FIFTEENTH EDITION

UNDERSTANDING NUTRITION

Whitney | Rolfes

Dietary Reference Intakes (DRI)

The Dietary Reference Intakes (DRI) include two sets of nutrient intake goals for individuals—the Recommended Dietary Allowance (RDA) and Adequate Intake (AI). The RDA reflects the average daily amount of a nutrient considered adequate to meet the needs of most healthy people. If there is insufficient evidence to determine an RDA, an AI is set. In addition, the Estimated Energy Requirement (EER) represents the average dietary energy intake considered adequate to maintain energy balance in healthy people.

The DRI also include the Tolerable Upper Intake Level (UL) that represents the estimated maximum daily amount of a nutrient that appears safe for most healthy people to consume on a regular basis. Turn the page for a listing of the UL for selected vitamins and minerals. Note that the absence of a UL for a nutrient does not indicate that it is safe to consume in high doses, but only that research is too limited to set a UL. Chapter 1 describes these DRI values in detail.

Estimated Energy Requirements (EER), Recommended Dietary Allowances (RDA), and Adequate Intakes (AI) for Water, Energy, and the Energy Nutrients

Age (yr)	Reference BMI	Reference Height cm (in.)	Reference Weight kg (lb)	Water[a] AI (L/day)	Energy EER[b] (kcal/day)	Carbohydrate RDA (g/day)	Total Fiber AI (g/day)	Total Fat AI (g/day)	Linoleic Acid AI (g/day)	Linolenic Acid[c] AI (g/day)	Protein RDA (g/day)[d]	Protein RDA (g/kg/day)
Males												
0–0.5	—	62 (24)	6 (13)	0.7[e]	570	60	—	31	4.4	0.5	9.1	1.52
0.5–1	—	71 (28)	9 (20)	0.8[f]	743	95	—	30	4.6	0.5	11	1.20
1–3[g]	—	86 (34)	12 (27)	1.3	1046	130	19	—	7	0.7	13	1.05
4–8[g]	15.3	115 (45)	20 (44)	1.7	1742	130	25	—	10	0.9	19	0.95
9–13	17.2	144 (57)	36 (79)	2.4	2279	130	31	—	12	1.2	34	0.95
14–18	20.5	174 (68)	61 (134)	3.3	3152	130	38	—	16	1.6	52	0.85
19–30	22.5	177 (70)	70 (154)	3.7	3067[h]	130	38	—	17	1.6	56	0.80
31–50	22.5[i]	177 (70)[i]	70 (154)[i]	3.7	3067[h]	130	38	—	17	1.6	56	0.80
>50	22.5[i]	177 (70)[i]	70 (154)[i]	3.7	3067[h]	130	30	—	14	1.6	56	0.80
Females												
0–0.5	—	62 (24)	6 (13)	0.7[e]	520	60	—	31	4.4	0.5	9.1	1.52
0.5–1	—	71 (28)	9 (20)	0.8[f]	676	95	—	30	4.6	0.5	11	1.20
1–3[g]	—	86 (34)	12 (27)	1.3	992	130	19	—	7	0.7	13	1.05
4–8[g]	15.3	115 (45)	20 (44)	1.7	1642	130	25	—	10	0.9	19	0.95
9–13	17.4	144 (57)	37 (81)	2.1	2071	130	26	—	10	1.0	34	0.95
14–18	20.4	163 (64)	54 (119)	2.3	2368	130	26	—	11	1.1	46	0.85
19–30	21.5	163 (64)	57 (126)	2.7	2403[j]	130	25	—	12	1.1	46	0.80
31–50	21.5[i]	163 (64)[i]	57 (126)[i]	2.7	2403[j]	130	25	—	12	1.1	46	0.80
>50	21.5[i]	163 (64)[i]	57 (126)[i]	2.7	2403[j]	130	21	—	11	1.1	46	0.80
Pregnancy												
1st trimester				3.0	+0	175	28	—	13	1.4	46	0.80
2nd trimester				3.0	+340	175	28	—	13	1.4	71	1.10
3rd trimester				3.0	+452	175	28	—	13	1.4	71	1.10
Lactation												
1st 6 months				3.8	+330	210	29	—	13	1.3	71	1.30
2nd 6 months				3.8	+400	210	29	—	13	1.3	71	1.30

NOTE: BMI is calculated as the weight in kilograms divided by the square of the height in meters. For all nutrients, values for infants are AI. The glossary on the insert defines units of nutrient measure. Dashes (—) indicate that values have not been determined.

