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# Nutrition Through the Life Cycle



Judith Brown





# Nutrition Through *the* Life Cycle

SEVENTH EDITION



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# Preface

It is our privilege to offer you the 7th edition of *Nutrition Through the Life Cycle*. This text was initially developed, and has been revised, to address the needs of instructors teaching, and students taking, a two- to four-credit course in life-cycle nutrition. It is written at a level that assumes students have had an introductory nutrition course. Overall, the text is intended to give instructors a tool they can productively use to enhance their teaching efforts, and to give students an engaging and rewarding educational experience they will carry with them throughout their lives and careers.

The authors of *Nutrition Through the Life Cycle* represent a group of experts with experience in clinical practice, teaching, and research related to nutrition during specific phases of the life cycle. All of us remain totally dedicated to the goals established for the text at its conception: to make the text comprehensive, logically organized, evidence-based, realistic, and relevant to the needs of instructors and students.

Chapter 1 summarizes key elements of introductory nutrition and gives students a chance to update or renew their knowledge. Students can “test” their knowledge of many aspects of introductory nutrition by answering the review questions listed at the end of the chapter. Coverage of the life-cycle phases begins with preconception nutrition and continues with each major phase of the life cycle through adulthood and the special needs of the elderly. Each of these 19 chapters was developed based on a common organizational framework that includes learning objectives, prevalence statistics, physiological principles, nutritional needs and recommendations, model programs, case studies, and recommended practices. Chapters end with a list of key points and review questions.

To meet the knowledge needs of students with the variety of career goals represented in many life-cycle nutrition courses, we include two chapters for each life-cycle phase. The first chapter for each phase covers normal nutrition topics, and the second covers nutrition-related conditions and interventions. Every chapter focuses on scientifically based information and employs up-to-date resources and references. Answers to the case studies and review questions, and Internet resources that lead to reliable information on topics presented in the chapters, are now located on the web and can be accessed through [www.cengagebrain.com](http://www.cengagebrain.com).

## New to the Seventh Edition

Advances in knowledge about nutrition and health through the life cycle are expanding at a remarkably high rate. New research is taking our understanding of the roles played by healthy dietary patterns, nutrients, gene variants and nutrient–gene interactions, body fat, physical activity, and dietary supplements to new levels. You will see in this edition these emerging areas of direct relevance to nutrition addressed as well as the new tools available through the updated MyPlate.gov resources.

## Chapter-by-Chapter Changes

Advances in knowledge about nutrition and health across the life cycle occur frequently and these advances have led to multiple changes in the seventh edition of *Nutrition Through the Life Cycle*. Review questions and case studies have been revised to match the updated content.

A summary of the major changes to the chapters are listed below.

### Chapter 1: Nutrition Basics

- Strengthened content on the benefits of healthy dietary patterns throughout the life-cycle
- Updated information of MyPlate resources, nutrition label requirements, and nutrition assessment methods
- Updated coverage of potential effectiveness of vitamin, minerals, and other dietary supplements on health

### Chapter 2: Preconception Nutrition

- Expanded depth of coverage on male and female reproductive physiology
- Added content on the new diagnostic category of functional hypothalamic amenorrhea
- Updated information on coffee/caffeine and alcohol intake and reproductive outcomes
- Updated components of preconceptional risk assessment and nutrition care
- Expanded content on the importance and benefits of preconceptional care
- Added a model program on preconceptional vitamin and mineral supplementation
- Removed content on soy isoflavones and fertility



### Chapter 3: Preconception Nutrition: Conditions and Interventions

- Added a focus on pre- and periconceptional nutritional factors in females and males that influence fecundity, gene variant development in the embryo, and long-term health of offspring
- Expanded/added coverage of functional hypothalamic amenorrhea, chronic energy deficits, PCOS, and wheat intolerance syndrome.

### Chapter 4: Nutrition During Pregnancy

- Updated content on artificial sweeteners and the course and outcome of pregnancy
- Expanded coverage of the microbiome, diet, and health during pregnancy
- Updated information of MyPlate resources
- Added coverage of a model program for postpartum weight loss
- Added the EPA's new recommendation for "Best Sources" of fish and seafood for pregnant women, and also new recommendations for omega-3 fatty acid and fish oil intake.
- Incorporated new recommendations on vitamin and mineral supplementation during pregnancy, coffee/caffeine intake, benefits of healthy dietary patterns, and physical activity
- Replaced an existing model program with a new one called "Fit Moms/Mamas Activas"

### Chapter 5: Nutrition During Pregnancy

- Incorporated new knowledge about effects of obesity during pregnancy
- Updated content on the effects of alcohol on reproductive outcomes, including the fetal spectrum disorder
- Revised content on effects of coffee/caffeine on the course and outcome of pregnancy promotion
- Added content of the expanding topics of gene variants and the microbiome during pregnancy
- Removed content on HIV, nutrition, and pregnancy
- Incorporated new standards for the diagnosis and management of diabetes in pregnancy
- Added content on the importance of healthy dietary patterns and physical activity for postpartum weight loss
- Updated recommendations for the use of vitamin and mineral supplements for various disorders of pregnancy

### Chapter 6: Nutrition During Lactation

- Added table of human milk contrasted with cow's milk-based human milk substitutes
- Updated breastfeeding prevalence in the United States
- Modified illustrations and tables
- Many minor updates to include current literature

### Chapter 7: Nutrition During Lactation: Conditions and Interventions

- Changed one learning objective to include impact of marijuana
- Updated information in sore nipples section
- Added information to define International Board-Certified Lactation Consultant (IBCLC), breastfeeding educators, and peer counselors and explained training and roles
- Updated low milk section
- Added information on Food and Drug Administration (FDA) new labeling for prescription medications used during pregnancy and lactation
- Updated information in marijuana section
- Added new section on Opioids
- Updated information in late-preterm section
- Updated data in the milk banking section
- Modified illustrations
- Updated references to support content

