasing linear trend in risk over the dietary intake categories, indicating whether there is a statistically significant association.

Another type of observational study is the case-control study. Case-control studies compare individuals with a particular condition to similar individuals without the condition. For example, a case-control study of cancer might include a comparison of the dietary intake of a 45-year-old man with cancer to a man of the same age and ethnic background who is free of the disease. This matching would be done for all participants of the study. If a pattern emerged, such as a lower fibre intake among the cancer patients (i.e., the cases) compared to individuals without cancer (i.e., the controls), then a hypothesis can be proposed that there is an inverse association between cancer risk and fibre intake. Case-control studies will not be discussed in great detail in this textbook.

TABLE 1.5b Understanding Confidence Intervals

Any calculated relative risk (RR), or similar ratio, is accompanied by a 95% confidence interval. For example, a RR = 1.14 (0.98–1.25). The range: (0.98–1.25) is the confidence interval. A 95% confidence interval means that there is a 95% chance that the true RR lies within the interval. It could be as low as 0.98 or as high as 1.25; 1.14 is the best estimate of the risk.
The confidence interval can be used to determine statistical significance. In most cohort studies comparisons are made with the reference group which has RR = 1.
If a confidence interval includes 1, then the relative risk is **not significantly different** from 1 or not significantly different from the reference group.
For example, the previous example: relative risk = 1.14 (0.98–1.25) Relative risk 1.14 is NOT significantly different from 1, because the interval (0.98–1.25) includes 1.
Other examples:

RR = 1.14 (1.04–1.23)	**RR = 0.78 (0.59–0.96)**
Because the interval does NOT include 1 (1.04–1.23), 1.14 is significantly different from the reference group. There is an increased risk, relative to the reference group.	Because the interval does NOT include 1 (0.59–0.96), 0.78 is significantly different from the reference group. There is a decreased risk, relative to the reference group.

The range of values in a confidence interval indicates the precision with which measurements were made. A narrow confidence interval is considered desirable. For example RR = 1.4 (1.32–1.50) is a MORE precise estimate of risk than RR = 1.4 (1.01–1.78)
The table that follows shows the results of a cohort study that sought to determine whether there was an association between whole-grain intake and cardiovascular disease. Data from cohort studies is often presented in tables like this one. The population is divided into five groups or quantiles, based on intake. Quantile 1 represents the lowest 20% of intake, quantile 2 the next 20%, and so on. Quantile 5 represents the top 20% of intakes. The ratio reported for this study is a hazard ratio. It is also important to note that this data has been statistically adjusted for confounders, to minimize their effect. Based on the confidence intervals, quantile 2 and 3 are not significantly different from quantile 1, but 4 and 5 are. They are also less than 1, suggesting that whole grains are associated with a reduced risk of cardiovascular disease. Also shown is a *P* trend which is discussed in Table 1.5c.

Quantiles	**Hazard Ratio of Cardiovascular Disease (fictious data)**
1-Lowest Intake of whole grains	**1.00**
2	**0.97 (0.88–1.07)**
3	**0.92 (0.83–1.02)**
4-	**0.89 (0.80–0.98)**
5-Highest intake of whole grains	**0.80 (0.72–0.89)**
***P* trend:**	**0.002**

Randomized Controlled Trials

Like the prospective cohort study and the case-control study, the **randomized controlled trial** is a type of study widely used in nutrition research. Unlike the observational studies, however, a randomized controlled trial does not solely observe the participants of a study but requires participants to alter their dietary intake, that is, the study includes a dietary treatment or intervention. A randomized controlled trial is also characterized by the presence of a **control group**, in which the participants do not receive the dietary intervention. The control group is a basis of comparison to determine the effectiveness of the intervention. Researchers conducting a randomized controlled trial, have an outcome in mind and determine whether there is a statistically significant difference between the treatment and control group, with respect to their effect on the outcome. The most important feature of the randomized controlled trials is the **randomization** process. Randomization means participants are assigned to either the control group or the **treatment group** totally by chance. This randomization is the strength of the intervention study. In observational studies, it is not possible to completely eliminate the effects of confounding factors. Because of randomization, however, any confounding factors, including ones that remain unidentified, are equally distributed between the control and intervention groups; for example, the individuals in the two groups will have the same average age, weight, blood pressure, same distribution of men and women, etc.

randomized controlled trial A study of a population in which there is an experimental manipulation of some members of the population (intervention group); observations and measurements are made to determine the effects of this manipulation, compared to members who did not undergo the manipulation(control group). Participants are randomized into the intervention (treatment) or control groups.

control group A group of participants in an experiment that is identical to the experimental group except that no experimental treatment is used. It is used as a basis of comparison.

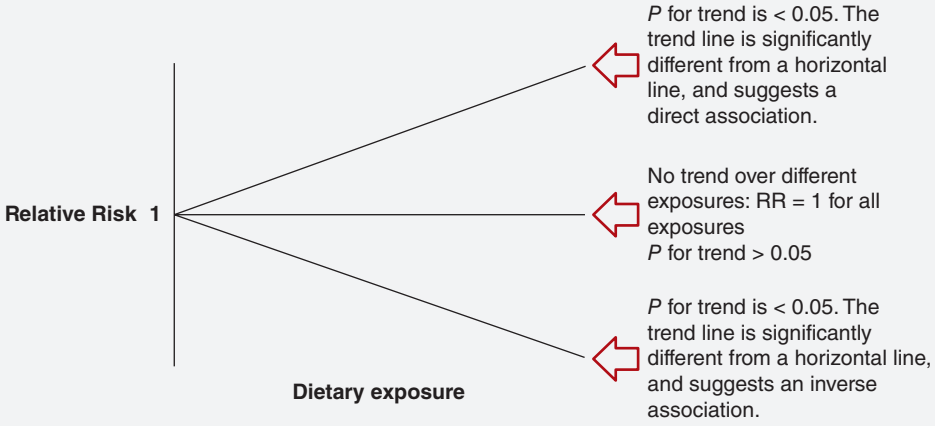
randomization The process by which participants in an intervention trial are assigned to either a treatment group or a control group entirely by chance.

treatment group A group of participants in an experiment who are receiving an experimental treatment. The effects of the treatment are compared to the control group.

TABLE 1.5c Understanding P for Trend

As described in Table 1.5b confidence intervals are useful for making comparisons between the reference group and another intake category. In many studies, rather than pairwise comparisons, what you want to know is whether there is a linear trend of increasing or decreasing disease risk over all intake categories i.e., is there an association between exposure and outcome? To determine whether an association exists another type of statistic is calculated: ***P* for trend**.

When we look at the risk data (Table 1.5b) we see that RRs decline 1.00, 0.97, 0.92, 0.89, 0.80. The value of *P* for trend determines whether these numbers likely represent a true downward trend or a chance occurrence, that is, if we were to plot these points, would the slope of the line be significantly different from a horizontal line. As shown in Table 1.5b, *P* for trend is less than 0.05, specifically, 0.002. This value is statistically significant and suggests that there is an inverse association between dietary intake, whole grains, and disease risk, cardiovascular disease. You can, of course, also have study results that indicate an upward trend or no trend ($P > 0.05$). This is illustrated in the following graphic:



This means that the only difference between the two groups is the intervention, or differences in diet. Because *only* the dietary intake differs, if the outcome is affected by the dietary intervention, then causation has been demonstrated, or, using slightly different language, it is very likely that there is a causal link between the dietary treatment and the outcome. This is the major difference between an observational study and a randomized controlled trial and is one of the reasons why evidence from randomized controlled trials is considered to be very strong evidence.