[a]The water AI includes drinking water, water in beverages, and water in foods; in general, drinking water and other beverages contribute about 70 to 80 percent, and foods, the remainder. Conversion factors: 1 L = 33.8 fluid oz; 1 L = 1.06 qt; 1 cup = 8 fluid oz.

[b]The Estimated Energy Requirement (EER) represents the average dietary energy intake that will maintain energy balance in a healthy person of a given gender, age, weight, height, and physical activity level. The values listed are based on an "active" person at the reference height and weight and at the midpoint ages for each group until age 19. Chapter 8 and Appendix F provide equations and tables to determine estimated energy requirements.

[c]The linolenic acid referred to in this table and text is the omega-3 fatty acid known as alpha-linolenic acid.

[d]The values listed are based on reference body weights.

[e]Assumed to be from human milk.

[f]Assumed to be from human milk and complementary foods and beverages. This includes approximately 0.6 L (~2½ cups) as total fluid including formula, juices, and drinking water.

[g]For energy, the age groups for young children are 1–2 years and 3–8 years.

[h]For males, subtract 10 kcalories per day for each year of age above 19.

[i]Because weight need not change as adults age if activity is maintained, reference weights for adults 19 through 30 years are applied to all adult age groups.

[j]For females, subtract 7 kcalories per day for each year of age above 19.

SOURCE: Adapted from the *Dietary Reference Intakes series*, National Academies Press. National Academies of Sciences.

Recommended Dietary Allowances (RDA) and Adequate Intakes (AI) for Vitamins

Age (yr)	Thiamin RDA (mg/day)	Riboflavin RDA (mg/day)	Niacin RDA (mg/day)[a]	Biotin AI (µg/day)	Pantothenic acid AI (mg/day)	Vitamin B_6 RDA (mg/day)	Folate RDA (µg/day)[b]	Vitamin B_{12} RDA (µg/day)	Choline AI (mg/day)	Vitamin C RDA (mg/day)	Vitamin A RDA (µg/day)[c]	Vitamin D RDA (µg/day)[d]	Vitamin E RDA (mg/day)[e]	Vitamin K AI (µg/day)
Infants														
0–0.5	0.2	0.3	2	5	1.7	0.1	65	0.4	125	40	400	10	4	2.0
0.5–1	0.3	0.4	4	6	1.8	0.3	80	0.5	150	50	500	10	5	2.5
Children														
1–3	0.5	0.5	6	8	2	0.5	150	0.9	200	15	300	15	6	30
4–8	0.6	0.6	8	12	3	0.6	200	1.2	250	25	400	15	7	55
Males														
9–13	0.9	0.9	12	20	4	1.0	300	1.8	375	45	600	15	11	60
14–18	1.2	1.3	16	25	5	1.3	400	2.4	550	75	900	15	15	75
19–30	1.2	1.3	16	30	5	1.3	400	2.4	550	90	900	15	15	120
31–50	1.2	1.3	16	30	5	1.3	400	2.4	550	90	900	15	15	120
51–70	1.2	1.3	16	30	5	1.7	400	2.4	550	90	900	15	15	120
>70	1.2	1.3	16	30	5	1.7	400	2.4	550	90	900	20	15	120
Females														
9–13	0.9	0.9	12	20	4	1.0	300	1.8	375	45	600	15	11	60
14–18	1.0	1.0	14	25	5	1.2	400	2.4	400	65	700	15	15	75
19–30	1.1	1.1	14	30	5	1.3	400	2.4	425	75	700	15	15	90
31–50	1.1	1.1	14	30	5	1.3	400	2.4	425	75	700	15	15	90
51–70	1.1	1.1	14	30	5	1.5	400	2.4	425	75	700	15	15	90
>70	1.1	1.1	14	30	5	1.5	400	2.4	425	75	700	20	15	90
Pregnancy														
≤18	1.4	1.4	18	30	6	1.9	600	2.6	450	80	750	15	15	75
19–30	1.4	1.4	18	30	6	1.9	600	2.6	450	85	770	15	15	90
31–50	1.4	1.4	18	30	6	1.9	600	2.6	450	85	770	15	15	90
Lactation														
≤18	1.4	1.6	17	35	7	2.0	500	2.8	550	115	1200	15	19	75
19–30	1.4	1.6	17	35	7	2.0	500	2.8	550	120	1300	15	19	90
31–50	1.4	1.6	17	35	7	2.0	500	2.8	550	120	1300	15	19	90