### Chapter 8: Infant Nutrition

- Updated baseline and target measures from U.S. 2020 Healthy People Objectives related to infants
- Expanded content of table comparing the Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) growth charts
- Expanded section on Food Allergies and added new content on Peanut Allergy
- Added new section on Primary Prevention of Obesity during Infancy
- Modified illustrations and tables

### Chapter 9: Infant Nutrition: Conditions and Interventions

- Expanded list of key definitions
- Modified case studies
- Modified illustrations and tables

### Chapter 10: Toddler and Preschooler Nutrition

- Updated poverty rates for children
- Included breastfeeding recommendations from the American Academy of Pediatrics and the World Health Organization
- Updated information on iron deficiency and screening in young children
- Discussed food insecurity and the effects on young children
- Updated data on overweight and obesity rates in toddlers and preschoolers and included ethnic breakdowns of such
- Added information on *Bright Futures: Nutrition 3rd Edition*
- Updated WIC and SNAP enrollment characteristics



### Chapter 11: Toddler and Preschooler Nutrition: Conditions and Interventions

- Updated data on children with special health care needs
- Updated information on Early Intervention services
- Included expanded definition of medical home
- Expanded information on cerebral palsy
- Updated information on celiac disease

### Chapter 12: Child and Preadolescent Nutrition

- Included latest recommendations for calculating and using *z* scores for assessing nutritional status
- Updated information on snacking behavior of American children
- Expanded content on the relationship between maternal eating disorders and dietary habits of their children
- Updated data on prevalence of overweight and obesity and distribution by sex and ethnicity
- Included definitions of Class I, II, and III obesity in children
- Expanded discussion of the relationship between childhood obesity and adult disease risk
- Updated media use recommendations from the American Academy of Pediatrics
- Included most recent Academy of Nutrition and Dietetics Position Statements on nutrition in schools and federally funded nutrition assistance programs
- Included new section on Farm to School programs
- Updated tables and illustrations

### Chapter 13: Child and Preadolescent Nutrition: Conditions and Interventions

- Updated data on prevalence of diabetes
- Added section on Food Allergies and their management at school
- Added comprehensive table comparing nutrition considerations for children with chronic diseases and disorders
- Updated tables and illustrations

### Chapter 14: Adolescent Nutrition

- Updated information related to frequency of consuming meals and snacks
- Updated information regarding current intake of food groups
- Updated information on school meals program regulations and best practices
- Modified illustrations and tables

### Chapter 15: Adolescent Nutrition: Conditions and Interventions

- Updated information on prevalence and treatment of overweight and obesity among teens

- Updated information about supplement use among teens
- Updated content related to screening and intervention for chronic health conditions
- Modified illustrations and tables

### Chapter 16: Adult Nutrition

- Expanded the Energy Recommendation section and case study to include new methods of measurement such as wrist bands and smartphones
- Expanded body composition role in EEE and added an energy calculator that incorporates the energy cost of physical activity
- Incorporated the revised Daily Values used in new food labels as reference standards for folate, vitamin D, and calcium, and changed units for vitamin A to RAE and folate to DFE on table of adult nutrient intakes
- Updated statistics with most current data from national surveys, including prevalence rates of chronic disease indicators and poverty and food security statistics
- Revised magnesium section of risk nutrients
- Expanded the list of diseases associated with alcohol consumption
- Revised dietary supplements and functional foods section to highlight naturally occurring phenolic compounds
- Incorporated updated clinical practice guidelines and position statements for physical activity and changed content to reflect that any increase in physical activity has physiological benefits
- Added the “food first” approach for support of health and athletic performance

### Chapter 17: Adult Nutrition: Conditions and Interventions

- Updated leading causes of death by age group, prevalence statistics for all conditions, and progress toward Healthy People 2020 objectives
- Added definitions of anorexia, cachexia, energy gap, and lipodystrophy
- Included technology-based intervention and monitoring tools including smart phone apps and wearable devices for managing weight and self-monitoring in diabetes
- Noted male-female differences in risk, impact of menopause, and response to intervention where relevant
- Added the role of gut-brain axis signaling in appetite regulation and obesity, and the use of new genome research to understand the genetic and epigenetic bases for obesity
- Revised the table of risk factors and criteria for CVD and CHD. Added and discussed non-high-density lipoprotein cholesterol and low-density lipoprotein particle number and coronary artery calcium (CAC) score as emerging risk factors, and noted that focus has been redirected to normal fat intake (30–35% of calories) with emphasis on the type of fat



- Added a new table with criteria for diagnosis of metabolic syndrome to reflect the international harmonized definition
- Updated information on pharmacological management of diabetes, and added illustration of the Plate Method for diabetic meal planning
- Revised the table of nutrition-related factors associated with cancer risk to incorporate latest from the Third Report of the World Cancer Research Fund/American Institute for Cancer Research released in 2018
- Added lab markers of malnutrition, inflammation, and hypermetabolic stress to assessment in cancer, and included more detail on nutritional impact of anticancer medications and implications for medical nutrition therapy
- Emphasized the increased occurrence of and need to treat obesity and other chronic conditions addressed in this chapter among those living with HIV and the role of multidisciplinary care and nutrition education and counseling in long-term management
- Expanded caloric recommendations on table of energy and macronutrient recommendations for HIV management

### Chapter 18: Nutrition and Older Adults

- Updated the statistics throughout the chapter
- Updated section on life expectancy
- Updated section on oral health
- Revised the section on Dietary Guidelines and MyPlate for older adults
- Revised the section on Fats and Cholesterol
- Changed the title of the section on potassium to include sodium
- Revised the section on Cross-Cultural Considerations in Making Dietary Recommendations
- Updated Tables 18.1, 18.6, 18.7, 18.9, 18.10, 18.15, and 18.16, and Illustrations 18.1 to 18.5
- Updated references

### Chapter 19: Nutrition and Older Adults: Conditions and Interventions

- Updated the statistics throughout the chapter
- Updated section on Hypertension
- Updated section on Diabetes
- Updated section on Osteoporosis
- Replaced Illustration 19.1
- Updated the tables
- Deleted the original Table 19.11 and renumbered all the tables
- Updated the references

### Student and Instructor Resources

**MindTap:** A new approach to highly personalized online learning. Beyond an eBook, homework solution, digital supplement, or premium website, MindTap is a digital learning platform that works alongside your campus LMS to deliver course curriculum across the range of

electronic devices in your life. MindTap is built on an “app” model allowing enhanced digital collaboration and delivery of engaging content across a spectrum of Cengage and non-Cengage resources.