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

Another important element of the randomized controlled trial is the use of the **placebo**, 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. Consider, for example, a trial to test whether a protein drink improves performance in trained athletes. Trained athletes would be used as the subjects and would be randomized into a control and treatment group.

If the experimental group is consuming a protein drink, an appropriate placebo for the control group would be a drink that looks and tastes just like the protein drink but does not contribute any nutrients. 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 but investigators conducting the experiment do, 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 athletes think they are taking the protein supplement, they may be convinced that they are getting stronger and as a result work harder in their training and develop bigger muscles even without the supplement. 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 study has concluded.

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

double-blind study An experiment in which neither the study participants nor the researchers know who is in the control or the experimental group.

Placebos can be developed when dietary supplements or single ingredients or single foods are being used in an experiment, but when entire diets or major portions of a diet are altered, a placebo may not be possible. The participants may be able to discern which group they are in although researchers may try to avoid disclosing to participants some details about the diets so as to reduce bias from expectations. The investigators can still be blinded even when participants are not.

Figure 1.18 shows a comparison of how the same nutrition-related hypothesis can be studied by both an observational study and an intervention trial. So, to test the hypothesis that dietary fibre (nutrient X in Figure 1.18) reduces the risk of colon cancer (disease Y in Figure 1.18), using a randomized controlled trial, a suitable number of participants would be recruited. You would want the population to be healthy but of an age where they are at reasonable risk of developing colon cancer. The treatment group would eat a high fibre diet, while the control group would be asked to eat their normal diet, which for the majority of Canadians is low in fibre. Ideally, the trial would go on for several years, long enough for some participants to develop colon cancer and the number of participants who developed the disease in the treatment group would be compared to the control group. If there is a statistically significant reduction in disease in the treatment group, compared to the control group, then increased dietary fibre intake likely causes a reduction in colon cancer (See Table 1.4 for a review of statistical significance).

While randomized controlled trials, which evaluate disease outcomes, like the one just described and shown in Figure 1.18, have been conducted, to see the impact of a dietary intervention directly on disease outcomes, they require a study that lasts many years. But it is very difficult to ask study participants to make major dietary changes and sustain them faithfully over very long periods of time. This is why biomarkers (see Section 1.4), which respond quickly to dietary change, are often measured instead of disease outcomes. For example, in the fibre-colon cancer example, instead of measuring the occurrence of colon cancer, researchers might look at some biomarkers of cellular growth in biopsied colon cells, because increased growth rate is a biomarker of increased risk of cancer development. It is also a biomarker that responds to dietary change within a few months. The use of biomarkers is a limitation of intervention

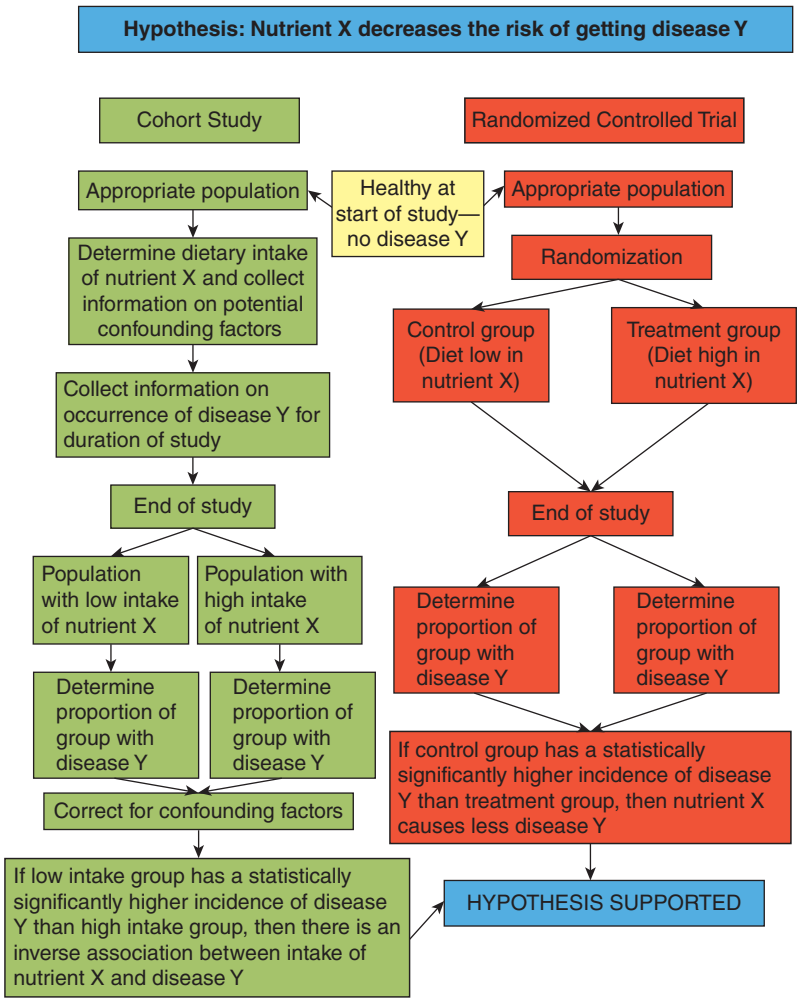


FIGURE 1.18 Comparison of prospective cohort study (observational study) and a randomized controlled trial, addressing the same hypothesis.

trials. Causal links are found, but they are most often between a dietary intervention and a biomarker or risk factor of disease, but not of the disease itself.

So, in nutritional research, observational studies, which demonstrate only association but typically measure disease outcomes, and randomized controlled trials, which demonstrate causation, but typically of biomarkers of disease, are both considered when assessing the impact of dietary intake on health and disease (see Critical Thinking: Doing Nutrition Research).

Critical Thinking

Doing Nutrition Research

Nutrition research depends on both prospective cohort studies and randomized controlled trials for its evidence. Consistent results between the different types of studies strengthens the scientific evidence for a specific hypothesis. Consider the following information about two studies testing the hypothesis that the intake of dairy products reduces the risk of colon cancer.

Study 1

Study 1 is a cohort study[1] with almost 480,000 healthy participants, 70% female and an average age of 52 years at the beginning of the study. Participants completed a survey about their food intake from which the intake of dairy products was used. Information on potential confounding factors was also collected. The participants were followed for 11 years and the number of cases of colon cancer recorded. The results, which have been adjusted for confounding, are shown here.

Total Dairy Intake (g/day)	Hazard Ratio
Quantile 1 (<134 g/day)	1.00
Quantile 2	0.90 (0.82–0.99)
Quantile 3	0.85 (0.77–0.93)
Quantile 4	0.79 (0.71–0.87)
Quantile 5 (> 400 g/day)	0.77 (0.70–0.86)
P trend	<0.001

Study 2

Study 2 is a randomized controlled trial[2] in which 70 participants (63% male; average age 66 yr) were randomized to a control group and a treatment group. The control group was advised to continue with their pre-study diet, while the treatment group was counselled to eat low-fat dairy products. Both groups were told not to take calcium supplements. An assessment of calcium intake found that the treatment group, on average, was consuming 2.5 times as much calcium as the control group, indicating that the counselling was effective. The study lasted one year. The researchers measured a protein called cytokeratin AE1, at the beginning and end of the study, which is a biomarker for reduced cellular growth rate. Increases in the level of this protein in colon cells would be considered a marker for reduced growth and hence a reduction in cancer risk. The results are shown here.

pilipphoto/Shutterstock.com

	Treatment Minus Control (% change)*
Cytokeratin AE1	22 ($p < 0.05$)**

*Treatment minus control means (% change in the treatment group from beginning to the end of the study) minus (% change in the control group from beginning to the end of the study).