NOTE: For all nutrients, values for infants are AI. The glossary on the inside back cover defines units of nutrient measure.

[a]Niacin recommendations are expressed as niacin equivalents (NE), except for recommendations for infants younger than 6 months, which are expressed as preformed niacin.

[b]Folate recommendations are expressed as dietary folate equivalents (DFE).

[c]Vitamin A recommendations are expressed as retinol activity equivalents (RAE).

[d]Vitamin D recommendations are expressed as cholecalciferol and assume minimal sunlight.

[e]Vitamin E recommendations are expressed as α-tocopherol.

Recommended Dietary Allowances (RDA) and Adequate Intakes (AI) for Minerals

Age (yr)	Sodium AI (mg/day)	Chloride AI (mg/day)	Potassium AI (mg/day)	Calcium RDA (mg/day)	Phosphorus RDA (mg/day)	Magnesium RDA (mg/day)	Iron RDA (mg/day)	Zinc RDA (mg/day)	Iodine RDA (µg/day)	Selenium RDA (µg/day)	Copper RDA (µg/day)	Manganese AI (mg/day)	Fluoride AI (mg/day)	Chromium AI (µg/day)	Molybdenum RDA (µg/day)
Infants															
0–0.5	120	180	400	200	100	30	0.27	2	110	15	200	0.003	0.01	0.2	2
0.5–1	370	570	700	260	275	75	11	3	130	20	220	0.6	0.5	5.5	3
Children															
1–3	1000	1500	3000	700	460	80	7	3	90	20	340	1.2	0.7	11	17
4–8	1200	1900	3800	1000	500	130	10	5	90	30	440	1.5	1.0	15	22
Males															
9–13	1500	2300	4500	1300	1250	240	8	8	120	40	700	1.9	2	25	34
14–18	1500	2300	4700	1300	1250	410	11	11	150	55	890	2.2	3	35	43
19–30	1500	2300	4700	1000	700	400	8	11	150	55	900	2.3	4	35	45
31–50	1500	2300	4700	1000	700	420	8	11	150	55	900	2.3	4	35	45
51–70	1300	2000	4700	1000	700	420	8	11	150	55	900	2.3	4	30	45
>70	1200	1800	4700	1200	700	420	8	11	150	55	900	2.3	4	30	45
Females															
9–13	1500	2300	4500	1300	1250	240	8	8	120	40	700	1.6	2	21	34
14–18	1500	2300	4700	1300	1250	360	15	9	150	55	890	1.6	3	24	43
19–30	1500	2300	4700	1000	700	310	18	8	150	55	900	1.8	3	25	45
31–50	1500	2300	4700	1000	700	320	18	8	150	55	900	1.8	3	25	45
51–70	1300	2000	4700	1200	700	320	8	8	150	55	900	1.8	3	20	45
>70	1200	1800	4700	1200	700	320	8	8	150	55	900	1.8	3	20	45
Pregnancy															
≤18	1500	2300	4700	1300	1250	400	27	12	220	60	1000	2.0	3	29	50
19–30	1500	2300	4700	1000	700	350	27	11	220	60	1000	2.0	3	30	50
31–50	1500	2300	4700	1000	700	360	27	11	220	60	1000	2.0	3	30	50
Lactation															
≤18	1500	2300	5100	1300	1250	360	10	13	290	70	1300	2.6	3	44	50
19–30	1500	2300	5100	1000	700	310	9	12	290	70	1300	2.6	3	45	50
31–50	1500	2300	5100	1000	700	320	9	12	290	70	1300	2.6	3	45	50