**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](http://www.cengage.com/login). Access and download PowerPoint presentations, images, instructors’ manual, videos, and more.

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

- Author, 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 over 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.

**Global Nutrition Watch:** Bring currency to the classroom with Global Nutrition Watch from Cengage Learning. This user-friendly website provides convenient access to thousands of trusted sources, including academic journals, newspapers, videos, and podcasts, for you to use for research projects or classroom discussion. Global Nutrition Watch is updated daily to offer the most current news about topics related to nutrition.

### Acknowledgments

It takes the combined talents and efforts of authors, editors, assistants, and the publisher to develop a new edition of a textbook and its instructional resources. We have had the pleasure of working with an ambitious and thorough group of professionals at Cengage, including Courtney Heilman, product manager; Miriam Myers, learning designer, and Teresa L. Trego, content manager. Their careful and complete work on the development and implementation of this new edition is appreciated greatly. Lori Hazzard, project manager from MPS Limited, once again served as the textbook producer. She kept us on time and on target in an effective and thoughtful way.

### Reviewers

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much as the authors relish the  
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to you.

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# Nutrition Basics

*Prepared by Judith E. Brown*

# 1

## LEARNING OBJECTIVES

After studying the materials in this chapter, you should be able to:

- 1.1** Demonstrate a working knowledge of the meaning of the 10 nutrition concepts presented.
- 1.2** Apply knowledge about the elements of nutrition labeling to decisions about the nutritional value of foods.
- 1.3** Cite two examples of how nutrient needs change during the life cycle and how nutritional status at one stage during the life cycle can influence health status during another.
- 1.4** Describe the components of individual-level nutrition assessment.
- 1.5** Identify the basic elements of four public food and nutrition programs.
- 1.6** Apply the characteristics of healthy dietary patterns to the design of one.



## Introduction

Need to freshen up your knowledge of nutrition? Or, do you need to get up to speed on basic nutrition for the course? This chapter presents information about nutrition that paves the way to understanding specific needs and benefits related to nutrition by life-cycle stage.

Nutrition is an interdisciplinary science focused on the study of how foods, **nutrients**, and other food constituents affect health. The body of knowledge about nutrition is large and is growing rapidly, changing views on what constitutes the best nutrition advice. You are encouraged to stay up-to-date on the best nutrition advice for diet and health-related issues.

This chapter centers on (1) the principles of the science of nutrition, (2) nutrients and other constituents of food, (3) healthy dietary patterns, (4) public food and nutrition programs, (5) nutritional assessment, and (6) nationwide priorities for improvements in the *public's nutritional health*.

### 1.1 Principles of the Science of Nutrition

Every field of science is governed by a set of principles that provides the foundation for growth in knowledge. These principles change little with time. Knowledge of the principles of nutrition, listed in Table 1.1, will serve as a springboard to greater understanding of the nutrition and health relationships explored in the chapters to come.

#### Principle #1

Food is a basic need of humans.

Humans need enough food to live and the right assortment of foods for optimal health (Illustration 1.1). People who have enough food to meet their needs at all times experience **food security**. They are able to acquire food in socially acceptable ways—without having to scavenge or steal food. **Food insecurity** exists when the availability of safe, nutritious foods, or the ability to acquire them in socially acceptable ways, is limited or uncertain.<sup>1</sup>

**nutrients** Chemical substances in foods that are used by the body for growth and health.

**food security** Access at all times to a sufficient supply of safe, nutritious foods.

**food insecurity** Limited or uncertain availability of safe, nutritious foods, or the ability to acquire them in socially acceptable ways.

**calorie** A unit of measure of the amount of energy supplied by food. Also known as the “kilocalorie” (kcal), or the “large Calorie.”

Table 1.1 ▼ Principles of human nutrition

<b>PRINCIPLE #1</b>	Food is a basic need of humans.
<b>PRINCIPLE #2</b>	Foods provide energy (calories), nutrients, and other substances needed for growth and health.
<b>PRINCIPLE #3</b>	Health problems related to nutrition originate within cells.
<b>PRINCIPLE #4</b>	Poor nutrition can result from both inadequate and excessive levels of nutrient intake.
<b>PRINCIPLE #5</b>	Humans have adaptive mechanisms for managing fluctuations in food intake.
<b>PRINCIPLE #6</b>	Malnutrition can result from poor diets and from disease states, genetic factors, or combinations of these causes.
<b>PRINCIPLE #7</b>	Some groups of people are at higher risk of becoming inadequately nourished than others.
<b>PRINCIPLE #8</b>	Poor nutrition can influence the development of certain chronic diseases.
<b>PRINCIPLE #9</b>	Adequacy, variety, and balance are key characteristics of healthy dietary patterns.
<b>PRINCIPLE #10</b>	There are no “good” or “bad” foods.