**Comparing treatment vs control

Critical Thinking Questions

1. **What is one strength and one limitation of cohort studies?***
2. **What association, if any, was found in study 1?**
3. **Why is randomization important?**
4. **Are the results of both studies consistent with each other?**

*Answers to all Critical Thinking questions can be found in Appendix J.

[1]Murphy, N., Norat, T., Ferrari, P., Jenab, M., Bueno-de-Mesquita, B., Skeie, G., Olsen, A., Tjønneland, A., Dahm, C. C., Overvad, K., Boutron-Ruault, M. C., Clavel-Chapelon, F., Nailler, L., Kaaks, R., Teucher, B., Boeing, H., Bergmann, M. M., Trichopoulou, A., Lagiou, P., Trichopoulos, D., Palli, D., Pala, V., Tumino, R., Vineis, P., Panico, S., Peeters, P. H., Dik, V. K., Weiderpass, E., Lund, E., Garcia, J. R., Zamora-Ros, R., Pérez, M. J., Dorronsoro, M., Navarro, C., Ardanaz, E., Manjer, J., Almquist, M., Johansson, I., Palmqvist, R., Khaw, K. T., Wareham, N., Key, T. J., Crowe, F. L., Fedirko, V., Gunter, M. J., Riboli, E. Consumption of dairy products and colorectal cancer in the European Prospective Investigation into Cancer and Nutrition (EPIC). *PLoS One*. 2013. 8(9):e72715, 2013. doi:10.1371/journal.pone.0072715.

[2]Holt, P. R., Atillasoy, E. O., Gilman, J., Guss, J., Moss S. F., Newmark, H., Fan, K., Yang, K. Lipkin, M. Modulation of abnormal colonic epithelial cell proliferation and differentiation by low-fat dairy foods: A randomized controlled trial. *JAMA*. 280(12):1074–9, 1998.

Systematic Reviews and Meta-Analysis

In nutritional research, and indeed, in most life sciences, when trying to assess the impact of a certain diet on health, it important to also look at multiple studies that have tested the same hypothesis, to evaluate whether there is a consistent pattern of results. The results of a single study are never considered sufficient evidence to definitively determine the impact of a particular dietary exposure or intervention.

Instead, scientists conduct **systematic reviews** of the scientific literature to find all the studies conducted on a topic of interest and then examine the results of these studies to determine whether a clear pattern of results emerges. The review is systematic because the reviewers decide what type of study e.g., prospective cohort studies or randomized controlled trials, they are going to review and what characteristics must be present for the study to be suitable for review before they begin their search. The characteristics may relate to population types, e.g., studies of middle-aged adults, specific dietary exposures, e.g., studies that looked at dietary fibre intake, and specific outcomes, e.g., studies that determined the occurrence of colon cancer and/or death from colon cancer, that should be evaluated. It is the selection of these characteristics that makes the review "systematic." It is intended to avoid bias in the study selection, because the results of the study are not considered in the selection process e.g., whether the occurrence of colon cancer increased or decreased is not part of the study selection process. It is also possible, in a systematic review, to calculate the weighted average result of the selected studies, a process called **meta-analysis** and to summarize these in a specialized figure called a **forest plot** (**Figures 1.19a** and **1.19b**). Systematic reviews of cohort studies and systematic reviews of randomized controlled trials are generally reviewed separately and separate forest plots are created. Because cohort studies almost always report their final result as a ratio, the no-effect line on the forest plot is a value of 1, e.g., a relative risk of 1. In randomized controlled trials the results are usually reported as the difference between the treatment and control group, so the no-effect line is a zero on the forest plot and the difference usually has units. For example, if the studies being reviewed were measuring blood pressure, the units would be mm Hg and the difference would be the change in blood pressure, in mm Hg, in the treatment group minus the change in control group. If blood pressure decreased in the treatment group, the difference would be a negative number. If the treatment had no significant effect, then the difference (treatment minus control) would be zero, or very close to zero.

systematic reviews A review of studies on the same topic such as the diet-disease association, with each study meeting pre-selected characteristics related to its design. The purpose of the review is to determine whether the results of the study reveal a consistent pattern that allows conclusions to made about the association studied. Conclusions drawn from multiple studies are more reliable than the results of any single study.

meta-analysis In systematic reviews, a single weighted average result of multiple studies that examined the same hypothesis.

forest plot A specialized plot that summarizes the quantitative results of studies in a systematic review

Figures 1.19a and 1.19b show some of the elements commonly seen in a forest plot. In Figure 1.19a a forest plot of cohort studies, looking at a food-disease relationship is

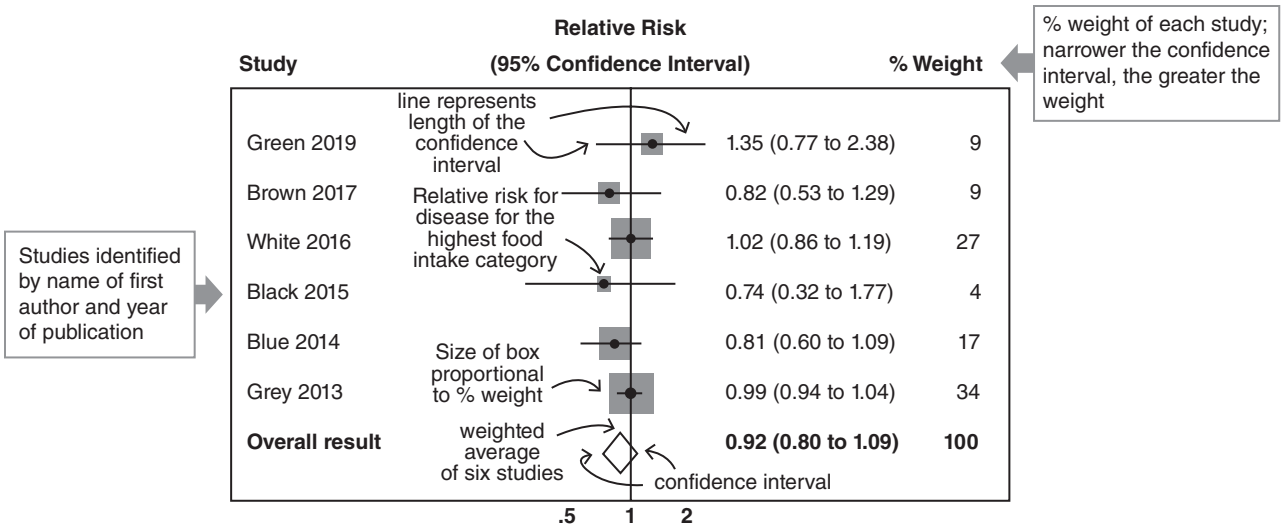


FIGURE 1.19a Forest plot. Results of a meta-analysis of six prospective cohort studies evaluating the intake of a food on the occurrence of disease. The RR shown are for the highest intake category compared to the lowest, the reference group. The overall result shows that there was a modest decrease in risk (0.92) but it was not statistically significant as the confidence interval includes 1 (0.80 to 1.09). Note: Data is fictitious.