NOTE: For all nutrients, values for infants are AI. The glossary on the inside back cover defines units of nutrient measure.

Tolerable Upper Intake Levels (UL) for Vitamins

Age (yr)	Niacin (mg/day)[a]	Vitamin B_6 (mg/day)	Folate (µg/day)[a]	Choline (mg/day)	Vitamin C (mg/day)	Vitamin A (µg/day)[b]	Vitamin D (µg/day)	Vitamin E (mg/day)[c]
Infants								
0–0.5	—	—	—	—	—	600	25	—
0.5–1	—	—	—	—	—	600	38	—
Children								
1–3	10	30	300	1000	400	600	63	200
4–8	15	40	400	1000	650	900	75	300
9–13	20	60	600	2000	1200	1700	100	600
Adolescents								
14–18	30	80	800	3000	1800	2800	100	800
Adults								
19–70	35	100	1000	3500	2000	3000	100	1000
>70	35	100	1000	3500	2000	3000	100	1000
Pregnancy								
≤18	30	80	800	3000	1800	2800	100	800
19–50	35	100	1000	3500	2000	3000	100	1000
Lactation								
≤18	30	80	800	3000	1800	2800	100	800
19–50	35	100	1000	3500	2000	3000	100	1000

[a]The UL for niacin and folate apply to synthetic forms obtained from supplements, fortified foods, or a combination of the two.
[b]The UL for vitamin A applies to the preformed vitamin only.
[c]The UL for vitamin E applies to any form of supplemental α-tocopherol, fortified foods, or a combination of the two.

Tolerable Upper Intake Levels (UL) for Minerals

Age (yr)	Sodium (mg/day)	Chloride (mg/day)	Calcium (mg/day)	Phosphorus (mg/day)	Magnesium (mg/day)[d]	Iron (mg/day)	Zinc (mg/day)	Iodine (µg/day)	Selenium (µg/day)	Copper (µg/day)	Manganese (mg/day)	Fluoride (mg/day)	Molybdenum (µg/day)	Boron (mg/day)	Nickel (mg/day)	Vanadium (mg/day)
Infants																
0–0.5	—	—	1000	—	—	40	4	—	45	—	—	0.7	—	—	—	—
0.5–1	—	—	1500	—	—	40	5	—	60	—	—	0.9	—	—	—	—
Children																
1–3	1500	2300	2500	3000	65	40	7	200	90	1000	2	1.3	300	3	0.2	—
4–8	1900	2900	2500	3000	110	40	12	300	150	3000	3	2.2	600	6	0.3	—
9–13	2200	3400	3000	4000	350	40	23	600	280	5000	6	10	1100	11	0.6	—
Adolescents																
14–18	2300	3600	3000	4000	350	45	34	900	400	8000	9	10	1700	17	1.0	—
Adults																
19–50	2300	3600	2500	4000	350	45	40	1100	400	10,000	11	10	2000	20	1.0	1.8
51–70	2300	3600	2000	4000	350	45	40	1100	400	10,000	11	10	2000	20	1.0	1.8
>70	2300	3600	2000	3000	350	45	40	1100	400	10,000	11	10	2000	20	1.0	1.8
Pregnancy																
≤18	2300	3600	3000	3500	350	45	34	900	400	8000	9	10	1700	17	1.0	—
19–50	2300	3600	2500	3500	350	45	40	1100	400	10,000	11	10	2000	20	1.0	—
Lactation																
≤18	2300	3600	3000	4000	350	45	34	900	400	8000	9	10	1700	17	1.0	—
19–50	2300	3600	2500	4000	350	45	40	1100	400	10,000	11	10	2000	20	1.0	—

[d]The UL for magnesium applies to synthetic forms obtained from supplements or drugs only.
NOTE: An Upper Limit was not established for vitamins and minerals not listed and for those age groups listed with a dash (—) because of a lack of data, not because these nutrients are safe to consume at any level of intake. All nutrients can have adverse effects when intakes are excessive.

