Nutrition Through the Lifecycle

Sixth Edition

JUDITH E. **BROWN**

NUTRITION

Through the Life Cycle

Sixth Edition

Judith E. Brown
Ph.D., M.P.H., R.D.
University of Minnesota

with

Ellen Lechtenberg, M.P.H., R.D., I.B.C.L.C.
Primary Children's Hospital

Maureen A. Murtaugh, Ph.D., R.D.
University of Utah School of Medicine

Patricia L. Splett, Ph.D., M.P.H., R.D.
Nutrition Consultant

Jamie Stang, Ph.D., M.P.H., R.D.
University of Minnesota

Robyn Wong, M.P.H., R.D., C.S.P., L.D.
Kaiser Permanente Medical Center - Hawaii

Ellen K. Bowser, M.S., R.D., LDN, FAND, R.N, B.S.N.
University of Florida Pediatric Pulmonary Division

Beth L. Leonberg, M.S., M.A., R.D., C.S.P., F.A.N.D., L.D.N.
Drexel University

Nadine R. Sahyoun, Ph.D., R.D.
University of Maryland

CENGAGE Learning®

Australia • Brazil • Mexico • Singapore • United Kingdom • United States

CENGAGE Learning®

***Nutrition Through the Life Cycle*, 6e**
Judith E. Brown

Product Manager: Krista Mastroianni
Content Developer: Lauren Oliveira
Product Assistant: Victor Luu
Marketing Manager: Tom Ziolkowski
Content Project Manager: Carol Samet
Art Director: Michael Cook
Manufacturing Planner: Karen Hunt
Production Service: Lynn Lustberg, MPS Limited
Photo Researcher: Lumina Datamatics
Text Researcher: Lumina Datamatics
Text Designer: Ellen Pettengell Design
Cover Designer: Michael Cook
Cover Image: Gts/Shutterstock.com
Compositor: MPS Limited

WCN: 02-200-203

Library of Congress Control Number: 2015945351
ISBN: 978-1-305-62800-7

Loose-leaf Edition:
ISBN: 978-1-305-88088-7

Cengage Learning
20 Channel Center Street
Boston, MA 02210
USA

Cengage Learning is a leading provider of customized learning solutions with employees residing in nearly 40 different countries and sales in more than 125 countries around the world. Find your local representative at **www.cengage.com.**

Cengage Learning products are represented in Canada by Nelson Education, Ltd.

To learn more about Cengage Learning Solutions, visit **www.cengage.com.**
Purchase any of our products at your local college store or at our preferred online store **www.cengagebrain.com.**

Printed in the United States of America
Print Number: 01 Print Year: 2016

Br IEf CONTENTs

CONTENTs

Ryan McVay/Getty Images

PrE f ACE

It is our privilege to offer you the 6th 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 who need it 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.

New to the Sixth 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 updated information on dietary patterns and health generated by the 2015 Dietary Guidelines for Americans.

Chapter-by-Chapter Changes

Chapter 1: Nutrition Basics

- Incorporated content from the 2015 Dietary Guidelines for Americans
- Updated information on USDA's ChooseMyPlate interactive diet planning and evaluation tools
- Updated content on effects of cholesterol, added sugar, and sodium on health
- Added content on nutrition labeling requirements
- Deleted content on functional foods
- Updated content on dietary assessment
- Modified illustrations and tables

Chapter 2: Preconception Nutrition

- Expanded content on female and male reproductive physiology
- Updated and revised content on nutrient status and fertility
- Condensed and updated content on periconcptional folate status
- Expanded dietary intake recommendations section to include preconception and early pregnancy dietary intake
- Modified illustrations and tables

Chapter 3: Preconception Nutrition: Conditions and Interventions

- New chapter opening with content on weight status and fertility
- Added content on PKU, including a menu plan for a person with PKU
- Modified content on celiac disease
- Modified illustrations and tables

Chapter 4: Nutrition During Pregnancy

- Revised some of the learning objectives
- Updated natality statistics
- Updated content on "Developmental Origins of Health and Disease"
- Modified illustrations and tables
- Expanded content on reproductive physiology
- Added content on metabolic effects of specific gene variants
- Extensively modified content on calcium and iron and pregnancy, and on dietary supplements
- Revised dietary recommendations to be consistent with the 2015 Dietary Guidelines