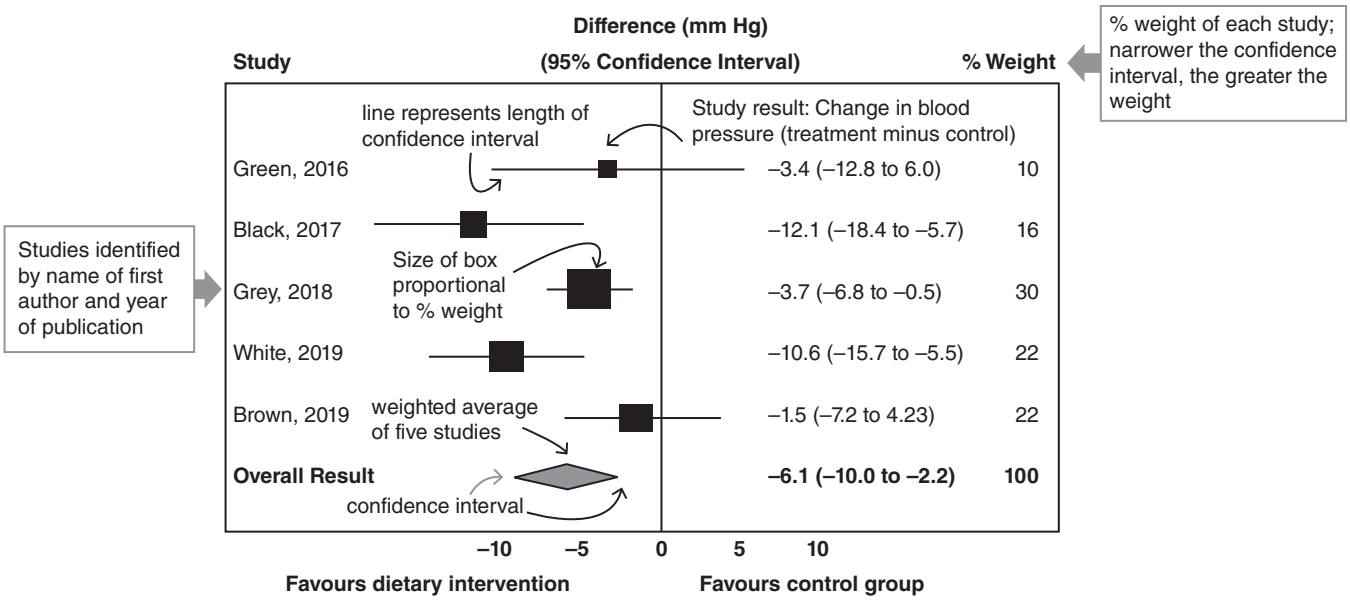


FIGURE 1.19b Forest plot. Results of a meta-analysis of five randomized controlled trials that evaluated the effect of a dietary intervention on blood pressure. The overall result was a statistically significant reduction in blood pressure of 6.1 mm Hg (−10 to −2.2). Note: Data is fictitious.

summarized. The no-effect line is RR = 1. Each study is listed and the RR, usually for the highest food intake category is plotted (in figure 1.19a, the centre of the grey square box). The size of the grey box represents the weight, or contribution, of the study to the calculated weighted average of the results. The weighting of each study is determined by a formula that includes the size of the 95% confidence interval of the RR for each study. The narrower the confidence interval, the more precise the measurements obtained by the study, and the greater the weight of the study. Narrower confidence intervals are normally seen in larger studies, while smaller studies have more variation and do not contribute as much to the overall average of results. The overall average of the results is indicated by a diamond, with the top to bottom points of the diamond, representing the overall average, and the left to right points representing the confidence interval of the overall result. If the diamond overlaps with the no-effect line (RR = 1) then the overall result is not statistically significant. If there is no overlap, the overall result is significantly different from RR = 1 and favours an association between food intake and disease. When systematic reviews demonstrate that many papers have similar results, confidence in the results is strengthened and they can be used to help make dietary recommendations (see Science Applied: From Systematic Reviews to Dietary Recommendations). The plot shown in Figure 1.19a indicates non-significant results (confidence interval of the diamond includes 1) and suggests that the food does not influence disease risk.

Figure 1.19b shows the results of a typical forest plot for a review of randomized controlled trials. The plot is similar, to figure 1.19a, except that the difference between treatment and control is plotted; this difference usually has units (mm Hg in this figure, for the measurement of blood pressure) and the no-effect line is a difference of zero. When systematic reviews of randomized controlled trials demonstrate that many papers have similar results, confidence in any causal links found is strengthened and the results can be used to help make dietary recommendations.

The strongest scientific evidence is when many cohort studies and randomized controlled trials have been reviewed and the overall results from both types of studies are consistent, that is, they show the same effect of diet on disease outcomes or disease biomarkers.

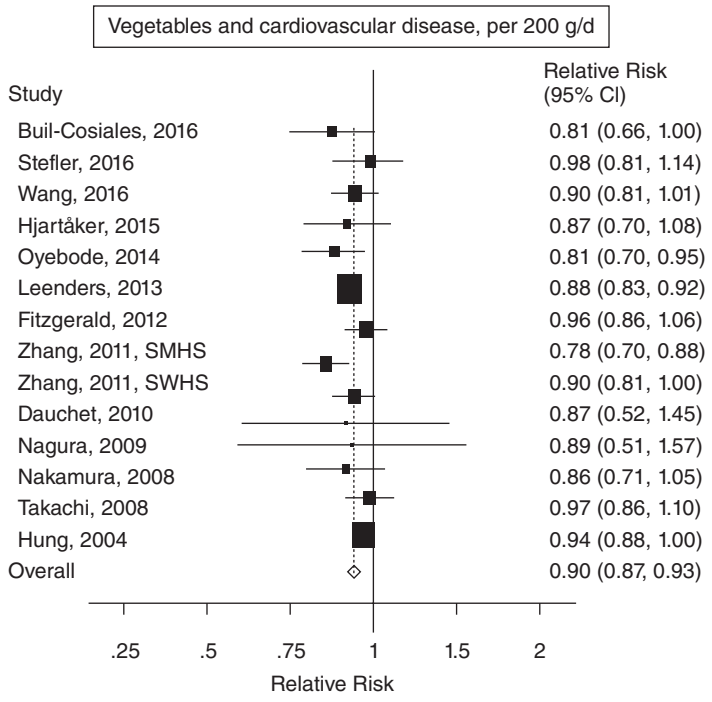
Science Applied

From Systematic Reviews to Dietary Recommendations

The science: As noted in the text, systematic reviews are conducted to evaluate multiple studies on a similar topic and to determine whether there is a consistent pattern of results. The forest plot that follows is from a systematic review of cohort studies that investigated the relationship between vegetable intake (200 g/day) and the relative risk (RR) of cardiovascular disease.[1] An examination of the forest plot indicates that 14 studies were reviewed. Based on the list of relative risks provided, we can see that every study reported a RR less than 1, although as indicated by the confidence intervals, for some studies these results were statistically significant, while for others they were not. The results are reflected visually by the black boxes (centre of box marks the relative risk) and lines through the boxes, representing the confidence interval. The studies by Leenders, 2013 and Hung, 2004 have the narrowest confidence intervals and as indicated by the size of the black boxes were given the heaviest weights in calculating the overall result. The overall result, a weighted average of all studies, was a statistically significant (confidence interval 0.87 to 0.93 does not include 1) relative risk of 0.90, meaning for each 200g of vegetables eaten, the risk of cardiovascular disease decreases by 10%. Assuming a generally linear decline in risk with increasing intake, consumption of 500 g of vegetables daily, corresponds to a reduction in risk of 25%.

