



Understanding Nutrition

Whitney | Rolfes



SIXTEENTH EDITION

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Ellie Whitney
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About the Authors

Ellie Whitney grew up in New York City and received her BA and PhD degrees in English and Biology at Harvard and Washington Universities, respectively. She taught at both Florida State University and Florida A&M University, wrote newspaper columns on environmental matters for the *Tallahassee Democrat*, and coauthored almost a dozen college textbooks on nutrition, health, and related topics, many of which repeatedly reappear as new editions. She spent three decades exploring outdoor Florida and studying its ecology, and then cowrote *Priceless Florida: Natural Ecosystems and Native Species* (Pineapple Press, 2004). Now retired, and more concerned about climate change than any other issue, she volunteers full-time for the nonpartisan national nonprofit Citizens Climate Lobby.

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Preface

Nutrition is a science. The details of a nutrient's chemistry or a cell's biology can be overwhelming and confusing to some, but it needn't be. When the science is explained step by step and the facts are connected one by one, the details become clear and understandable. By telling stories about overweight mice, using analogies of lamps, and applying guidelines to groceries, we make the science of nutrition meaningful and memorable. That has been our mission since the first edition—to reveal the fascination of science and share the excitement of nutrition with readers. We have learned from the thousands of professors and more than a million students who have used this book through the years that readers want an *understanding* of nutrition so they can make healthy choices in their daily lives. We hope that this book serves you well.

A Book Tour of This Edition

Understanding Nutrition presents the core information of an introductory nutrition course. The early chapters introduce the nutrients and their work in the body, and the later chapters apply that information to people's lives—describing the role of foods and nutrients in energy balance and weight control, in physical activity, in the life cycle, in disease prevention, in food safety, and in hunger.

The Chapters Chapter 1 begins by exploring why we eat the foods we do and continues with a brief overview of the nutrients, the science of nutrition, recommended nutrient intakes, assessment, and important relationships between diet and health. Chapter 2 describes the diet-planning principles and food guides used to create eating patterns that support good health and includes instructions on how to read a food label. In Chapter 3 readers follow the journey of digestion and absorption as the body breaks down foods into nutrients. Chapters 4, 5, and 6 describe carbohydrates, fats, and proteins—their chemistry, roles in the body, and places in the diet. Then Chapter 7 shows how the body derives energy from these three nutrients. Chapters 8 and 9 continue the story with a look at energy balance, the factors associated with overweight and underweight, and the benefits and dangers of weight loss and weight gain. Chapters 10, 11, 12, and 13 complete the introductory lessons by describing the vitamins, the minerals, and water—their roles in the body, deficiency and toxicity symptoms, and sources.

The next seven chapters weave that basic information into practical applications, showing how nutrition influences people's lives. Chapter 14 describes how physical activity and nutrition work together to support fitness. Chapters 15, 16, and 17 present the special nutrient needs of people through the life cycle—pregnancy and lactation; infancy, childhood, and adolescence; and adulthood and the later years. Chapter 18 focuses on the dietary risk factors and recommendations associated with chronic diseases, and Chapter 19 addresses consumer concerns about the safety of the food and water supply. Chapter 20 closes the book by examining hunger, the environment, and food sustainability.

The Highlights Every chapter is followed by a highlight that provides readers with an in-depth look at a current, and often controversial, topic that relates to its companion chapter. Each highlight closes with Critical Thinking Questions designed to encourage readers to develop clear, rational, open-minded, and informed thoughts based on the evidence presented in the text.

Special Features The photos, art, and layout in this edition have been carefully designed to be inviting while enhancing student learning. In addition, special features help readers identify key concepts and apply nutrition knowledge. When a new term is introduced, it is printed in bold type, and a **definition** is provided in the margin nearby. These definitions often include pronunciations and derivations to facilitate understanding. The glossary at the end of the book includes all defined terms.

definition (DEF-eh-NISH-en): the meaning of a word.

- **de** = from
- **finis** = boundary

CHAPTER OUTLINE & LEARNING OBJECTIVES

The opening page of each chapter provides an outline and directs readers to the main heads within the chapter. Each main head is followed by a learning objective for the content covered in that section. These learning objectives also appear within the text at the start of each main section. After reading the chapter, students will be able to demonstrate competency in the learning objectives.

Nutrition in Your Life

The opening paragraph of each chapter—called Nutrition in Your Life—introduces the chapter’s content in a friendly and familiar way. This short paragraph closes with a preview of how readers might apply that content to their daily lives.

> How To

Many of the chapters include “How To” features that guide readers through problem-solving tasks. For example, a “How To” in Chapter 1 presents the steps in calculating energy intake from the grams of carbohydrate, fat, and protein in a food.