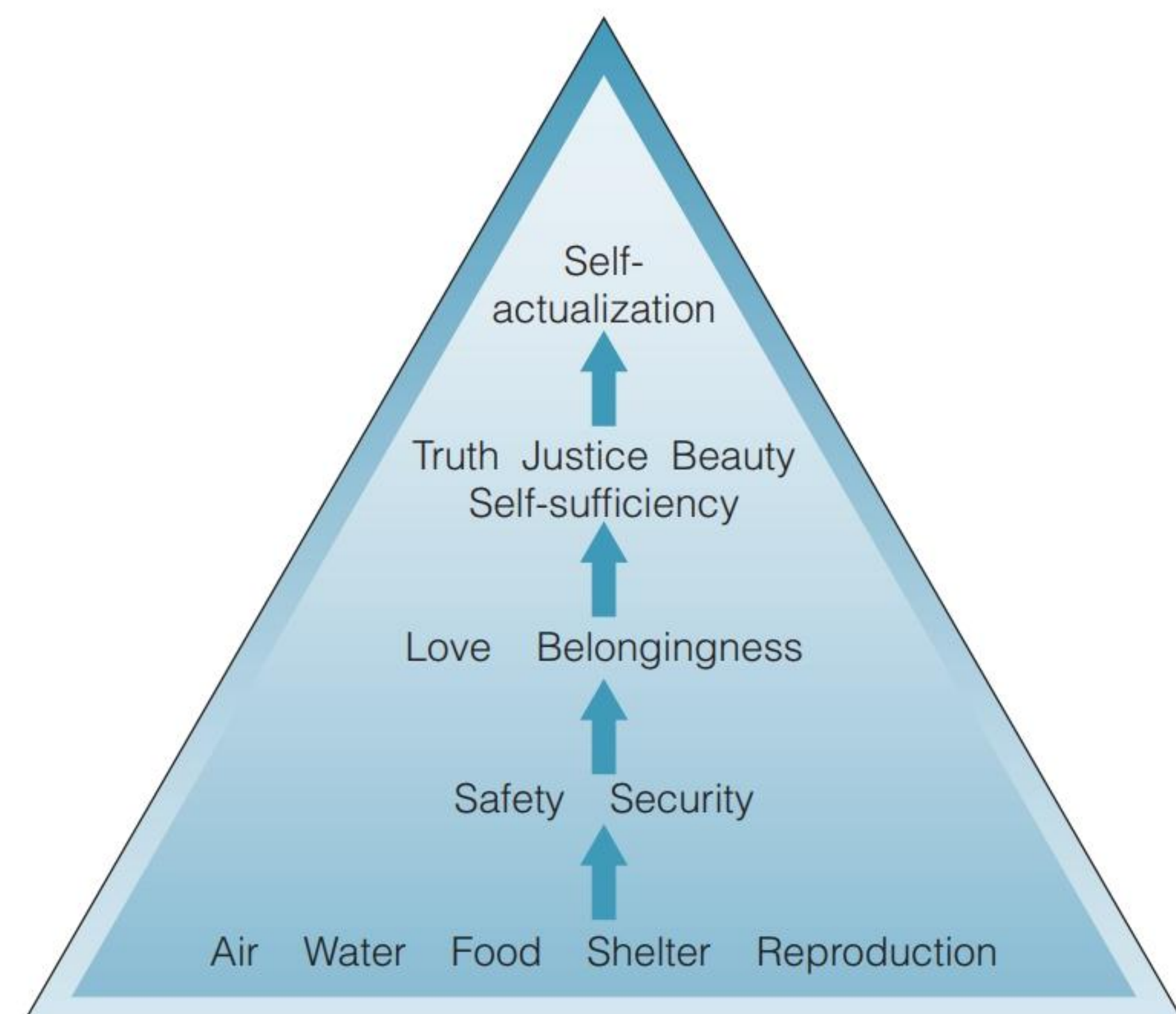
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It exists in 12.3 percent of United States and 7.7 percent of Canadian households.<sup>2,3</sup>

#### Principle #2

Foods provide energy (calories), nutrients, and other substances needed for growth and health.

People eat foods for many different reasons. The most compelling reason is the requirement for **calories** (energy), nutrients, and other substances supplied by foods for growth and health.



Barry Austin/Photodisc/Getty Images

Illustration 1.1 | The need for food is part of Maslow's hierarchy of needs.



A calorie is a measure of the amount of energy transferred from food to the body. Because calories are a unit of measure and not a substance actually present in food, they are not considered to be nutrients.

Nutrients are chemical substances in food that the body uses for a variety of functions that support growth, tissue maintenance and repair, and ongoing health. Essentially, every part of our body was once a nutrient consumed in food. There are six categories of nutrients (Table 1.2). Each category except water consists of a number of different substances.

## Essential and Nonessential Nutrients

Of the many nutrients required for growth and health, some must be provided by the diet while others can be made by the body.

**Essential Nutrients** Nutrients the body cannot manufacture, or generally produce in sufficient amounts, are referred to as **essential nutrients**. Here *essential* means “required in the diet.” All of the following nutrients are considered essential:

- Carbohydrates
- Certain amino acids (the **essential amino acids**: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine)
- Linoleic acid and alpha-linolenic acid (essential fatty acids)
- Vitamins
- Minerals
- Water

**Table 1.2** ▼ The six categories of nutrients

1.	<b>Carbohydrates</b> Chemical substances in foods that consist of a single sugar molecule or multiples of sugar molecules in various forms. Sugar and fruit, starchy vegetables, and whole grain products are good dietary sources.
2.	<b>Proteins</b> Chemical substances in foods that are made up of chains of amino acids. Animal products and dried beans are examples of protein sources.
3.	<b>Fats (Lipids)</b> Components of food that are soluble in fat but not in water. They are more properly referred to as “lipids.” Most fats are composed of glycerol attached to three fatty acids. Oil, butter, sausage, and avocado are examples of rich sources of dietary fats.
4.	<b>Vitamins</b> Fourteen specific chemical substances that perform specific functions in the body. Vitamins are present in many foods and are essential components of the diet. Vegetables, fruits, and grains are good sources of vitamins.
5.	<b>Minerals</b> In the context of nutrition, minerals consist of 15 elements found in foods that perform particular functions in the body. Milk, dark, leafy vegetables, and meat are good sources of minerals.
6.	<b>Water</b> An essential component of the diet provided by food and fluid.