SOURCE: Adapted from the *Dietary Reference Intakes series,* National Academies Press. National Academies of Sciences.

Understanding Nutrition

Fifteenth Edition

Ellie Whitney
Sharon Rady Rolfes

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To the memory of Eva May Nunnelly Hamilton, who first undertook to write this book with me in 1975. Her scholarship, enthusiasm, and warmth pervade its pages still.

Ellie Whitney

Nourishment means more than providing food; it also means giving love. Anyone joining my family at one of our gatherings would see an abundance of both. I dedicate this book to all the members of my family—including those who have departed and those who have yet to arrive.

Sharon Rady Rolfes

About the Authors

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

Sharon Rady Rolfes received her MS in nutrition and food science from Florida State University. She is a founding member of Nutrition and Health Associates, an information resource center that maintains a research database on more than 1000 nutrition-related topics. She has taught at Florida State University and coauthored several other college textbooks, including *Understanding Normal and Clinical Nutrition*. In addition to writing, she serves as a consultant for various educational projects. Her volunteer work includes serving on the board of Working Well, a community initiative dedicated to creating a healthy workforce. She maintains her registration as a dietitian nutritionist and membership in the Academy of Nutrition and Dietetics.

Brief Contents

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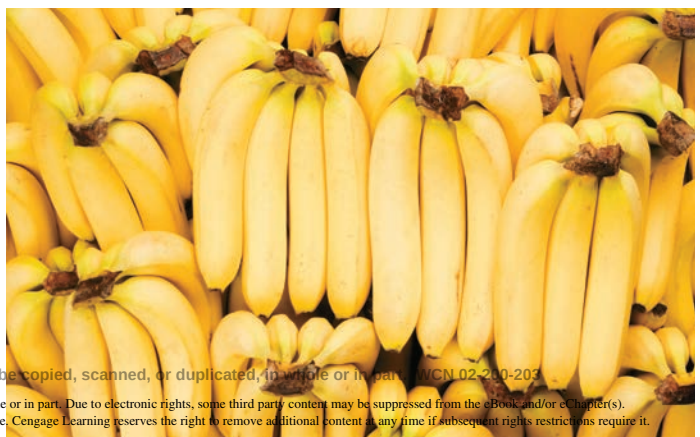

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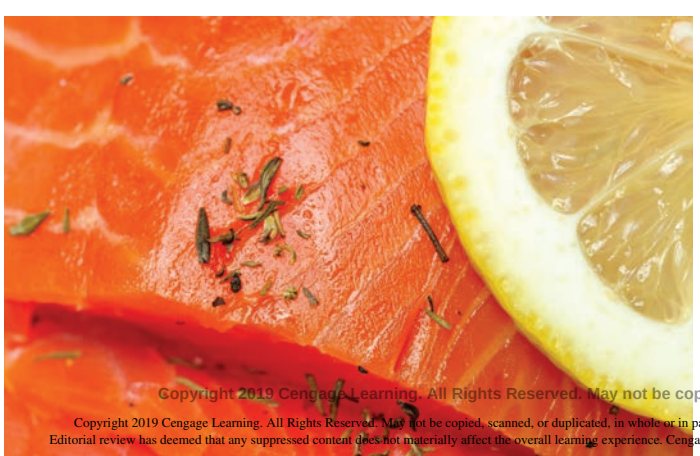

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Preface

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

A Book Tour of This Edition

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

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

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

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

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

definition (DEF-eh-NISH-en): the meaning of a word.
- **de** = from
- **finis** = boundary

LEARNING GUIDE

The opening page of each chapter provides a Learning Guide that serves as an outline and directs readers to the main heads within the chapter. Each main head is followed by a Learn It—a learning objective for the content covered in that section. The Learn It also appears within the text at the start of each main section as well as at the start of each Review It. After reading the chapter, students will be able to demonstrate competency in the Learn It objectives.