Chapter 5: Nutrition During Pregnancy: Conditions and Interventions

- Updated content on obesity, diabetes, and hypertension in pregnancy to incorporate recent recommendations and research results
- Added content on gene variants and their effect on nutrient metabolism and disease and disorder risk during pregnancy
- Modified illustrations and tables

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
- Updated breastfeeding promotion (U.S. Surgeon General)
- Modified illustrations and tables
- Many minor updates to include current literature

Chapter 7: Nutrition During Lactation: Conditions and Interventions

- Updated information on sore nipples
- Updated information on effectiveness of cabbage leaves
- Additional information on use of Reglan, including FDA black box warning
- Updated information on alcohol and breastfeeding
- Updated information on marijuana, caffeine, and drugs of abuse
- New section on e-cigarettes
- New section on milk sharing
- Modified illustrations and tables

Chapter 8: Infant Nutrition

- Incorporated Nutrition Care process language
- Expanded content on infant hunger and satiety cues
- Condensed information on infant formula types and indications for use
- Updated content on sequence of infant development and feeding skills
- Expanded content on early childhood caries
- Modified illustrations and tables

Chapter 9: Infant Nutrition: Conditions and Interventions

- Updated table on potential nutrition problems in infants with special health care needs
- Expanded section on growth in preterm infants
- Expanded content on brain development in early life and vital role of protein and iron
- Updated table comparing term, post-discharge, and premature formulas
- Modified illustrations and tables

Chapter 10: Toddler and Preschooler Nutrition

- Updated poverty rates for children and deleted sentence on health insurance rates for children
- Updated information on dental caries rate in children and included ethnic information
- Updated information on CDC lead exposure in children
- Added AAP recommendation on consumption of pasteurized milk and milk products for pregnant women and children
- Updated data on overweight and obesity rates in toddlers and preschoolers and included ethnic breakdowns of such
- Updated data on the use of supplements by children ages 1–3 and 4–8
- Included FDA information on which fish young children should avoid due to mercury content
- Updated WIC and SNAP enrollment characteristics

- Discussed WIC changes to meet the Dietary Guidelines for Americans
- Revised case study to include more cultural implications
- Modified illustrations and tables

Chapter 11: Toddler and Preschooler Nutrition: Conditions and Interventions

- Updated data on children with special health care needs
- Updated information on autism and use of gluten and/or casein free diets, and the "Combating Autism Act of 2006."
- Revised information on asthma and nutrition
- Expanded information on bronchopulmonary dysplasia
- Expanded information on food allergies including resources for families
- Modified illustrations and tables

Chapter 12: Child and Preadolescent Nutrition

- Incorporated results of meta-analysis on the importance of family mealtime to nutritional status
- Included evidence analysis of the influence of media and screen time on children's food choices
- Updated information on trends in childhood overweight and obesity prevalence
- Included recent recommendations for expanding physical education in schools
- Provided most recent recommendations for hydration for children in organized sports
- Updated and expanded information on recommended changes to the school food environment
- Modified tables and illustrations

Chapter 13: Child and Preadolescent Nutrition: Conditions and Interventions

- Updated information on prevalence of Autism Spectrum Disorders
- Provided most recent data on increasing prevalence of types 1 and 2 diabetes mellitus
- Expanded content on nutrition and growth in children with attention deficit hyperactivity disorder
- Expanded information on resources for families of children with chronic health conditions
- Modified tables and illustrations

Chapter 14: Adolescent Nutrition

- Updated information related to frequency of snacking, meal skipping, and consuming family meals
- Updated information regarding current intake of nutrients compared to DRI/EAL values
- Updated information regarding current intake of food groups
- Updated information on school meals program regulations and requirements
- Included description of a new model program for community-engaged nutrition education for teens
- 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 the use of tobacco, alcohol, and illicit substances among teens
- Expanded content related to screening and intervention for chronic health conditions
- Updated information on eating disorders to be consistent with DSM V criteria
- Modified illustrations and tables

Chapter 16: Adult Nutrition

- Updated statistics in tables with most current data from national surveys
- Revised definition of determinants of health as used by Healthy People 2020
- Added description of accumulation of adipose tissue
- Added section on the gut microbiome
- Updated section on risk nutrients and added choline and iron
- Revised recommendations for beverage selections
- Included new illustration to represent the complexity of factors influencing nutrition and health
- Added table of Nutrient and Fluid Considerations for Intensive Physical Activity