**Nonessential Nutrients** Cholesterol, creatine, and glucose are examples of nonessential nutrients. **Nonessential nutrients** are present in food and used by the body, but they do not have to be part of our diets. Many of the beneficial chemical substances in plants are not considered essential, for example, yet they play important roles in maintaining health.

**Requirements for Essential Nutrients** All humans require the same set of essential nutrients, but the amount of nutrients needed varies based on:

- Age
- Body size
- Gender
- Genetic traits
- Growth
- Illness
- Physical activity
- Medication use
- Pregnancy and lactation

Amounts of essential nutrients required each day vary a great deal, from cups (for water) to micrograms (e.g., for folate and vitamin B<sub>12</sub>).

## Dietary Intake Standards

Dietary intake standards developed for the public cannot take into account all of the factors that influence nutrient needs, but they do account for the major ones of age, gender, growth, and pregnancy and lactation. Intake standards are called Dietary Reference Intakes (DRIs).

- *Dietary Reference Intakes (DRIs)*. This is the general term used for the nutrient intake standards for healthy people.
- *Recommended Dietary Allowances (RDAs)*. These are levels of essential nutrient intake judged to be adequate to meet the known nutrient needs of practically all (98 percent) of healthy people while decreasing the risk of certain chronic diseases.
- *Adequate Intakes (AIs)*. These are “tentative” RDAs. AIs are based on less conclusive scientific information than are the RDAs.

**essential nutrients** Substances required for growth and health that cannot be produced, or produced in sufficient amounts, by the body. They must be obtained from the diet.

**essential amino acids** Amino acids that cannot be synthesized in adequate amounts by humans and therefore must be obtained from the diet. Also called *indispensable amino acids*.

**nonessential nutrients** Nutrients required for growth and health that can be produced by the body from other components of the diet.



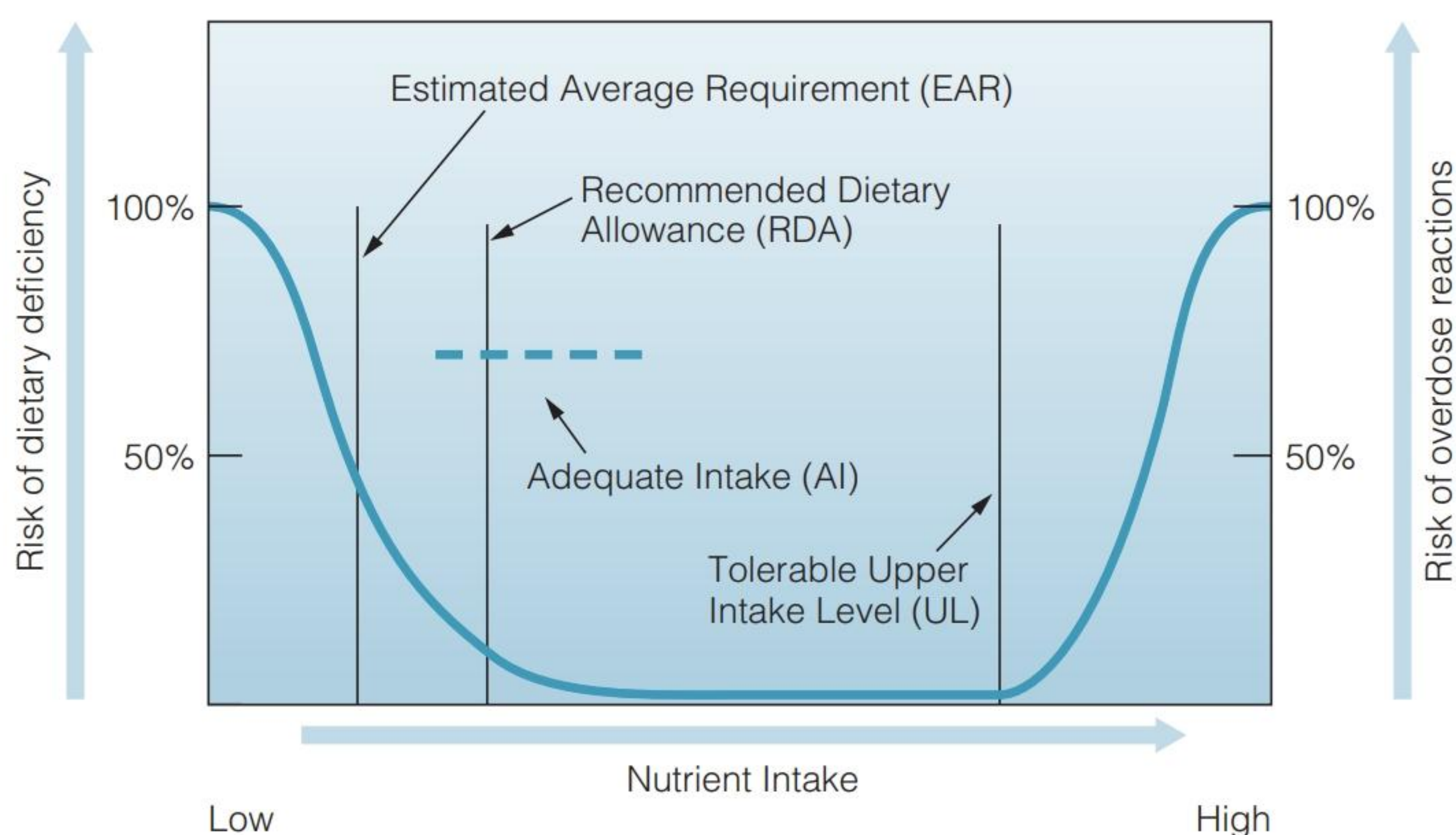
- **Estimated Average Requirements (EARs).** These are nutrient intake values that are estimated to meet the requirements of half the healthy individuals in a group. The EARs are used to assess adequacy of intakes of population groups.
- **Tolerable Upper Intake Levels (ULs).** These are upper limits of nutrient intake compatible with health. The ULs do not reflect desired levels of intake. Rather, they represent total, daily levels of nutrient intake from food, fortified foods, and supplements that should not be exceeded.