Robert-Owen-Wahl/Pixabay

The limitations of a systematic review of prospective cohort studies reflects the limitations of cohort studies. The overall RR is an association only, not a causal link, and may reflect residual confounding.



The application: Public health professionals read studies like this and others and use them to inform dietary recommendations. Studies like this one would be part of the evidence used to support the dietary recommendations, such as recommendations in Canada's Food Guide, described in Chapter 2, to cover half your plate with vegetables and fruits.

[1] Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., Greenwood, D. C, Riboli, E., Vatten, L. J., Tonstad, S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. *Int. J. Epidemiol*. 46(3): 1029–1056, 2017.

Other Nutritional Studies

Cohort studies, randomized controlled trials and their systematic reviews are the most common studies used to research the impact of diet on health and disease. But experiments are also conducted to answer questions such as how much of a nutrient a person requires, how a nutrient is absorbed and metabolized, and how it functions in the body that differ in their design from cohort studies or randomized controlled trials. Studies asking questions about nutrient function can use human subjects, but often use animal models or cells grown in the laboratory (*in vitro* studies).

Studies to Determine Nutrient Requirements

There are many approaches to determining nutrient requirements, that is, how much of a nutrient someone needs to maintain health. Two approaches that will be described here include **depletion-repletion** and **balance studies**.

depletion-repletion study A study that feeds subjects 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 and health is restored.

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 the deficiency symptoms and restore health. An example of a depletion-repletion study will be discussed in Section 2.2.

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 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 (**Figure 1.20**). 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 and will be discussed in more detail in Section 6.6. It is not useful for determining the requirements for nutrients such as fat and iron that are stored when an excess is available.

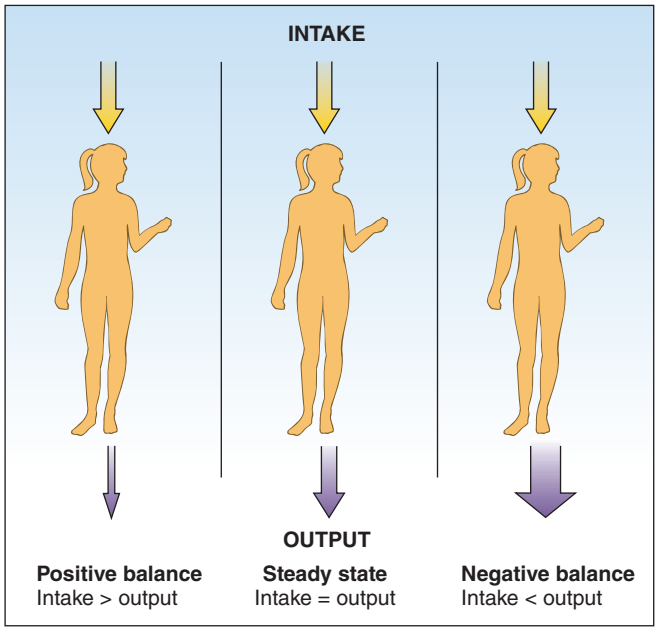
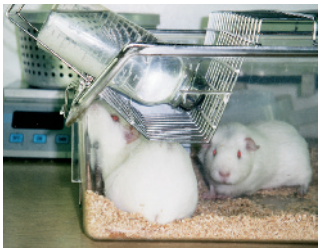


FIGURE 1.20 Nutrient balance. Nutrient balance studies compare the amount of a nutrient that is consumed with the amount excreted to determine whether the body is in positive balance, steady state, or negative balance.

Using Animals 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. Questions about how a nutrient functions in the brain or liver, for example, cannot be easily examined in humans. But in animal studies, the animals are sacrificed at the end of the experiment, and organs can be examined and analyzed at the cellular and molecular level.

An ideal animal model is one with metabolic and digestive processes similar to 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 the effects of nutritional changes develop rapidly. Their food intake can be easily controlled, and their excretions can be measured accurately using special cages. Even when using small animals, the species of animal must be carefully chosen. 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. Both rabbits and rats, however, are poor choices for a study of vitamin C requirements because they can synthesize this vitamin in their bodies. Guinea pigs would be a better choice because the guinea pig is one of the few animals, other than humans, that cannot make vitamin C in its body (**Figure 1.21**). 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.



Lori Smolin

FIGURE 1.21 What are the advantages and disadvantages of using guinea pigs and other laboratory animals to study human nutrition?

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 1.22**). Methods from biochemical research can be used to study how nutrients are used to provide energy and how they regulate biochemical reactions in cells. Molecular biology methodology can be used to study how genes regulate cell functions. The types and amounts of nutrients available to cells can affect the action of genes. For example, vitamin A can directly activate or inactivate certain genes. Knowledge gained from biochemical and molecular biological research can be used to study nutrition-related conditions that affect the entire organism. Molecular biology can help us understand the hereditary basis of diseases like heart disease, cancer, diabetes, and obesity and is helping us to identify individuals who have a genetic susceptibility to specific diseases so that intervention can begin early.

SPL/Science Source

FIGURE 1.22 The ability to grow cells in the laboratory allows scientists to study nutrients without using whole organisms.

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. For example, studying body fluids, cells grown in the laboratory, and even computer models can help predict how changes in nutrient intake affect body processes. However, such alternatives cannot always be used; human and animal experimentation is still necessary to answer many questions. To avoid harm and protect the rights of humans and animals used in experimental research, government guidelines have been developed.

Human Subjects

Before an experiment involving human subjects can be conducted, the study must first be reviewed by a committee of scientists and nonscientists to ensure that the rights of the subjects are respected and that the risk of physical, social, and psychological injury is balanced against the potential benefit of the research. Before subjects participate

in a study, the researchers must explain to them the purpose of the research, the procedures used, and the possible risks and benefits. In addition to an oral explanation of the study, each subject must be given a written description of the study and its risks and benefits. Those who choose to participate must then sign a consent form stating exactly what they have agreed to do. Signing a consent form does not mean a subject must complete the study if it turns out to be difficult to do so—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. This protects subjects, but limits 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. This type of study would not be approved if researchers wanted to repeat it today.

Animal Studies 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 close a research facility.

Genetic Modification The development of new techniques in the field of molecular biology has given rise to ethical issues regarding the manipulation of genes. Guidelines for manipulating genes have been developed and are constantly being revised to stay abreast of advances in this field.

Accessing Nutrition Research Information

As noted previously, research scientists publish in peer-reviewed journals. Research articles are typically composed of the following parts:

1. Abstract: A short paragraph that summarizes the experiment and its main findings.
2. Introduction: Describes the purpose of the experiment and summarizes the current scientific knowledge on the subject of the paper.
3. Materials and Methods: Describes the methods used, e.g., type of experiment (e.g., case-control study, clinical study); the population used (e.g., men, women, age range, health status, etc.); the duration of the study; the biomarkers measured; and the statistical analysis conducted.
4. Results: Describes the results of the study.
5. Discussion and conclusion: Interprets the results and explains their usefulness.
6. Bibliography: A list of publications referred to in the paper.

The abstract is useful because it can be read quickly and provides the reader with the most important information about a paper. Scientific databases store these abstracts and can be searched by keyword, so anyone interested in learning about a nutrition topic can read the abstracts on a topic and get a quick overview of current scientific knowledge. One popular database that can be accessed by anyone through the Internet is PubMed, which is supported by the National Institutes of Health in the United States (www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed). **Figure 1.23** shows the different parts of a PubMed abstract.