Nutrition in Your Life

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

> How To

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

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

REVIEW IT Each major section within a chapter concludes with a Review It paragraph that summarizes key concepts. Similarly, Review It tables cue readers to important summaries.

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

What's Online

MINDTAP From Cengage

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

The Appendixes

The appendixes are valuable references for a number of purposes. Appendix A summarizes background information on the hormonal and nervous systems, complementing Appendixes B and C on basic chemistry, the chemical structures of nutrients, and major metabolic pathways. Appendix D describes measures of protein quality. Appendix E provides detailed coverage of nutrition assessment, and Appendix F presents the estimated energy requirements for men and women at various levels of physical activity. Appendix G presents the 2014 publication *Choose Your Foods: Food Lists for Diabetes and Weight Management*. Appendix H features aids to calculations, a short tutorial on converting metric measures and handling basic math problems commonly found in the world of nutrition. Appendix I lists nutrition recommendations from the World Health Organization (WHO), and Appendix J presents the 2020 Healthy People nutrition-related objectives.

The Inserts

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

Notable Changes in This Edition

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

- Reviewed and updated content
- Created several new figures and tables and revised others to enhance learning

Chapter 1

- Added new section on marketing to the food choices section
- Expanded discussion on processed foods, clarifying the distinction between minimally processed and ultra-processed foods
- Simplified figure comparing inaccurate and accurate view of nutrient intakes
- Created new figure illustrating how energy nutrients contribute to the total
- Expanded discussion on misinformation from TV talk shows and ads in fitness magazines
- Added short section on critical thinking

Chapter 2

- Revised entire section on Dietary Guidelines for Americans, including texts, tables, and figures to reflect 2015–2020 edition
- Updated and simplified figure comparing recommended and actual intakes from food groups
- Created new figure illustrating how the US population exceeds recommended limits for added sugars, saturated fats, and sodium

- Added more details on food allergens and front-of-label ingredients

Chapter 3

- Expanded discussion on microbiota
- Expanded discussion on celiac disease and introduced nonceliac gluten sensitivity

Chapter 4

- Introduced FODMAP—fermentable oligosaccharides, disaccharides, monosaccharides, and polyols
- Simplified figure on glucose homeostasis
- Created new figure illustrating high- vs. low-glycemic response

Chapter 5

- Revised recommendations and discussion for cholesterol based on the 2015–2020 *Dietary Guidelines for Americans*
- Added a new table for the USDA Healthy Mediterranean Eating Pattern

Chapter 6

- Reorganized the preview of protein metabolism
- Shortened sections on heart disease and osteoporosis
- Rewrote much of the supplement section
- Created new figure illustrating how genetics and lifestyle factors influence health and longevity

Chapter 7

- Added a new paragraph on intermittent fasting
- Revised the table of blood alcohol effects

Chapter 8

- Introduced the term *ectopic fat* and expanded discussion on obesity's role in inflammation and the metabolic syndrome
- Revised and expanded discussion on "healthy obese" and "metabolically normal obese"
- Introduced the term *orthorexia nervosa*

Chapter 9

- Updated figure of maps showing prevalence of obesity among US adults
- Revised figure of surgical procedures for severe obesity to include sleeve gastrectomy
- Created new table to summarize ghrelin and leptin
- Added new drugs to table of FDA-approved weight-loss drugs
- Added new discussion of other medical procedures to treat obesity, including endoscopic procedures, intragastric balloons, and gastric aspiration
- Created new table to introduce SMART goals

Chapter 10

- Added a brief review of DRI terms to the introduction
- Deleted How To Estimate Niacin Equivalents
- Added a figure showing folate in its polyglutamate and monoglutamate forms; deleted the figure showing decline in neural tube defects since folate fortification
- Deleted How To Estimate Dietary Folate Equivalents