> **TRY IT** Each “How To” feature ends with a “Try It” activity that gives readers an opportunity to practice these new lessons.

> REVIEW

Each major section within a chapter concludes with a paragraph that summarizes key concepts. Similarly, review tables and figures cue readers to important summaries.

Each chapter ends with an invitation to explore activities in the *Understanding Nutrition* MindTap.

What’s Online



Visit www.cengage.com to access MindTap, a complete digital course that includes Diet & Wellness Plus, interactive quizzes, videos, and more.

The Appendixes

The appendixes are valuable references for a number of purposes. Appendix A summarizes background information on the hormonal and nervous systems, complementing Appendixes B and C on basic chemistry, the chemical structures of nutrients, and major metabolic pathways. Appendix D describes measures of protein quality. Appendix E provides details of nutrition assessment, and Appendix F presents the estimated energy requirements for men and women at various levels of physical activity. Appendix G presents the 2019 publication *Choose Your Foods: Food Lists for Diabetes and Weight Management*. Appendix H features aids to calculations, a short tutorial on converting metric measures and handling basic math problems commonly found in the world of nutrition. Appendix I lists nutrition recommendations from the World Health Organization (WHO).

Inside Covers

The inside covers of the book put commonly used information at your fingertips. Pages A–C present the current nutrient recommendations. The Daily Values used on food labels plus a glossary of nutrient measures are shown on page Y, and suggested weight ranges for various heights are shown on page Z.

Notable Changes in This Edition

Because nutrition is an active science, staying current is paramount. Just as nutrition research continuously adds to and revises the accepted body of knowledge, this edition builds on the science of previous editions with the latest in nutrition research. Much has changed in the world of nutrition and in our daily lives since the first edition. The number of foods has increased dramatically—even as we spend less time than ever in the kitchen preparing meals. The connections between diet and disease have become more apparent—and consumer interest in making smart health choices has followed. More people are living longer and healthier lives. The science of nutrition has grown rapidly, with new understandings emerging daily. In this edition, as with all previous editions, every chapter has been revised to enhance learning by presenting current information accurately and attractively. For all chapters and highlights we have:

- Reviewed and updated content
- Applied findings from the scientific report of the *2020–2025 Dietary Guidelines for Americans*
- Presented new food labels in figures throughout the text
- Included COVID-19 in discussions as appropriate

Chapter 1

- Introduced Chronic Disease Risk Reduction (CDRR), the newest DRI value
- Added a new How To feature detailing how to Calculate the AMDR in Grams and kCalories
- Revised the figure comparing the energy density of two breakfast meals

Chapter 2

- Revised the figure comparing the nutrient density of two breakfast meals
- Introduced the *2020–2025 Dietary Guidelines for Americans* with new text and figure
- Directed readers to Appendix G for the 2019 *Choose Your Foods: Food Lists for Diabetes and Weight Management*
- Expanded focus of highlight to plant-based eating patterns and introduced current generation of plant-based meat alternatives (non-meat meats)

Chapter 4

- Reorganized dietary strategies to manage lactose intolerance

Chapter 5

- Revised figure detailing the structure of bile in emulsification
- Revised figure showing the pathway from one omega fatty acid to another to include omega-3 pathway and the competition for enzymes
- Revised figure comparing the fat contents of two meals

Chapter 6

- Created new figure showing the competition for amino acid absorption when supplements are used

Chapter 7

- Added short section on metabolic disorders caused by prolonged nutrient excesses
- Reorganized several figures—revising, deleting, and moving

Chapter 8

- Reorganized several figures and tables—creating, deleting, and moving

Chapter 9

- Clarified LPL discussion
- Added discussion of ultra-processed foods in weight gain
- Moved figure of pear-shape and apple-shape from Chapter 8 to here
- Deleted table of weight-loss drugs

Chapters 10–13

- Refreshed figures and photos featuring sources of vitamins and minerals
- Reorganized presentation of minerals (in Chapter 13) based on quantities found in the body

Chapter 14

- Presented recommendations from the 2nd edition of the *Physical Activity Guidelines for Americans*
- Included new information about health screening before beginning a fitness program

Chapter 16

- Revised table of supplements for full-term infants
- Enhanced table of infant development and recommended foods
- Added new section entitled How to Introduce Complementary Foods that includes responsive eating and baby-led feeding
- Added the 5-2-1-0 goals for obesity prevention