Chapter 17: Adult Nutrition: Conditions and Interventions

- Reorganized sections for greater continuity throughout chapter
- Updated statistics on disease prevalence and Healthy People 2020 objectives

- Expanded information about the metabolic and hedonistic origins of obesity and included new race-specific waist circumferences criteria for obesity
- Included links to risk calculators for cardiovascular disease and diabetes
- Incorporated new guidelines for cardiovascular diseasing screening and prevention
- Incorporated the latest standard for diabetes management, including criteria for diagnosis of prediabetes and diabetes, and the more flexible approach to dietary management
- Added self-management education and support, replaced exchange lists with carbohydrate counting as the preferred approach for dietary self-management, and updated antihyperglycemic drug information
- Incorporated updated research on cancer and nutrition
- Revised the HIV section to address the impact of newer medications on nutrition needs and intervention throughout the phases of HIV and AIDS
- Included new and updated references
- Modified illustrations and tables

Chapter 18: Nutrition and Older Adults

- Revised the introductory section
- Updated life expectancy information
- Revised the section on calorie restriction
- Updated all statistics—prevalence, incidence
- Deleted Table 18–7, medication use among older adults
- Revised section on folate, nutrient supplement
- Revised section on federal nutrition programs for older adults

Chapter 19: Nutrition and Older Adults: Conditions and Interventions

- New illustration added—Decline in mortality by leading causes of deaths
- Updated statistics on all disease prevalence
- Revised sections to reflect new guidelines issued in 2013–2015 on heart disease, stroke, diabetes, hypertension, and lifestyle modifications
- Revised sections to include new information on periodontal disease, vitamin B_{12}, obesity, and unintentional weight loss

Instructor Resources

Updated for the 6th edition is the Instructor Companion site that contains Microsoft PowerPoint™ lecture presentations with artwork, chapter outlines, and discussion questions. The Instructor's Manual, images from the text, videos, and animations, and more can also be found on this site. The Test Bank is offered through Cengage Learning Testing Powered by Cognero and contains multiple-choice, true/false, matching, and discussion exercises. Cengage Learning Testing is a flexible, online system that allows you to author, edit, and manage test bank content, create multiple test versions, and deliver tests from your LMS, your classroom or wherever you want.

Acknowledgments

This edition introduces four new chapter authors: Robyn Wong, MPH, RD, CSP, Nutrition Specialist—NICU and Pediatrics, Kaiser Permanente Medical Center in Honolulu (Chapters 8, 9); Ellen Bowser, MS, RDN, LDN, RN, an associate in pediatrics who is a faculty nutritionist with the University of Florida Pediatric Pulmonary Division (Chapters 10, 11); Beth L. Leonberg, MS, RDN, CSP, FAND, LDN, an assistant clinical professor and director, Didactic Program in Dietetics at Drexel University (Chapters 12, 13); and Nadine Sahyoun, PhD, RD, a professor and director of the graduate program in Nutrition and Food Science Department of Nutrition and Food Science at the University of Maryland, College Park (Chapters 18, 19). We are very fortunate to have such high-caliber authors continue work on the comprehensive and instructive chapters begun by Janet Isaacs, Nancy Wooldridge, and Bea Krinke five editions ago. Thank you Janet, Nancy, and Bea for bringing your intelligence, experience, and dedicated efforts to these chapters.

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 Yolanda Cossion and Krista Mastroianni, product managers; and Lauren Oliveira, content developer of Life Sciences. Their careful and complete work on the development and implementation of this new edition is appreciated greatly. Lynn Lustberg, 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

Many thanks to the following reviewers, whose careful reading and thoughtful comments helped enormously in shaping revisions to the 6th edition.