DRI's have been developed for most of the essential nutrients and will be updated periodically. (These are listed on the inside front covers of this text.) Current DRI's were developed through a joint U.S.–Canadian effort, and the standards apply to both countries. The DRI's are levels of nutrient intake intended for use as reference values for planning and assessing diets for healthy people. They consist of the RDAs and the other categories of intake standards described in Illustration 1.2. It is recommended that individuals aim for nutrient intakes that approximate the RDAs or AI levels. Additional tests are required to confirm inadequate nutrient intakes and status.<sup>4</sup>

### Standards of Nutrient Intake for Nutrition Labels

The Nutrition Facts panel on packaged foods uses standard levels of nutrient intakes based on an earlier edition of recommended dietary intake levels. The levels are known as **Daily Values (DVs)** and are used to identify the amount

**daily values (DVs)** Scientifically agreed-upon standards for daily intakes of nutrients from the diet developed for use on nutrition labels.



**Illustration 1.2** | Theoretical framework, terms, and abbreviations used in the Dietary Reference Intakes.

**Table 1.3** ▼ Daily Values (DVs) for nutrition labeling based on intakes of 2000 calories per day in adults and children aged 4 years and above

Mandatory Components of the Nutrition Label	
Food Component	Daily Value (DV)
Total fat	65 g <sup>a</sup>
Saturated fat	20 g
Cholesterol	300 mg <sup>a</sup>
Sodium	2400 mg
Total carbohydrate	300 g
Dietary fiber	25 g
Vitamin A	5000 IU <sup>a</sup>
Vitamin C	60 mg
Calcium	1000 mg
Iron	18 mg

<sup>a</sup>g = grams; mg = milligrams; IU = International Units

of a nutrient provided in a serving of food compared to the standard level.

The “% DV” listed on nutrition labels represents the percentages of the standards obtained from one serving of the food product. Table 1.3 lists DV standard amounts for nutrients that are mandatory or voluntary components of nutrition labels. Additional information on nutrition labeling is presented later in this chapter.

### Carbohydrates

Carbohydrates are used by the body mainly as a source of readily available energy. They consist of the simple sugars (monosaccharides and disaccharides), complex carbohydrates (the polysaccharides), most dietary sources of fiber, and alcohol sugars. Alcohol (ethanol) is closely related chemically to carbohydrates and is usually considered to be part of this nutrient category. Illustration 1.3 shows

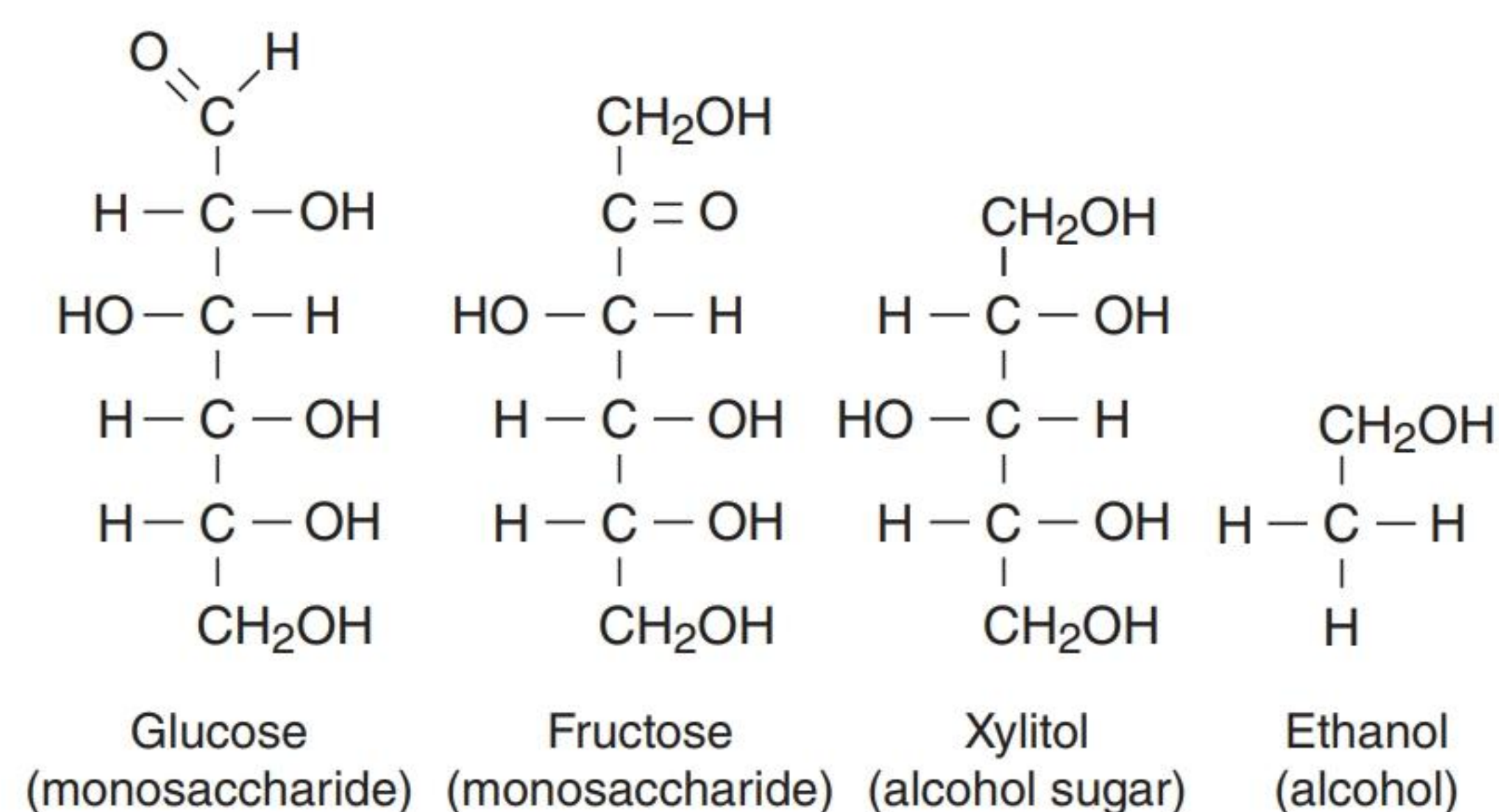
the similarity in the chemical structure of basic carbohydrate units. The most basic forms of carbohydrates are single molecules called monosaccharides.