Chapter 18

- Split the table of Standards for CHD Risk Factors into two tables: one for blood lipid standards and another for new blood pressure standards
- Introduced and defined medical nutrition therapy
- Added discussion on potassium intake to recommendations to reduce hypertension risk
- Updated table of Recommendations and Strategies for Reducing Cancer Risk based on latest information from the World Cancer Research Fund and the American Institute for Cancer Research

Chapter 19

- Reorganized section on safe handling of fruits and vegetables and revised the accompanying table
- Added figure on handwashing
- Revised table on refrigerator storage times
- Revised genetic engineering figure in the highlight

Chapter 20

- Updated figures for world hunger map, water-scarcity map, and ecological footprints
- Created new figure showing greenhouse gas emissions per 100 grams protein
- Reorganized sections on world food shortages and malnutrition
- Created new section called Feeding the World that substantially revised the final section, describing the environmental damage of food production and possible sustainable solutions
- Revised the highlight with a tighter focus on food-related decisions to reduce a person's ecological footprint

Student and Instructor Resources

MindTap for Whitney & Rolfes, *Understanding Nutrition*, 16th Edition, is a digital learning solution that empowers learners to go beyond memorization—enabling a deeper understanding of concepts and topics. MindTap provides engaging content and activities that help build student confidence. Accelerate progress with MindTap. Visit cengage.com/login to learn more.

Instructor Companion Site: Everything you need for your course in one place! This collection of book-specific lecture and class tools is available online via www.cengage.com/login. Access and download PowerPoint presentations, images, instructor's manual, videos, and more.

Test Bank with Cognero: Cengage Learning Testing Powered by Cognero is a flexible, online system that allows you to:

- Write, edit, and manage test bank content from multiple Cengage Learning solutions

- Create multiple test versions in an instant
- Deliver tests from your LMS, your classroom, or wherever you want

Diet & Wellness Plus: Diet & Wellness Plus helps you understand how nutrition relates to your personal health goals. Track your diet and activity, generate reports, and analyze the nutritional value of the food you eat. Diet & Wellness Plus includes more than 75,000 foods as well as custom food and recipe features. The Behavior Change Planner helps you identify risks in your life and guides you through the key steps to make positive changes. Diet & Wellness Plus is also available as an app that can be accessed from the app dock in MindTap.

Closing Comments

We have taken great care to provide accurate information and have included many references at the end of each chapter and highlight. To keep the number of references manageable over the decades, however, many statements that appeared in previous editions with references now appear without them. All statements reflect current nutrition knowledge, and the authors will supply references upon request. In addition to supporting text statements, the end-of-chapter references provide readers with resources for finding a good overview or more details on the subject. Nutrition is a fascinating subject, and we hope our enthusiasm for it comes through on every page.

Ellie Whitney
Sharon Rady Rolfes
December 2020

Acknowledgments

To produce a book requires the coordinated effort of a team of people—and, no doubt, each team member has another team of support people as well. We salute, with a big round of applause, everyone who has worked so diligently to ensure the quality of this book.

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1

An Overview of Nutrition

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Nutrition in Your Life

Believe it or not, you have probably eaten at least 20,000 meals in your life. Without any conscious effort on your part, your body uses the nutrients from foods to make and repair all its components, fuel all its activities, and defend itself against diseases. How successfully your body handles these tasks depends, in part, on your food choices. Nutritious food choices support healthy bodies. As you read this chapter, consider how your food choices are influencing your health and risks of diseases.

Nutrition plays a significant role in your life. Every day, several times a day, you select **foods** that influence your body's health. Each day's food choices may benefit or harm health only a little, but over time, the effects of these choices become major. That being the case, improving food choices now supports health benefits later.¹ Conversely, carelessness about food choices can contribute to **chronic diseases**. Of course, some people will become ill or die young no matter what choices they make, and others will live long lives despite making poor choices. For most of us, however, the food choices we make will improve or impair our health in proportion to how well those choices meet the body's needs.

Although most people realize that food habits affect health, they often choose foods for other reasons. After all, foods bring pleasures, traditions, and associations as well as nourishment. The challenge, then, is to combine favorite foods to create a nutritionally balanced **diet**. Notice from the definition that *diet* does *not* mean a restrictive food plan designed for weight loss. It simply refers to the foods and beverages a person consumes. Whether it's a vegetarian diet, a weight-loss diet, or an elite runner's diet depends on the types of foods and beverages a person chooses. Importantly, diets often change with life's changing circumstances.

1.1 Food Choices

LO 1.1 Describe how various factors influence personal food choices.

People decide what to eat, when to eat, how much to eat, and even whether to eat in highly personal ways. A variety of food choices can support good health, and an understanding of human nutrition can help a person make healthy selections more often.