Theresa Loomis
SUNY Oneonta

Beverly Moellering
University of Saint Francis

Cydne Perry
Shepherd University

Dean Chiarelli
Arizona State University

Laura Horn
Cincinnati State Technical and Community College

Bruce Rengers
Metropolitan State University of Denver

Allison Childress
Texas Tech University

Christen Harris
Bastyr University

Wendy Buchan
California State University Sacramento

Karen Kubena
Texas A&M University

Betty Alford
Texas Woman's University

Leta Aljadir
University of Delaware

Clint Allred
Texas A&M University

Dea Hanson Baxter
Georgia State University

Janet Colson
Middle Tennessee State University

Kathleen Davis
Texas Women's University

Shelley R. Hancock
The University of Alabama

Laura Horn
Cincinnati State Community College

Dr. Mary Jacob
California State University, Long Beach

Pera Jambazian
California State University, Los Angeles

Tay Seacord Kennedy
Oklahoma State University

Younghee Kim
Bowling Green State University

Barbara Kirks
California State University, Chico

Kaye Stanek Krogstrand
University of Nebraska

Karen Kubena
Texas A&M University

Sally Ann Lederman
Columbia University

Richard Lewis
University of Georgia

Marcia Magnus
Florida International University

J. Harriett McCoy
University of Arkansas

Sharon McWhinney
Prairie View A&M University

Janis Mena
University of Florida

Robert Reynolds
University of Illinois at Chicago

Sharon Nickols-Richardson
Virginia Polytechnic Institute and State University

Lisa Roth
University of Florida

Claire Schmelzer
Eastern Kentucky University

Adria Sherman
Rutgers University

Carmen R. Roman-Shriver
Texas Tech University

Joanne Slavin
University of Minnesota

Joanne Spaide
Professor Emeritus, University of Northern Iowa

Diana-Marie Spillman
Miami University, Oxford, Ohio

Wendy Stuhldreher Slippery Rock
University of Pennsylvania

Anne VanBeber
Texas Christian University

Phyllis Moser-Veillon
University of Maryland

Janelle Walter
Baylor University

Doris Wang
University of Minnesota Crookston

Suzy Weems, Ph.D.
Stephen F. Austin State University

Kay Wilder
Point Loma Nazarene College

Angela Stiegemeyer
Southeast Missouri State University

Janelle M. Walter
Baylor University

Virginia A. Bennett
Central Washington University

Mark S. Meskin
California State Polytechnical University–Pomona

May you enjoy using this text as much as the authors relish the opportunity of making it available to you.

Judith Brown *with*

Ellen Lechenberg

Maureen Murtaugh

Patricia Splett

Jamie Stang

Robyn Wong

Ellen Bowser

Beth L. Leonberg

Nadine Sahyoun

CHAPTER 1

Nutrition Basics

Prepared by
Judith E. Brown

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.

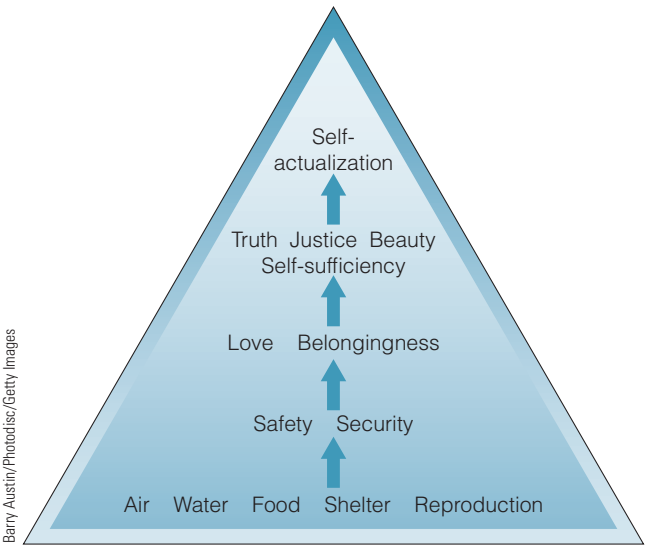
iStockphoto.com/Catherine Yeulet

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*.



Barry Austin/Photodisc/Getty Images

ILLUSTRATION 1.1 ◗ The need for food is part of Maslow's hierarchy of needs.

Principles of the Science of Nutrition

LO 1.1 Demonstrate a working knowledge of the meaning of the 10 nutrition concepts presented.

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.

TABLE 1.1 ◗ Principles of human nutrition

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

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.[1] It exists in 14.3 percent of United States and 7.7 percent of Canadian households.[2,3]

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.