Glucose (also called “blood sugar” and “dextrose”), fructose (“fruit sugar”), and galactose are the most common monosaccharides. Molecules containing two monosaccharides are called disaccharides. The most common disaccharides are:

- Sucrose (glucose + fructose, or common table sugar)
- Maltose (glucose + glucose, or malt sugar)
- Lactose (glucose + galactose, or milk sugar)

Complex carbohydrates (also called polysaccharides) are considered “complex”





**Illustration 1.3** | Chemical structures of some simple carbohydrates.

because they have more elaborate chemical structures than the simple sugars. They include:

- Starches (the plant form of stored carbohydrate)
- Glycogen (the animal form of stored carbohydrate)
- Most types of fiber

Each type of simple and complex carbohydrate, except fiber, provides four calories per gram. Dietary fiber supplies two calories per gram on average, even though fiber cannot be broken down by human digestive enzymes. Bacteria in the large intestine can digest some types of dietary fiber, however. These bacteria excrete fatty acids as a waste product of fiber digestion. The fatty acids are absorbed and used as a source of energy. The total contribution of fiber to our energy intake is modest (around 50 calories), and supplying energy is not a major function of fiber.<sup>5</sup> The main function of fiber is to provide “bulk” for normal elimination. It has other beneficial properties, however. High-fiber diets reduce the rate of glucose absorption (a benefit for people with diabetes) and may help prevent cardiovascular disease and obesity.<sup>10</sup>

Alcohol sugars (nonalcoholic in the beverage sense) are like simple sugars, except they include a chemical component of alcohol. Xylitol, mannitol, and sorbitol are common forms of alcohol sugars. Some are very sweet, and only small amounts are needed to sweeten commercial beverages, gums, yogurt, and other products. Unlike the simple sugars, alcohol sugars do not promote tooth decay.

Alcohol (consumed as ethanol) is considered to be part of the carbohydrate family because its chemical structure is similar to that of glucose. It is a product of the fermentation of sugar with yeast. With seven calories per gram, alcohol has more calories per gram than do other carbohydrates.

**Glycemic Index of Carbohydrates and Carbohydrates in Foods** In the not-too-distant past, it was assumed that “a carbohydrate is a carbohydrate is a carbohydrate.” If all types of carbohydrates had the same effect on blood glucose levels and health, then it didn’t matter what type was consumed. As is the case with many untested assumptions, this one fell by the wayside. It is now known that

some types of simple and complex carbohydrates in foods elevate blood glucose levels more than do others. Such differences are particularly important to people with disorders such as **insulin resistance** and **type 2 diabetes**.<sup>6</sup>

Carbohydrates and carbohydrate-containing foods are now being classified by the extent to which they increase blood glucose levels. This classification system is called the **glycemic index**. Carbohydrates that are digested and absorbed quickly have a high glycemic index and raise blood glucose levels to a higher extent than do those with lower glycemic index values (Table 1.4).

**Recommended Intake Level** Recommended intake of carbohydrates is based on their contribution to total energy intake. It is recommended that 45–65 percent of calories come from carbohydrates. Added sugar should constitute no more than 25 percent of total caloric intake. It is recommended that adult females consume between 21 and 25 g, and males 30–38 g of total dietary fiber daily.<sup>7</sup>

**Food Sources of Carbohydrates** Carbohydrates are widely distributed in plant foods, while milk is the only important animal source of carbohydrates (lactose). Table 1.5 lists selected food sources by type of carbohydrate.

## Protein

Protein in foods provides the body with **amino acids** used to build and maintain protein-based components of the body such as muscle, bone, enzymes, and red blood cells. The body can also use protein as a source of energy—it provides four calories per gram. However, this is not a primary function of protein. Of the common types of amino acids, nine must be provided by the diet and are classified as essential amino acids. Amino acids that the body needs but can manufacture from other amino acids and components of the diet are classified as **nonessential amino acids**.

**insulin resistance** A condition in which cell membranes have a reduced sensitivity to insulin so that more insulin than normal is required to transport a given amount of glucose into cells.

**type 2 diabetes** A disease characterized by high blood glucose levels due to the body’s inability to use insulin normally, to produce enough insulin, or both.

**glycemic index** A measure of the extent to which blood glucose levels are raised by consumption of an amount of food that contains 50 grams of carbohydrate compared to 50 grams of glucose. A portion of white bread containing 50 grams of carbohydrate is sometimes used for comparison.

**amino acids** The “building blocks” of protein. Unlike carbohydrates and fats, amino acids contain nitrogen.

**nonessential amino acids** Amino acids that can be readily produced by humans from components of the diet. Also referred to as *dispensable amino acids*.