Preferences As you might expect, the number one reason most people choose certain foods is taste—they like the flavor. Two widely shared preferences are for the sweetness of sugar and the savoriness of salt. High-fat foods also appear to be a universally common preference. Other preferences might be for the hot peppers common in Mexican cooking or the curry spices of Indian cuisine. Research suggests that genetics may influence taste perceptions and therefore food likes and dislikes.² Similarly, the hormones of pregnancy seem to influence food cravings and aversions (see Chapter 15).

Habit People sometimes select foods out of habit. They eat cereal every morning, for example, simply because they have always eaten cereal for breakfast. Eating a familiar food and not having to make any decisions can be comforting. Similarly, people may find certain foods and beverages most appropriate at certain times of day—orange juice in the morning, for example.

Ethnic Heritage and Regional Cuisines Among the strongest influences on food choices are ethnic heritage and regional cuisines. People tend to prefer the foods they grew up eating, but they may also be willing to try new foods, especially when

nutrition: the science of the nutrients in foods and their actions within the body. A broader definition includes the study of human behaviors related to food and eating.

foods: products derived from plants or animals that are taken into the body to yield energy and nutrients for the maintenance of life and the growth and repair of tissues.

chronic diseases: diseases characterized by slow progression and long duration. Examples include heart disease, diabetes, and some cancers.

diet: the foods and beverages a person eats and drinks.



pepsee30/Shutterstock.com

> **PHOTO 1-1** An enjoyable way to learn about a culture is to taste the ethnic foods.

traveling. Every country, and in fact every region of a country, has its own typical foods and ways of combining them into meals. These cuisines reflect unique combinations of local ingredients and cooking styles. Chowder in New England is made with clams, but in the Florida Keys conch is the featured ingredient. The Pacific Northwest is as famous for its marionberry pie as Georgia is for its peach cobbler. Philly has its cheesesteaks and New Orleans has its oyster po'boys. The "American diet" includes many ethnic foods and regional styles, all adding variety to the diet.

Enjoying traditional **ethnic foods** provides an opportunity to learn about a culture (Photo 1-1). People offering ethnic foods share a part of their culture with others, and those accepting the foods learn about others' ways of life. Developing **cultural competence** honors individual preferences and is particularly important for professionals who help others plan healthy diets.³

Social Interactions Meals are often social events, and sharing food is part of hospitality. Social customs invite people to accept food or drink offered by a host or shared by a group—regardless of hunger signals. Such social interactions can be a challenge for people trying to limit their food intakes; Chapter 9 describes how people tend to eat more food when socializing with others than when eating alone. People also tend to eat the kinds of foods eaten by those in their social circles, thus helping to explain why obesity seems to spread in social networks and weight loss is easier with a partner.

Marketing Another major influence on food choices is marketing. The food industry competes for our food dollars, persuading consumers to eat more food, more often. These marketing efforts pay off well, with sales exceeding \$900 billion each year. In addition to building brand loyalty, food companies attract busy consumers with their promises of convenience.

Availability, Convenience, and Economy Consumers' food choices and behaviors shifted when the COVID-19 pandemic forced restaurant closings and infrequent grocery trips. For some, unemployment added financial pressures (Chapter 20 includes a discussion of hunger in the time of COVID-19). Even with these changes, however, people still select foods that are accessible and within their financial means. Consumers who value convenience prefer to eat out, bring home prepared foods, or have meals delivered. Even when they venture into the kitchen, they want to prepare a meal in less than 20 minutes, using fewer than a half dozen ingredients. Whether decisions based on convenience meet a person's nutrition needs depends on the choices made. Eating a banana or a candy bar may be equally convenient, but the fruit provides more vitamins and minerals and less sugar and fat.

Given the abundance of convenient food options, fewer adults have learned the cooking skills needed to prepare meals at home. This trend has its downside: people lacking cooking skills frequently buy prepackaged, processed items which tend to be high in sugar, sodium, and saturated fat.⁴ In contrast, people who are skilled in cooking and frequently eat their meals at home tend to make healthier food choices.

Not surprisingly, when eating out, consumers often choose low-cost fast-food outlets over more expensive fine-dining restaurants. Foods eaten away from home, especially fast-food meals, tend to be high in nutrients that Americans overconsume (saturated fat and sodium) and low in nutrients that Americans underconsume (calcium, fiber, and iron)—all of which can contribute to health problems.