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

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 1.2 ◗ The six categories of nutrients

1. **Carbohydrates** 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. **Proteins** Chemical substances in foods that are made up of chains of amino acids. Animal products and dried beans are examples of protein sources.
3. **Fats (Lipids)** 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. **Vitamins** 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. **Minerals** 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. **Water** An essential component of the diet provided by food and fluid.

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

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_{12}).

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.
- *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

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 *indispensible amino acids*.

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

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.

DRIs 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 DRIs were developed through a joint U.S.–Canadian effort, and the standards apply to both countries. The DRIs 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.[4]

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 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.

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[a]
Saturated fat	20 g
Cholesterol	300 mg[a]
Sodium	2400 mg
Total carbohydrate	300 g
Dietary fiber	25 g
Vitamin A	5000 IU[a]
Vitamin C	60 mg
Calcium	1000 mg
Iron	18 mg

[a]g = grams; mg = milligrams; IU = International Units

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

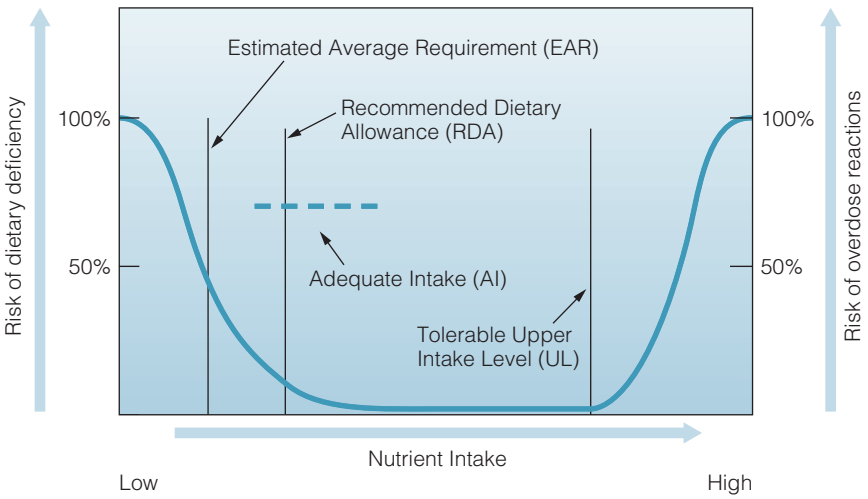


ILLUSTRATION 1.2 ◗ Theoretical framework, terms, and abbreviations used in the Dietary Reference Intakes.

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

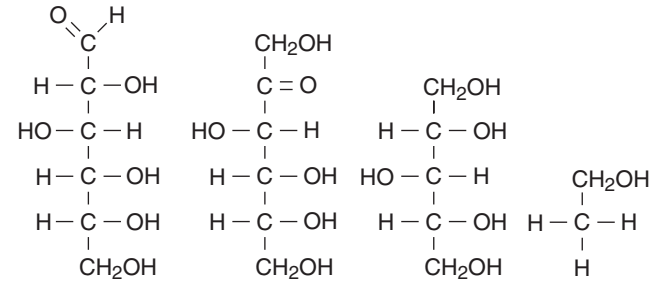


ILLUSTRATION 1.3 ◗ Chemical structures of some simple carbohydrates.

- 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.[5] 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.[10]

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***.[6]

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 grams, and males 30–38 grams of total dietary fiber daily.[7]

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[71,72]

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	61	Apple	38
French fries	75	Bran muffin	60	Pear	38
Grape Nuts	75	Just Right cereal	60	Tomato juice	38
Shredded Wheat	75	Blueberry muffin	59	Yam	37
White rice	75	Mini Wheats	59	Yogurt	31
Cheerios	74	Coca-Cola	58	Flour tortilla	30
Popcorn	72	Power Bar	56	Dried beans	25
Watermelon	72	Special K	56	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 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.[7] 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.***

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.