**Table 1.4** ▼ Glycemic Index (GI) of selected foods<sup>71,72</sup>

High GI (70 and higher)	Medium GI (56–69)	Low GI (55 or lower)			
Glucose	100	Breadfruit	69	Honey	55
French bread	95	Fruit Loops	69	Oatmeal	54
Scone	92	Orange soda	68	Corn	53
Sticky rice	87	Pita bread	68	Cracked wheat bread	53
Broken rice	86	Sucrose	68	Orange juice	52
Potato, baked	85	Taco shells	68	Banana	52
Potato, instant mashed	85	Croissant	67	Mango	51
Special K, rice	84	Angel food cake	67	Potato, boiled	50
Corn Chex	83	Fruit punch	67	Corn tortilla	49
Pretzel	83	Cherries	66	Green peas	48
Rice Krispies	82	Cream of Wheat	66	Pasta	48
Cornflakes	81	Brown rice	66	Carrots, raw	47
Corn Pops	80	Couscous	65	Lactose	46
Gatorade	78	Quaker Quick Oats	65	Milk chocolate	43
Jelly beans	78	Raisins	64	All-Bran	42
Cocoa pops	77	Chapati	62	Orange	42
Doughnut, cake	76	French bread with butter and jam	62	Peach	42
Waffle, frozen	76	Raisin Bran	61	Apple juice	40
Doughnuts	75	Sweet potato	60	Apple	38
French fries	75	Bran muffin	60	Pear	38
Grape Nuts	75	Just Right cereal	59	Tomato juice	38
Shredded Wheat	75	Blueberry muffin	59	Yam	37
White rice	75	Mini Wheats	58	Yogurt	31
Cheerios	74	Coca-Cola	56	Flour tortilla	30
Popcorn	72	Power Bar	56	Dried beans	25
Watermelon	72	Special K		Grapefruit	25
Carrots, diced, cooked	70			Milk	25
Wheat bread	70			Fructose	19
White bread	70			Pinto beans	14
				Hummus	6

Food sources of protein (Table 1.6) differ in quality based on the types and amounts of amino acids they contain. Foods of high protein quality include a balanced assortment of all of the essential amino acids. Protein from milk, cheese, meat, eggs, and other animal products is considered high quality. Plant sources of protein, with the exception of soybeans for adults, do not provide all nine essential amino acids in amounts needed

**Kwashiorkor** A severe form of protein-energy malnutrition in young children. It is characterized by swelling, fatty liver, susceptibility to infection, profound apathy, and poor appetite. The cause of kwashiorkor is unclear.

to support growth in children and tissue maintenance. Combinations of plant foods, such as grains or seeds with dried beans, however, yield high-quality protein. The variety of amino acids found in these foods complement each other, thus providing a source of high-quality protein.

**Recommended Protein Intake** DRIs for protein are shown on the inside front cover of this text. In general, proteins should contribute 10–35 percent of total energy intake.<sup>7</sup> Protein deficiency, although rare in economically developed countries, leads to loss of muscle tissue, growth failure, weakness, reduced resistance to disease, and kidney and heart problems. It contributes to the development of a severe form of protein-energy malnutrition in young children known as **kwashiorkor**.



**Table 1.5** ▼ Food sources of carbohydrates

A. SIMPLE SUGARS (MONO- AND DISACCHARIDES)					
The Simple Sugar Content of Some Common Foods					
	Portion Size	Grams of Carbohydrates		Portion Size	Grams of Carbohydrates <sup>a</sup>
<b>Sweeteners</b>			<b>Beverages</b>		
Corn syrup	1 tsp	5	Fruit drinks	1 cup	29
Honey	1 tsp	6	Soft drinks	12 oz	38
Maple syrup	1 tsp	4	Skim milk	1 cup	12
Table sugar	1 tsp	4	Whole milk	1 cup	11
<b>Fruits</b>			<b>Candy</b>		
Apple	1 medium	16	Gumdrops	1 oz	25
Peach	1 medium	8	Hard candy	1 oz	28
Watermelon	1 wedge (4" × 8")	25	Caramels	1 oz	21
Orange	1 medium	14	Fudge	1 oz	21
Banana	1 medium	21	Milk chocolate	1 oz	16
<b>Vegetables</b>			<b>Breakfast cereals</b>		
Broccoli	½ cup	2	Apple Jacks	1 oz	13
Corn	½ cup	3	Raisin Jacks	1 oz	19
Potato	1 cup	1	Cheerios	1 oz	14
B. COMPLEX CARBOHYDRATES (STARCHES)					
Complex					
	Portion Size	Grams of Carbohydrates		Portion Size	Grams of Carbohydrates
<b>Grain and grain products</b>			<b>Dried beans (cooked)</b>		
Rice (white), cooked	½ cup	21	Lima beans	½ cup	11
Pasta, cooked	½ cup	15	White beans	½ cup	13
Cornflakes	1 cup	11	Kidney beans	½ cup	12
Oatmeal, cooked	½ cup	12	<b>Vegetables</b>		
Cheerios	1 cup	11	Potato	1 medium	30
Whole wheat bread	1 slice	7	Corn	½ cup	10
			Broccoli	½ cup	2
C. DIETARY FIBER					
	Portion Size	Grams of Fiber		Portion Size	Grams of Fiber
<b>Grain and grain products</b>			<b>Fruits</b>		
Bran Buds	½ cup	12.0	Raspberries	1 cup	8.0
All Bran	½ cup	11.0	Avocado	½ medium	7.0
Raisin Bran	1 cup	7.0	Mango	1 medium	4.0
Granola (homemade)	½ cup	6.0	Pear (with skin)	1 medium	4.0
Bran Flakes	¾ cup	5.0	Apple (with skin)	1 medium	3.3
Oatmeal	1 cup	4.0	Banana	6" long	3.1
Spaghetti noodles	1 cup	4.0	Orange (no peel)	1 medium	3.0
Shredded Wheat	1 biscuit	2.7	Peach (with skin)	1 medium	2.3
Whole wheat bread	1 slice	2.0	Strawberries	10 medium	2.1
Bran (dry; wheat, oat)	2 Tbsp	2.0			

(Continued)