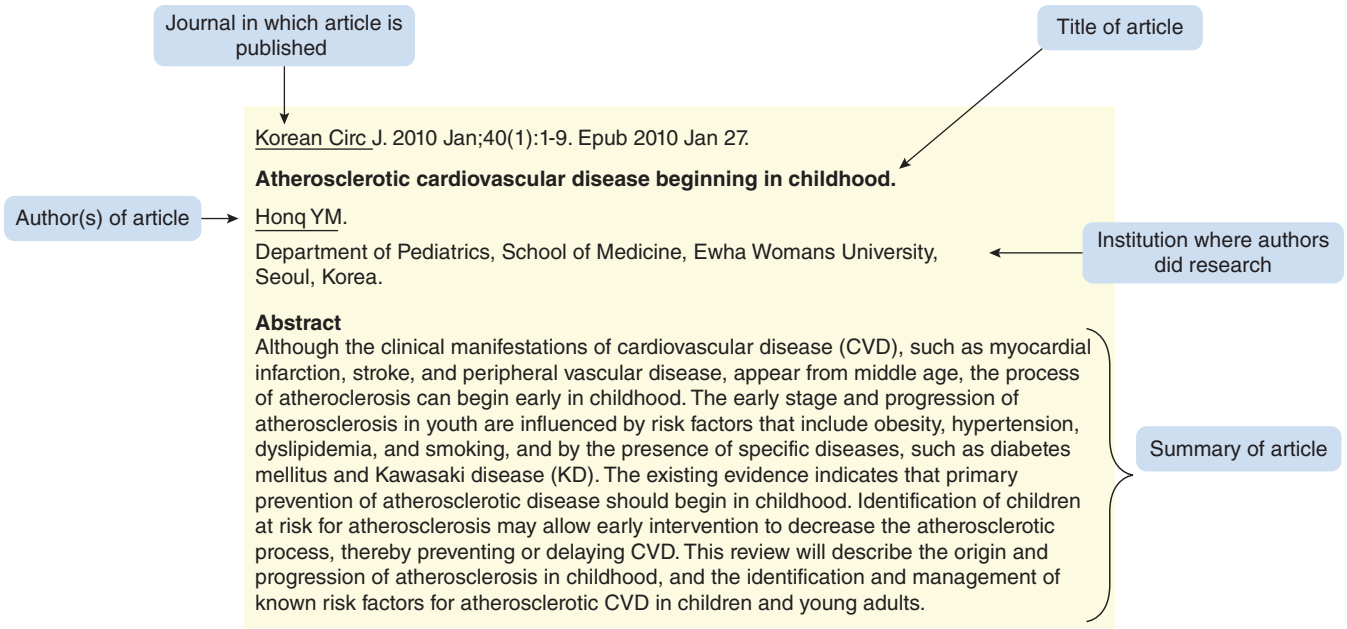


FIGURE 1.23 Anatomy of an abstract: An abstract is a summary of a scientific paper.

Source: PubMed, US National Library of Medicine National Institutes of Health. www.ncbi.nlm.nih.gov/pubmed. Accessed February 9, 2020.

1.5 Concept Check

1. What is the difference between association and causation?
2. What are confounding factors? Why are they problematic in cohort studies?
3. What are the major differences between a cohort study and a randomized controlled trial?
4. What is the main purpose of the randomization process in an experimental trial?
5. What is a systematic review? What are the key features of a forest plot?
6. How does science monitor the ethics of human and animal studies?
7. Describe the components of a research paper.
8. What is the function of PubMed?
9. Describe how an observational study and an intervention trial can be used to determine the relationship between diet and colon cancer.

1.6 Sorting Out Nutrition Information

LEARNING OBJECTIVES

- Describe the first question to consider when assessing nutrition information.
- List some reliable sources of nutrition information.
- Describe what should form the basis of reliable claims about nutrition advice and/or products.
- Explain why it is important to ask who benefits from a claim about a nutrition product.
- Explain whether one study is sufficient support for a nutrition-related claim.

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-carbohydrate

TABLE 1.6 Ask These Questions BEFORE You Believe It

Does the claim presented make sense? • If it is too incredible to believe, disregard it.
Where did the information come from? • If it is based on personal opinions, be aware that one person's perception does not make something true. • Information from government agencies, universities, and nonprofit organizations is generally sound. • Check the credentials of the person providing the information. If they do not have a legitimate degree in nutrition or medicine, view the material with skepticism. If no credentials are listed, there is no way to determine if they are qualified to give this information.
Was the information based on well-designed experiments? • Reliable information is based on scientific studies that use proper controls, include enough experimental subjects to get reliable results, and collect quantifiable data. • Studies published in peer-reviewed journals have been evaluated for accuracy before they can be published.
Were the experimental results interpreted accurately? • Compare news reports to study results to see if the importance of the study has been exaggerated to make the headline more attractive. • If the study was done on animals, consider carefully whether the results will also apply to humans.
Who stands to benefit? • If the information is helping to sell a product, it may be biased toward that product. • If the information is making a magazine cover or newspaper headline more appealing, the claims may be exaggerated to promote sales.
Has it stood the test of time? • If the study is the first to support a particular finding, wait before changing your diet based on the result. • If the finding has been shown repeatedly in different studies over a period of years, it will become the basis for reliable nutrition recommendations.
Does it pose a risk? • Be sure the expected benefit of the product is worth the risk associated with using it.

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 next and summarized in **Table 1.6**.

Does the Information Make Sense?

The first question to ask yourself when evaluating nutrition information is does the claim being made make sense? Some claims are too incredible to be true. For example, the hypothetical advertisement for WellShield illustrated in **Figure 1.24** states that this product will make illness a thing of the past. 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 WellShield will reduce cold symptoms, however, is not so outrageous.

Where Did the Information Come From?

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? Was it the result of a research study? Is it in a news story or an advertising promotion? Is it on television, in a magazine, or on a Web page?

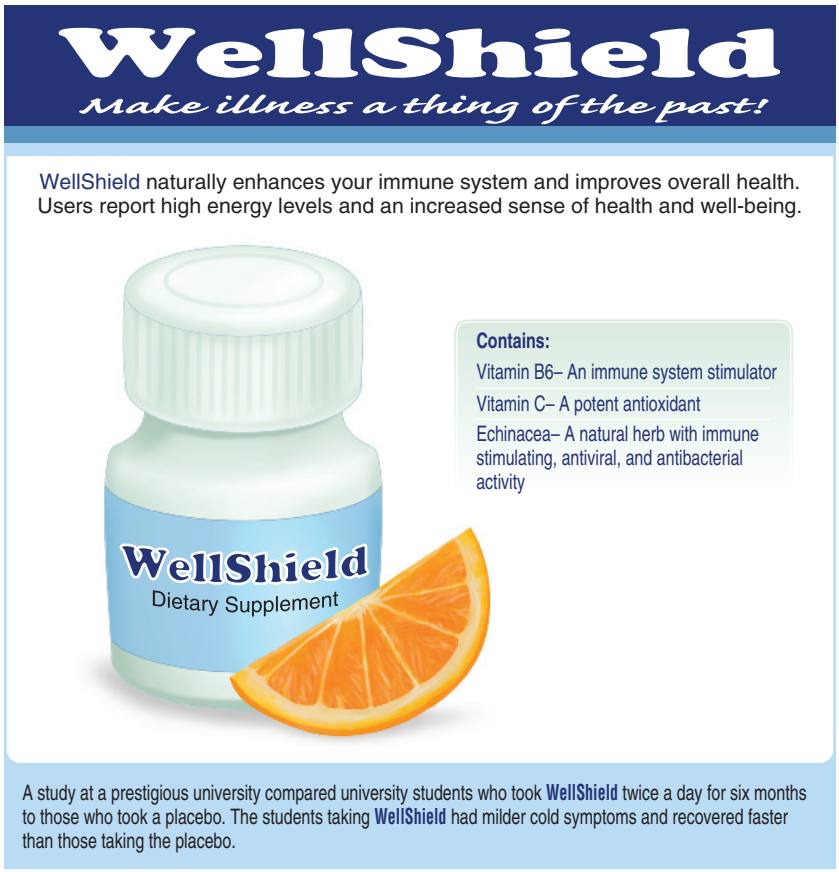


FIGURE 1.24 This hypothetical supplement advertisement illustrates the types of nutrition claims that consumers must be prepared to evaluate.