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[a]
Sweeteners			**Beverages**		
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
Fruits			**Candy**		
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
Vegetables			**Breakfast cereals**		
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
Grain and grain products			**Dried beans (cooked)**		
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	**Vegetables**		
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
Grain and grain products			**Fruits**		
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)

TABLE 1.5 ▸ Food sources of carbohydrates (*Continued*)

	PORTION SIZE	GRAMS OF FIBER
Vegetables		
Lima beans	½ cup	6.6
Green peas	½ cup	4.4
Potato (with skin)	1 medium	3.5
Brussels sprouts	½ cup	3.0
Broccoli	½ cup	2.8
Carrots	½ cup	2.8
Green beans	½ cup	2.7
Collard greens	½ cup	2.7
Cauliflower	½ cup	2.5
Corn	½ cup	2.0
Nuts		
Almonds	¼ cup	4.5
Peanuts	¼ cup	3.3
Peanut butter	2 Tbsp	2.3
Dried beans (cooked)		
Pinto beans	½ cup	10.0
Peas, split	½ cup	8.2
Black beans (turtle beans)	½ cup	8.0
Lentils	½ cup	7.8
Kidney or navy beans	½ cup	6.9
Black-eyed peas	½ cup	5.3
Fast foods		
Big Mac	1	3
French fries	1 regular serving	3
Whopper	1	3
Cheeseburger	1	2
Taco	1	2
Chicken sandwich	2	1
Egg McMuffin	1	1
Fried chicken, drumstick	1	1

[a]4 grams sucrose = 1 teaspoon.

TABLE 1.6 ▸ Food sources of protein

	PORTION SIZE	GRAMS OF PROTEIN
Meats		
Beef, lean	3 oz	26
Tuna, in water	3 oz	24
Hamburger, lean	3 oz	24
Chicken, no skin	3 oz	24
Lamb	3 oz	22
Pork chop, lean	3 oz	20
Haddock, broiled	3 oz	19
Egg	1 med	6
Dairy Products		
Cottage cheese, low fat	½ c	14
Yogurt, low fat	1 c	13
Milk, skim	1 c	9
Milk, whole	1 c	8
Swiss cheese	1 oz	8
Cheddar cheese	1 oz	7
Grain Products		
Oatmeal, cooked	½ cup	4
Pasta, cooked	½ cup	4
Bread	1 slice	2
Rice, white or brown	½ cup	2

Fats (Lipids)

Fats in food share the property of being soluble in fats but not in water. They are actually a subcategory of *lipids,* but this category of macronutrient is referred to as fat in the DRIs.[7] Lipids include fats, oils, and related compounds such as cholesterol. Fats are generally solid at room temperature, whereas oils are usually liquid. Fats and oils are made up of various types of triglycerides (triacylglycerols), which consist of three ***fatty acids*** attached to ***glycerol*** (Illustration 1.4). The number of carbons contained in the fatty acid component of triglycerides varies from 8 to 22.

Fats and oils are a concentrated source of energy, providing nine calories per gram. Fats perform a number of important functions in the body. They are needed for cholesterol and sex-hormone synthesis, components of cell membranes, vehicles for carrying certain vitamins that are soluble in fats only, and suppliers of the ***essential fatty acids*** required for growth and health.

fatty acids The fat-soluble components of fats in foods.

glycerol A component of fats that is soluble in water. It is converted to glucose in the body.

essential fatty acids Components of fat that are a required part of the diet (i.e., linoleic and alpha-linolenic acids). Both contain unsaturated fatty acids.

Essential Fatty Acids There are two essential fatty acids: linoleic acid and alpha-linolenic acid. Because

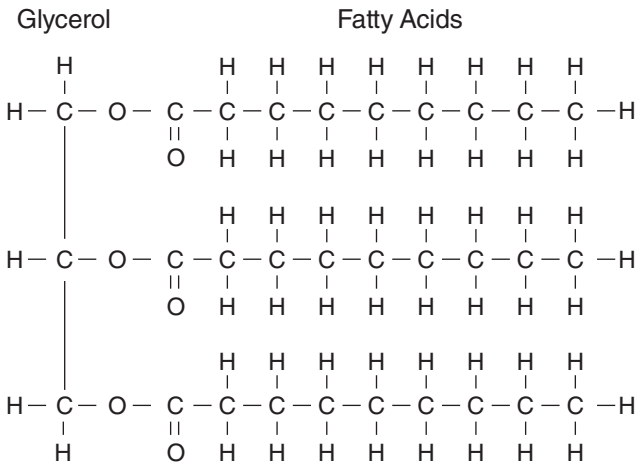


ILLUSTRATION 1.4 Basic structure of a triglyceride.