Unfortunately, healthful diets that include plenty of fruits, vegetables, fish, and nuts tend to cost about \$1.50 per person per day more than less healthful diets that feature meats, refined grains, and processed foods. Also, milk is more expensive than soda.⁵ Marketing strategies that can help consumers improve diet quality include reducing the prices of fruits and vegetables, taxing processed foods, placing healthy options in strategic locations, and limiting discounts on less-healthy foods. Chapter 20 examines the costs of foods needed for a healthy and sustainable diet and presents tips on how to plan and shop for healthy meals on a budget.

ethnic foods: foods associated with particular cultural groups.

cultural competence: awareness and acceptance of cultures; ability to interact effectively with people of diverse cultures.

Positive and Negative Associations People tend to like particular foods associated with happy occasions—such as hot dogs at ball games or cake and ice cream at birthday parties. By the same token, people may have aversions to foods that they ate when they felt sick or that they were forced to eat in negative situations. Similarly, children learn to like and dislike certain foods when their parents use foods as rewards or punishments. Negative experiences can have long-lasting influences on food preferences. More than 50 years after World War II, veterans who experienced intense combat in the Pacific still disliked Asian food significantly more than their peers who were not engaged in battle or those who fought elsewhere.

Emotions Emotions guide food choices and eating behaviors. Some people cannot eat when they are emotionally upset. Others may eat more in response to emotional stimuli—for example, to relieve boredom or depression or to calm anxiety. A lonely person may choose to eat rather than to call a friend. A person who has returned home from an exciting evening out may unwind with a late-night snack. These people may find emotional comfort, in part, because foods can influence the brain’s chemistry and the mind’s response. Carbohydrates and alcohol, for example, tend to calm, whereas proteins and caffeine are more likely to stimulate. Eating in response to emotions and stress can easily lead to overeating and weight gain, but it may be helpful at times. For example, sharing food at times of bereavement serves both the giver’s need to provide comfort and the receiver’s need to be cared for and to interact with others as well as to take nourishment.

Values People’s religious beliefs, political views, or environmental concerns may influence their food choices. For example, some Christians forgo meat on Fridays during Lent (the period prior to Easter), Jewish law includes an extensive set of dietary rules that govern the use of foods derived from animals, and Muslims fast between sunrise and sunset during Ramadan (the 9th month of the Islamic calendar). Some vegetarians select foods based on their support for animal rights. A concerned consumer may boycott fruit picked by migrant workers who have been exploited. People may buy vegetables from local farmers to support the local economy or select foods packaged in containers that can be reused or recycled to help save the environment. Some consumers accept or reject foods that have been irradiated, grown organically, or genetically modified, depending on their approval of these processes (see Chapter 19 for a complete discussion).

Body Weight and Health Sometimes people select certain foods and supplements that they believe will improve their body weight, health, or allergies and avoid those they believe might be detrimental. Such decisions can be beneficial when based on nutrition science, but decisions based on fads or carried to extremes undermine good health, as pointed out in later discussions of eating disorders (Highlight 8) and dietary supplements commonly used by athletes (Highlight 14).

Nutrition Finally, of course, many consumers make food choices they believe are nutritious and healthy (Photo 1-2). Making healthy food choices 100 years ago was rather easy; the options were relatively few and markets sold mostly fresh, **whole foods**. Examples of whole foods include vegetables; fruits; seafood, meats, poultry, eggs, nuts, and seeds; milk; and whole grains. Today, tens of thousands of food items fill the shelves of super-grocery stores and most of those items are **processed foods**. Whether a processed food is a healthy choice depends, in part, on how extensively the food was processed. When changes are minimal, processing can provide an abundant, safe, convenient, affordable, and nutritious product. Examples of minimally processed foods include frozen vegetables, fruit juices, smoked salmon, cheeses, and breads. The nutritional value diminishes, however, when changes are extensive. **Ultra-processed foods** no longer resemble whole foods; they are made from numerous ingredients that are typically not used in kitchens



> **PHOTO 1-2** To enhance your health, keep nutrition in mind when selecting foods.

whole foods: fresh foods such as fruits, vegetables, grains, meats, and milk that are unprocessed or minimally processed.

processed foods: foods that have been intentionally changed by the addition of substances, or a method of cooking, preserving, milling, or such.

ultra-processed foods: foods that have been made from substances that are typically used in food preparation, but not consumed as foods by themselves (such as oils, fats, flours, refined starches, and sugars) that undergo further processing by adding a little, if any, minimally processed foods, salt and other preservatives, and additives such as flavors and colors.