Chapter 11

- Simplified the figure showing the blood-clotting process

Chapter 12

- Reorganized water section
- Added new figure illustrating the color of urine in relation to hydration
- Deleted How To Estimate Your Calcium Intake

Chapter 13

- Deleted How To Estimate the Recommended Daily Intake for Iron

Chapter 14

- Defined and discussed myokines
- Reorganized the section on glucose use during physical activity
- Created a table of carbohydrate recommendations for physical activities
- Updated protein recommendations for athletes and created a table of food sources
- Added discussion of dietary nitrate as an ergogenic aid; removed carnitine and chromium picolinate

Chapter 15

- Created new table of advice for pregnant (and lactating) women eating fish
- Added discussions on dietary factors related to postpartum depression, benefits of lactation in delaying onset of type 2 diabetes in women with gestational diabetes, and use of breast pumps

Chapter 16

- Updated table of supplements for infants
- Included current recommendations about peanut allergy during infancy
- Added discussion about zinc when introducing complementary foods during infancy
- Updated the table of energy needs for children
- Revised section on children's dietary patterns
- Created a "How To" feature for the figure of body mass index for age percentiles

Chapter 17

- Added discussion about influence of obesity on the aging brain

Chapter 18

- Removed short discussion of HIV from the infectious disease section
- Added brief discussion emphasizing the importance of lifestyle choices to disease prevention, even in those who are at a high genetic risk of disease
- Included new information about the importance of assessing cardiorespiratory fitness as an indicator of heart disease risk
- Added How To Count Carbohydrates feature in the section on diabetes
- Added discussions about sugar alcohols and artificial sweeteners in the diabetes section and about nitrites and nitrates in processed meats in the cancer section

Chapter 19

- Expanded discussion on product date labeling
- Removed discussion on dioxin

Chapter 20

- Expanded discussion on sustainable diets
- Refocused section on agriculture and the environment