these fatty acids are essential, they must be supplied in the diet. The central nervous system is particularly rich in derivatives of these two fatty acids. They are found in phospholipids, which—along with cholesterol—are the primary lipids in the brain and other nervous system tissue. Biologically active derivatives of essential fatty acids include ***prostaglandins***, ***thromboxanes***, and ***prostacyclins***:

Linoleic Acid Linoleic acid is the parent of the omega-6 (or n-6) fatty acid family. One of the major derivatives of linoleic acid is arachidonic acid. Arachidonic acid serves as a primary structural component of the central nervous system. Most vegetable oils and meats, as well as human milk, are good sources of linoleic acid. American diets tend to provide sufficient to excessive levels of linoleic acid, and considerable amounts are stored in body fat.

Alpha-Linolenic Acid Alpha-linolenic acid is the parent of the omega-3 (n-3) fatty acid family. It is present in many types of dark green vegetables, vegetable oils, and flaxseed. Derivatives of this essential fatty acid include eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Relatively small amounts of EPA and DHA are produced in the body from alpha-linolenic acid because the conversion is low.[7] EPA and DHA also enter the body through intake of fatty, cold-water fish, shellfish, and human milk. Regular consumption of fish (two or more servings per week) reduces chronic inflammation and the risk of heart disease and sudden cardiac death.[11] DHA is found in large amounts in the central nervous system, the retina of the eye, and the testes. The body stores only small amounts of alpha-linolenic acid, EPA, and DHA.[12] On average, adults in the United States and Canada consume around 100 mg of EPA plus DHA daily, far short of the estimated need of 300–500 mg daily.[13]

Saturated and Unsaturated Fats Fats (lipids) come in two basic types: ***saturated*** and ***unsaturated***. Whether a fat is saturated or not depends on whether it has one or more double bonds between carbon atoms in one or more of its fatty acid components. If one double bond is present in one or more of the fatty acids, the fat is considered ***monounsaturated***; if two or more are present, the fat is ***polyunsaturated***.

Some unsaturated fatty acids are highly unsaturated. Alpha-linolenic acid, for example, contains three double bonds, arachidonic acid four, EPA five, and DHA six. These fatty acids are less stable than fatty acids with fewer double bonds, because double bonds between atoms are weaker than single bonds.

Saturated fats contain no double bonds between carbons and tend to be solid at room temperature. Animal products such as butter, cheese, and meats and two plant oils (coconut and palm) are rich sources of saturated fats. Fat we consume in our diets, whether it contains primarily saturated or unsaturated fatty acids, is generally in the triglyceride (or triacylglyceride) form.

Although most foods contain both saturated and unsaturated fats, animal foods tend to contain more saturated and less unsaturated fat than plant foods. Saturated fatty acids tend to increase blood levels of LDL cholesterol (the lipoprotein that is associated with heart-disease risk when present in high levels), whereas unsaturated fatty acids tend to decrease LDL cholesterol levels.[11,14]

- ***Hydrogenation and Trans Fats*** Oils can be made solid by adding hydrogen to the double bonds of their unsaturated fatty acids. This process, called hydrogenation, makes some of the fatty acids in oils saturated and enhances storage life and baking qualities. Hydrogenation may alter the molecular structure of the fatty acids; however,

prostaglandins A group of physiologically active substances derived from the essential fatty acids. They are present in many tissues and perform such functions as the constriction or dilation of blood vessels and stimulation of smooth muscles and the uterus.

thromboxanes Biologically active substances produced in platelets that increase platelet aggregation (and therefore promote blood clotting), constrict blood vessels, and increase blood pressure.

prostacyclins Biologically active substances produced by blood vessel walls that inhibit platelet aggregation (and therefore blood clotting), dilate blood vessels, and reduce blood pressure.

saturated fats Fats in which adjacent carbons in the fatty acid component are linked by single bonds only (e.g., –C–C–C–C–).

unsaturated fats Fats in which adjacent carbons in one or more fatty acids are linked by one or more double bonds (e.g., –C–C=C–C=C–).

monounsaturated fats Fats in which only one pair of adjacent carbons in one or more of its fatty acids is linked by a double bond (e.g., –C–C=C–C–).

polyunsaturated fats Fats in which more than one pair of adjacent carbons in one or more of its fatty acids are linked by two or more double bonds (e.g., –C–C=C–C=C–).