(such as high-fructose corn syrup, hydrogenated or interesterified oils, and hydrolysed proteins). Flavors, colors, emulsifiers, and other additives are also used to make the product more palatable and appealing. Examples of ultra-processed foods include soft drinks, corn chips, fruit gummies, chicken nuggets, canned cheese spreads, and toaster pastries. Notably, these foods cannot be made in a home kitchen using common grocery ingredients. Dominating the global market, ultra-processed foods tend to be attractive, tasty, and cheap—as well as high in fat and sugar.⁶ Consumers who want to make healthy food choices will select few ultra-processed foods and more whole and minimally processed foods.⁷

> REVIEW

A person selects foods for a variety of reasons. Whatever those reasons may be, food choices influence health. Individual food selections neither make nor break a diet's healthfulness, but the balance of foods selected over time can make an important difference to health. For this reason, people are wise to think "nutrition" when making their food choices.

1.2 The Nutrients

LO 1.2 Name the six major classes of nutrients and identify which are organic and which yield energy.



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> **PHOTO 1-3** Foods offer energy, nutrients, and phytochemicals to support the body's work and maintain its health.

Biologically speaking, people eat to receive nourishment. Do you ever think of yourself as a biological being made of carefully arranged atoms, molecules, cells, tissues, and organs? Are you aware of the activity going on within your body even as you sit still? The atoms, molecules, and cells of your body continuously move and change, even though the structures of your tissues and organs and your external appearance remain relatively constant. The ongoing growth, maintenance, and repair of the body's tissues depend on the energy and the nutrients received from foods (see Photo 1-3).

Nutrients in Foods and in the Body Amazingly, our bodies can derive all the energy, structural materials, and regulating agents we need from the foods we eat. This section introduces the nutrients that foods deliver and shows how they participate in the dynamic processes that keep people alive and well.

Nutrient Composition of Foods Chemical analysis of a food such as a tomato shows that it is composed primarily of water (95 percent). Most of the solid materials are carbohydrates (including fibers), lipids (fats), and proteins. If you could remove these materials, you would find a tiny residue of vitamins, minerals, and other compounds. Water, carbohydrates, lipids, proteins, vitamins, and some of the minerals found in foods represent the six classes of nutrients—substances the body uses for the growth, maintenance, and repair of its tissues.

This book focuses mostly on the nutrients, but foods contain other compounds as well—**phytochemicals**, pigments, additives, alcohols, and others. Some are beneficial to health, some are neutral, and a few are harmful. Later chapters discuss these compounds and their significance.

Nutrient Composition of the Body A chemical analysis of your body would show that it is made of materials similar to those found in foods (see Figure 1-1). A healthy 150-pound body contains about 90 pounds of water and about 20 to 45 pounds of fat. The remaining pounds are mostly protein, carbohydrate, and the major minerals of the bones. Vitamins and other minerals constitute a fraction of a pound.

Chemical Nature of Nutrients The simplest of the nutrients are the minerals. Each mineral is a chemical element; its atoms are all alike. As a result, its identity never changes. For example, iron may have different electrical charges, but the individual iron atoms remain the same when they are in a food, when a

energy: the capacity to do work. The energy in food is chemical energy. The body can convert this chemical energy to mechanical, electrical, or heat energy.

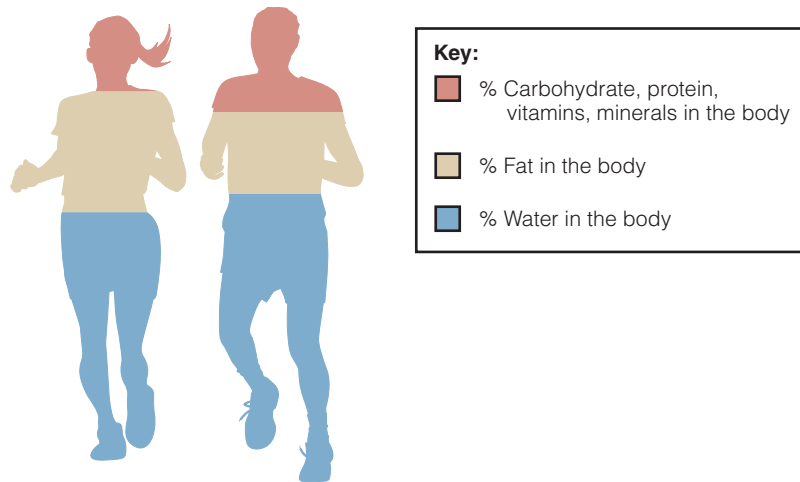
nutrients: chemical substances obtained from food and used in the body to provide energy, structural materials, and regulating agents to support growth, maintenance, and repair of the body's tissues. Nutrients may also reduce the risks of some diseases.

phytochemicals (FIE-toe-KEM-ih-cals): nonnutrient compounds found in plants. Some phytochemicals exhibit biological activity in the body.