Although health professionals such as dietitians are sources of reliable nutrition information, Canadians are also exposed to many messages about food and nutrition information in the mass media. Mass media are very powerful tools in promoting health and nutrition messages. Information that would take individual health-care workers years to disseminate can reach millions of individuals in a matter of hours or days. Much of this information is reliable, but some can be misleading. The motivation for news stories is often to sell subscriptions or improve ratings, not to promote the nutritional health of the population. Some nutrition and health information originates from food manufacturers, and is usually in the form of marketing and advertising designed to sell existing products or target new ones. This promotional information can be confusing to the consumer, who may not know how to interpret it. For instance, in the 1990s, the now-obsolete recommendation to reduce fat intake to protect against heart disease and help maintain a healthy weight created a demand for products low in fat. Food manufacturers responded by creating fat-free, low-fat, and reduced-fat products at an astonishing rate. Weight- and health-conscious consumers responded by increasing their consumption of these foods, but waistlines continued to increase. The message that reducing fat intake promotes health was received, but consumers did not understand that fat-free foods are not kcalorie-free and simply adding low-fat foods to the diet was not a prescription for good health. Knowing what information to believe and how to use this information to choose a diet can be challenging (see Label Literacy: Look Beyond the Banner on the Label).

Individual Testimonies

Claims that come from individual testimonies have not been tested by experimentation. For example, the claim in Figure 1.24 that WellShield improves energy levels and overall sense of health and well-being is based on the comments of supplement users and is therefore anecdotal, and not based on measured parameters.

Label Literacy

Look Beyond the Banner on the Label

Canadian Content

Extra-lean!; Reduced in energy!; Fat-free! Claims like these on a food package stand out and catch your eye, but what do these terms mean? Food labels provide a lot of nutritional information but the interpretation of this information is not always straightforward. Food labels must conform to Canadian Food and Drugs regulations, which are described in the Canadian Food Inspection Agency's Food Labelling for Industry[1] and use standard definitions, but these definitions may not necessarily make sense to the consumer. Extra-lean, for example, can be used only to describe meat products and means that the product is less than 7.5% fat. Reduced in energy means that a product contains at least 25% less than a similar reference food. A fat-free cookie means that it contains less than 0.5 grams of fat per reference serving (which is also defined by regulations).

Furthermore, many food label descriptors highlight individual nutrients. But because no single nutrient makes a food good or bad for you, you must look beyond these descriptors to understand the overall contribution that the food makes to your diet. For example, chocolate cookies labelled "fat free" may not be your best choice if you are trying to reduce your sugar intake or increase your fibre consumption. Product names, which also comply with regulations of the Food and Drugs Act, can still be confusing. Vegetable stew with beef must contain at least 12% beef, while beef stew must contain at least 20% beef. Weiners with beans contains at least 25% wieners, while beans with wieners contains at least 10% wieners.[2] To get the whole picture, you need to look beyond the healthy-sounding descriptors and the product name. Read the label, which must include the food's nutrient content and information to see how it fits into the diet as a whole. Section 2.5 and Label Literacy boxes throughout this book provide more information on how to read food labels.

[1] Canadian Food Inspection Agency. Food Labelling for Industry. Available online at https://inspection.gc.ca/food/requirements-and-guidance/labelling/industry/eng/1383607266489/1383607344939. Accessed June 25, 2019.

[2] Justice Canada Food & Drugs Regulations-Division 14: Meat B.14.070: Meat Specialities. Available online at https://www.laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._870/page-72.html#h-573137. Accessed June 25, 2019.

Information from Government, Nonprofit, and Educational Institutions

Canadian Content The three most important government agencies in Canada that provide health and dietary information are Health Canada, the Canadian Food Inspection Agency, and the Public Health Agency of Canada. Health Canada is the government agency that deals with many health-related matters including the development of recommendations regarding healthy dietary practices. These recommendations are developed by committees of scientists who interpret the latest well-conducted research studies and use their conclusions to provide guidelines for the population as a whole. For example, Health Canada developed *Canada's Food Guide* and, in collaboration with American agencies, the Dietary Reference Intakes, both of which are discussed in Sections 2.3 and 2.2, respectively. Health Canada provides information about food safety and recommendations on food choices and the amounts of specific nutrients needed to avoid nutrient deficiencies and excesses, and to prevent chronic diseases. These recommendations are used to develop food-labelling regulations and are the basis for public health policies and programs. Health Canada publishes very useful information on many health-related topics on their website (https://www.canada.ca/en/health-canada.html). The Canadian Food Inspection Agency (www.inspection.gc.ca) enforces Canadian regulations to ensure the safety of the Canadian food supply, for example, the prevention of food-borne illness, the contamination of food with toxic chemicals, and the mislabelling of food. The Public Health Agency of Canada has the goal of preventing disease and improving the health of Canadians and, like Health Canada, also provides useful nutrition-related information on their website (https://www.canada.ca/en/public-health.html). Another useful website for Canadians to access is www.healthycanadians.ca, which provides information to Canadians on a variety of important issues including food and nutrition.

Nonprofit organizations such as Dietitians of Canada, Diabetes Canada, the Canadian Medical Association, the Heart and Stroke Foundation of Canada, and the Canadian Cancer Society are also good sources of nutrition information. See **Table 1.7** for web addresses of these organizations. 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 peer-reviewed journals and are well scrutinized. The WellShield ad in Figure 1.24 cites a university research study that demonstrated reduced cold symptoms. If the study was published in a peer-reviewed journal, the information is probably reliable.

TABLE 1.7 Non-Profit Organizations in Canada that Provide Reliable Nutrition Information

Organization	Web Address
Dietitians of Canada	www.dietitians.ca
Diabetes Canada	www.diabetes.ca
Canadian Medical Association	www.cma.ca
Heart and Stroke Foundation of Canada	www.heartandstroke.ca
Canadian Cancer Society	www.cancer.ca
Osteoporosis Canada	www.osteoporosis.ca
Hypertension Canada	www.hypertension.ca

Qualified Individuals Knowing who is providing the information can help you decide whether or not to believe it. What are the credentials of the individual providing the information? Where do they work? Do they have a degree in nutrition or medicine? If you are looking at an article or a website, check the credentials of the author. Care must be taken even when obtaining information from nutritionists. 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 the registered dietitian. Registered dietitians (RD or RDt) are nutrition professionals who have completed a 4-year college degree in a nutrition-related field and who have met established criteria to certify them in providing nutrition counseling. In addition to the term registered dietitian, the terms registered dietitian nutritionist (RDN), professional dietitian (PDt) or dietetiste professionnelle (Dt. P) are also used in Canada to denote professionals with the same training.

Is the Information Based on Well-Designed, Accurately Interpreted Research Studies?