• **phyto** = plant

> FIGURE 1-1 Body Composition of Healthy-Weight Men and Women

The human body is made of compounds similar to those found in foods—mostly water (60 percent) and some fat (18 to 21 percent for young men, 23 to 26 percent for young women), with carbohydrate, protein, vitamins, minerals, and other minor constituents making up the remainder. (Chapter 8 describes the health hazards of too little or too much body fat.)



person eats the food, when the iron becomes part of a red blood cell, when the cell is broken down, and when the iron is excreted from the body. The next simplest nutrient is water, a compound made of two elements—hydrogen and oxygen. Minerals and water are **inorganic** nutrients—which means they do not contain carbon.

The other four classes of nutrients (carbohydrates, lipids, proteins, and vitamins) are more complex. In addition to hydrogen and oxygen, they all contain carbon, an element found in all living things; they are therefore called **organic** compounds (meaning, literally, “alive”).* This chemical definition of *organic* differs from the agricultural definition, as Chapter 19 explains.

Essential Nutrients The body can make some, but not all, nutrients. Also, it makes some in insufficient quantities to meet its needs and, therefore, must obtain these nutrients from foods. The nutrients that foods must supply are **essential nutrients**. When used to refer to nutrients, the word *essential* means more than just “necessary”; it means “needed from outside the body”—normally, from foods.

The Energy-Yielding Nutrients: Carbohydrate, Fat, and Protein

In the body, three of the organic nutrients can be used to provide energy: carbohydrate, fat, and protein. In contrast to these **energy-yielding nutrients**, vitamins, minerals, and water do not yield energy in the human body.

Carbohydrate, fat, and protein are sometimes called **macronutrients** because the body requires them in relatively large amounts (many grams daily). In contrast, vitamins and minerals are **micronutrients**, required only in small amounts (milligrams or micrograms daily). Table 1-1 (p. 8) summarizes some of the ways the six classes of nutrients can be described.

Energy Measured in kCalories The energy released from carbohydrate, fat, and protein can be measured in **calories**—tiny units of energy so small that a single apple provides tens of thousands of them. To ease calculations, energy is expressed in 1000-calorie metric units known as kilocalories (shortened to **kcalories**, but commonly called “calories”). When you read in popular books or magazines that an apple provides “100 calories,” it actually means 100 kcalories. This book uses

* Note that this definition of *organic* excludes coal, diamonds, and a few carbon-containing compounds that contain only a single carbon and no hydrogen, such as carbon dioxide (CO₂), calcium carbonate (CaCO₃), magnesium carbonate (MgCO₃), and sodium cyanide (NaCN).

inorganic: not containing carbon or pertaining to living organisms. The two classes of nutrients that are inorganic are minerals and water.

• **in** = not

organic: in chemistry, substances or molecules containing carbon-carbon bonds or carbon-hydrogen bonds that are characteristic of living organisms. The four classes of nutrients that are organic are carbohydrates, lipids (fats), proteins, and vitamins.

essential nutrients: nutrients a person must obtain from food because the body cannot make them for itself in sufficient quantity to meet physiological needs; also called *indispensable nutrients*. About 40 nutrients are currently known to be essential for human beings.

energy-yielding nutrients: the nutrients that break down to yield energy the body can use:

- carbohydrate
- fat
- protein

calories or kcalories: a measure of *heat* energy. Energy provided by foods and beverages is measured in *kilocalories* (1000 calories equal 1 kilocalorie), abbreviated *kcalories* or *kcal*. One kcalorie is the amount of heat necessary to raise the temperature of 1 kilogram (kg) of water 1°C. The scientific use of the term *kcalorie* is the same as the popular use of the term *calorie*.

TABLE 1-1 The Six Classes of Nutrients

Nutrient	Organic	Inorganic	Energy-yielding	Macronutrient	Micronutrient
Carbohydrates	✓		✓	✓	
Lipids (fats)	✓		✓	✓	
Proteins	✓		✓	✓	
Vitamins	✓				✓
Minerals		✓			✓
Water		✓			

TABLE 1-2 kCalorie Values of Energy Nutrients

Nutrients	Energy
Carbohydrate	4 kcal/g
Fat	9 kcal/g
Protein	4 kcal/g

NOTE: Alcohol contributes 7 kcal/g that can be used for energy, but it is not considered a nutrient because it interferes with the body's growth, maintenance, and repair.

the term *kcalorie* and its abbreviation *kcal* throughout, as do other scientific books and journals. How To 1-1 provides a few tips on “thinking metric.”

Energy from Foods The amount of energy a food provides depends on how much carbohydrate, fat, and protein it contains. When completely broken down in the body, a gram of carbohydrate yields about 4 kcalories of energy; a gram of protein also yields 4 kcalories; and a gram of fat yields 9 kcalories (see Table 1-2).*

Because fat provides more energy per gram, it has a greater **energy density** than either carbohydrate or protein. Figure 1-2 compares the energy density of two breakfast options, and later chapters describe how foods with a high energy density contribute to weight *gain*, whereas those with a low energy density support weight *loss*.

> FIGURE 1-2 Energy Density of Two Breakfast Options Compared

The energy density of a food describes how many kcalories per gram it delivers. Both of these breakfast options provide about 500 kcalories, but the one on the left delivers more food and weighs considerably more than the one on the right. The strawberries, scrambled eggs, turkey sausage, milk, and toast with jam has a lower energy density than the cinnamon roll. Selecting a variety of foods also helps ensure nutrient adequacy.



Angel Tucker

LOWER ENERGY DENSITY

This 525-gram breakfast delivers 500 kcalories, for an energy density of 0.95 (500 kcal ÷ 525 g = 0.95 kcal/g).



Angel Tucker

HIGHER ENERGY DENSITY

This 150-gram breakfast delivers 500 kcalories, for an energy density of 3.33 (500 kcal ÷ 150 g = 3.33 kcal/g).

energy density: a measure of the energy a food provides relative to the weight of the food (kcalories per gram).

*For those using kilojoules: 1 g carbohydrate = 17 kJ; 1 g protein = 17 kJ; 1 g fat = 37 kJ; and 1 g alcohol = 29 kJ.

> How To 1-1 Think Metric

Like other scientists, nutrition scientists use metric units of measure. They measure food energy in kilocalories, people's height in centimeters, people's weight in kilograms, and the weights of foods and nutrients in grams, milligrams, or micrograms. For ease in using these measures, it helps to remember that the prefixes imply 1000. For example, a *kilogram* is 1000 grams, a *milligram* is 1/1000 of a gram, and a *microgram* is 1/1000 of a milligram (or 1/1,000,000 of a gram).

Most food labels and many recipes provide dual measures, listing both household measures, such as cups, quarts, and teaspoons, and metric measures, such as

milliliters, liters, and grams. This practice gives people an opportunity to gradually learn to think in metric terms.

A person might begin to “think metric” by simply observing the measure—by noticing the amount of soda in a 2-liter bottle, for example. Through such experiences, a person can become familiar with a metric measure without having to do any conversions.

The international unit for measuring food energy is the joule—the amount of energy expended when 1 kilogram is moved 1 meter by a force of 1 newton. The joule is thus a measure of *work* energy, whereas the calorie is a measure of *heat* energy. While many

scientists and journals report their findings in kilojoules (kJ), many others, particularly those in the United States, use calories (kcal). To convert energy measures from calories to kilojoules, multiply by 4.2; to convert kilojoules to calories, multiply by 0.24. For example, a 50-kcalorie cookie provides 210 kilojoules:

$$50 \text{ kcal} \times 4.2 = 210 \text{ kJ}$$

Appendix H provides math assistance and conversion factors for these and other units of measure.

Volume: Liters (L)

1 L = 1000 milliliters (mL)
0.95 L = 1 quart
1 mL = 0.03 fluid ounces
240 mL = 1 cup



Angel Tucker

A liter of liquid (on the left) is a little more than one US quart (on the right). Four liters are only about 5 percent more than a gallon.

Weight: Grams (g)

1 g = 1000 milligrams (mg)
1 g = 0.04 ounce (oz)
1 oz = 28.35 g (or 30 g)
100 g = 3½ oz
1 kilogram (kg) = 1000 g
1 kg = 2.2 pounds (lb)
454 g = 1 lb

Length: Centimeters (cm)

1 cm = 0.39 inches (in.)
1 in. = 2.54 cm



Thomas Harm & Tom Peterson/Quest Photographic, Inc./Gengage

A half-cup of vegetables weighs about 100 grams; one pea weighs about ½ gram.

A kilogram is slightly more than 2 lb; conversely, a pound is about ½ kg.



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One cup of liquid is about 240 milliliters; a half-cup of liquid is about 120 milliliters.



Albo003/Shutterstock.com

A 5-pound bag of potatoes weighs about 2 kilograms.

> **TRY IT** Convert your body weight from pounds to kilograms and your height from inches to centimeters.

One other substance contributes energy—alcohol. Alcohol, however, is not considered a nutrient. Unlike the nutrients, alcohol does not sustain life. In fact, it interferes with the growth, maintenance, and repair of the body. Its only common characteristic with nutrients is that it yields energy (7 kcalories per gram) when metabolized in the body.