If the source of the information seems reliable and cites a research study, ask if the study was well designed and if the results were interpreted accurately. Even well-designed, carefully executed, peer-reviewed 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 1.24 states that WellShield improves overall health. However, the study investigates only cold symptoms; overall health is not addressed.

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 university study described in the WellShield ad is a trial that compares the severity of cold symptoms and the cold recovery time (quantifiable parameters) of college students who took the WellShield supplement (experimental group) with the same parameters in a similar group of students who took a placebo (control group). The results indicate that the experimental group had milder cold symptoms and shorter recovery times than the control or placebo group. This supports the claim that the product can reduce cold symptoms. The ad, on the other hand, has not provided consumers with enough information to find the study or its abstract on PubMed, so they can judge the claims for themselves.

Who Stands to Benefit?

Another important question to ask when judging nutrition claims is who stands to benefit from the information? 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 helps 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 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 cite a study that shows that rats fed a diet high in vitamin E, that is, the vitamin E comes from food sources only, live longer than those consuming less vitamin E. However, the fact that a diet high in vitamin E increased longevity does not mean that Vitamin E supplements will have the same effect. In addition, this study was done in rats. Can the result be extrapolated to human health? Just because rats consuming diets high in vitamin E live longer does not mean that vitamin E supplements will extend human life. Information on the Internet is also likely to be biased toward a product or service if it comes from a site where you can buy the product.

Has It Stood the Test of Time?

Often the results of a new scientific study are on the morning news the same day they are published in a peer-reviewed journal. Sometimes this information is accurate, but a single study is never enough to develop a reliable theory. Results need to be reproducible before they can be 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.

1.6 Concept Check

1. Name seven questions you should ask yourself when evaluating the reliability of nutritional information.

2. Why are individual testimonies not considered reliable sources of information?

3. Why is it important to read food labels?

Case Study Outcome

Kaitlyn found it hard to eat a healthy diet living in residence for the first time. Her choices were limited to the meals in the cafeteria and it was difficult to figure out what a healthy diet was. Now that she's read this chapter, she knows that a healthy diet includes a variety of foods. She aims to eat fruits, vegetables, whole grains and many protein foods. She recognizes that eating a healthy diet involves using moderation, so she doesn't consume too much of any one food and avoids kcalorie-rich foods high in fat and sugar. Kaitlyn now knows that she can occasionally have study snacks like potato chips, as long as she selects nutrient-dense foods most of the time. 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 and armed with a better understanding of nutrition, Kaitlyn is maintaining a healthy weight and using the principles of adequacy, variety, balance, kcalorie control, and moderation to choose a nutrient-dense diet that minimizes her risks of developing heart disease and high blood pressure.

Applications

Personal Nutrition

1. How healthy is your diet?

a. How many different vegetables and fruits did you eat today? How about this week? If you average fewer than five a day, make some suggestions that would increase the fruit and vegetable variety in your diet.

b. How often do you eat treats such as a doughnut or an extravagant dessert? Are you exercising regularly?

c. Do you order large portions? Use iProfile to look up how many more kcalories are in a large burger, fries, and drink than in a medium-sized order.

d. Do you ever eat foods right out of the package? If you do, it is hard to tell how much you really ate. Suggest some things you could do to control your portion size.

2. What factors affect your food choices?

a. List four food items you ate today or yesterday.

b. For each food listed, indicate the factor or factors that influenced your selection of that particular food. For example, if you ate a candy bar before your noon class, did you choose it because it was available in the vending machine outside the lecture hall, because you did not have enough money for anything else, because you just like candy bars, because you were depressed, because all of your friends were eating them, because you believe it is good for you, or for some other reason?

c. For each food, indicate what information you used in making the selection. For example, did you read the label on the product, or consider something you had read or heard recently in the news media?

d. List three factors that commonly influence your food choices.

e. List three types of information you regularly use to make your food choices.

General Nutrition Issues

1. Consider the hypothesis: A diet high in calcium reduces the risk of colon cancer. Using figure 1.18 as a guide, describe how you would test this hypothesis with a cohort study and with a randomized controlled trial. For the trial, the outcome is a protein biomarker that increases in concentration in colon cells when cells begin to grow and divide. Increased levels of this protein reflect increased cancer risk.
2. Does this nutritional supplement live up to its claims?

a. Examine a nutritional supplement ad provided by your instructor or select one from a health- or fitness-related magazine or website. What is the claim made about this product, and is it believable?

b. Does the ad refer to any research studies? If so, do they seem well controlled? Were the results based on objective measurements? Were the conclusions consistent with the results obtained? Were they published in peer-reviewed journals? Can you find the abstract for the study in PubMed?

c. Were claims based on anecdotal reports of individual users?

d. Who stands to benefit if you spend money on this product?

e. Based on this ad alone, would you choose to take this supplement? Why or why not?

Summary

1.1 Nutrition and the Canadian Diet

- Nutrition is a science that encompasses all the interactions that occur between living organisms and food. Canadians today are eating more fast food, processed foods, and prepared foods and spending less time preparing meals and eating at home than 50 years ago. This is affecting the healthfulness of the diet.
- Many Canadians are not eating foods that meet the recommendations for a healthy diet. This contributes to the incidence 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 natural health products, such as vitamin and mineral supplements. In addition to nutrients, food provides phytochemicals and zoochemicals, and nonessential substances, which may provide health benefits. There are six classes of nutrients: carbohydrates, lipids, proteins, water, vitamins, and minerals.
- Food contains nutrients that are needed by the body for growth, maintenance and repair, and reproduction. Carbohydrates, lipids, and proteins are energy-yielding nutrients. The energy they provide to the body is measured in kcalories or kjoules. 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.
- When energy or one or more nutrients are deficient or excessive in the diet, malnutrition may result. Malnutrition includes both undernutrition and overnutrition. Undernutrition is caused by a deficiency of energy or nutrients. Overnutrition may be caused by a toxic dose of a nutrient or chronic over-consumption of energy or of nutrients that increases the risk of chronic disease. 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.
- The diet you consume can affect your genetic predisposition for developing a variety of chronic diseases.

1.3 Food Choices for a Healthy Diet

- Food choices are affected by food availability, sociocultural influences, personal tastes, emotional factors, and what we think we should eat to stay healthy. 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.
- 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, salt, and alcohol within reason.

1.4 Understanding Science Helps Us Understand 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.

- To be valid, nutrition information should be based on experiments that use quantifiable measurements, the right type and number of experimental subjects, are of appropriate duration, are carefully analyzed using statistical methods, have results that are correctly interpreted, and are of sufficient quality to be published in a peer-reviewed journal.

1.5 Nutrition Research

- Nutrition research uses many types of studies to investigate the relationship between diet and health. Observational studies include prospective cohort studies and case-control studies. Randomized controlled trials are not observational but randomize participants into a treatment (or intervention) group and a control group. Other experiments investigate nutrient function and nutrient requirements and can include human, animal, or in vitro studies.
- Ethical guidelines protect humans and animals involved in research studies, but limit the type of experiments that can be done.
- PubMed is an Internet database that can be used to access abstracts of research papers on nutrition.

1.6 Sorting Out Nutrition Information

- When judging nutrition claims, first consider whether the information makes sense and whether it comes from a reliable source, such as educational institutions, government, and nonprofit organizations. Individual testimonies cannot be trusted because they have not been tested by experimentation.
- If information is based on experimentation, determine if the studies were well designed and accurately interpreted.
- Information that promotes a product or in any other way benefits the person or organization providing it should be viewed with skepticism.
- Accurate information will be supported by more than a single research study.

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