Student and Instructor Resources

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Closing Comments

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

Ellie Whitney
Sharon Rady Rolfes
January 2018

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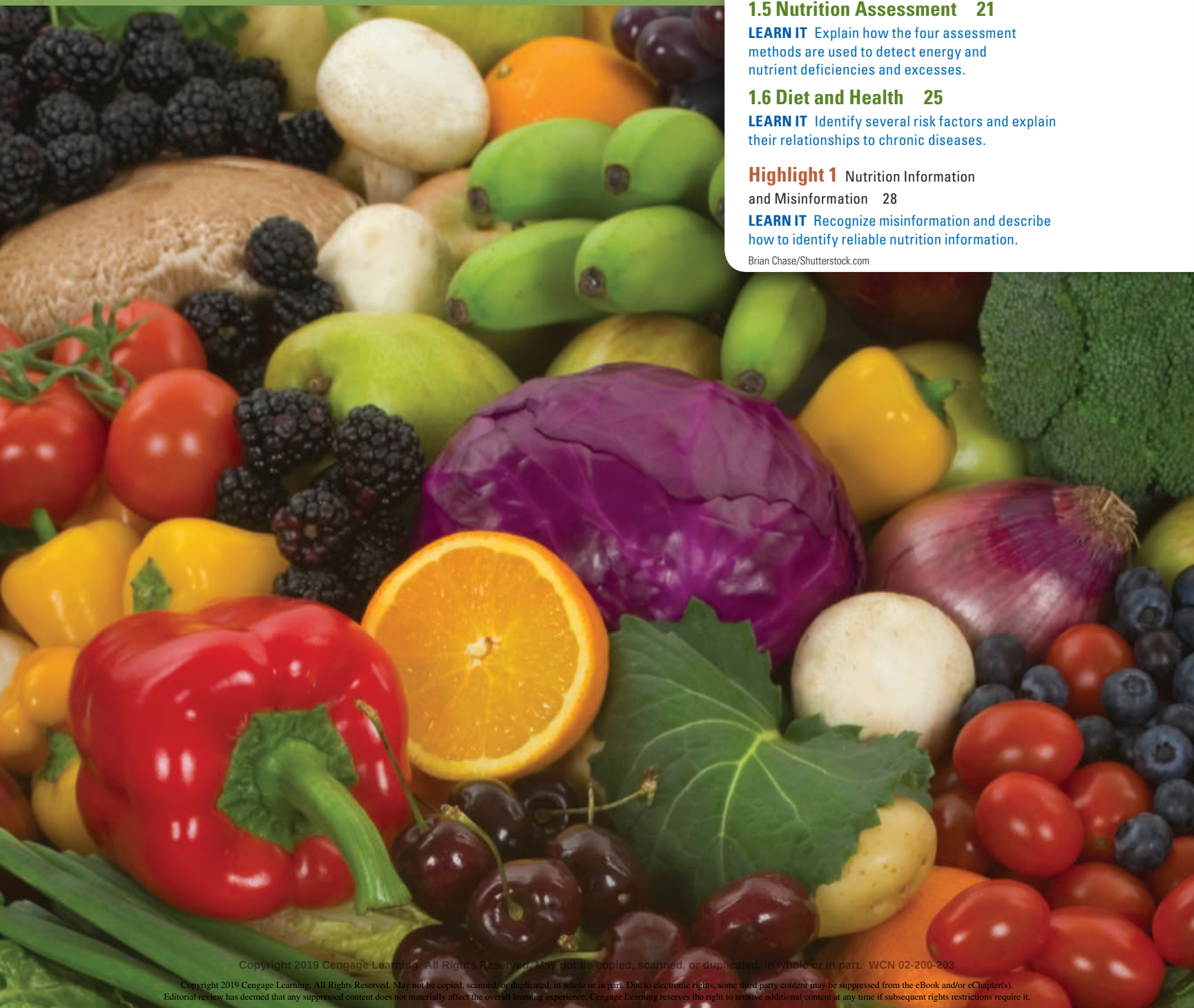
1 An Overview of Nutrition

LEARNING GUIDE



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Nutrition in Your Life

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

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

Although most people realize food habits affect health, they often choose foods for other reasons. After all, foods bring pleasures, traditions, and associations as well as nourishment. The challenge, then, is to combine favorite foods and fun times with a nutritionally balanced **diet**. Take a moment to review the definition and note that *diet* does *not* mean a restrictive food plan designed for weight loss. It simply refers to the foods and beverages a person consumes. Whether it's a vegetarian diet, a weight-loss diet, or any other kind of diet depends on the types of foods and beverages a person chooses. Importantly, diets can change over time.

1.1 Food Choices

LEARN IT Describe how various factors influence personal food choices.

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

Preferences As you might expect, the number one reason most people choose certain foods is taste—they like the flavor. Two widely shared preferences are for the sweetness of sugar and the savoriness of salt.[1] High-fat foods also appear to be a universally common preference.[2] Other preferences might be for the hot peppers common in Mexican cooking or the curry spices of Indian cuisine. Research suggests that genetics may influence taste perceptions and therefore food likes and dislikes.[3] Similarly, the hormones of pregnancy seem to influence food cravings and aversions (see Chapter 15).

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

Ethnic Heritage and Regional Cuisines Among the strongest influences on food choices are ethnic heritage and regional cuisines. People tend to prefer the foods

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

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

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

- **chronos** = time

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

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

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

Enjoying traditional **ethnic foods** provides an opportunity to celebrate a person's cultural heritage (Photo 1-1). People offering ethnic foods share a part of their culture with others, and those accepting the foods learn about another's way of life. Developing **cultural competence** honors individual preferences and is particularly important for professionals who help others plan healthy diets.[4]

Social Interactions Meals are often social events, and sharing food is part of hospitality. Social customs invite people to accept food or drink offered by a host or shared by a group—regardless of hunger signals. Such social interactions can be a challenge for people trying to limit their food intake; Chapter 9 describes how people tend to eat more food when socializing with others. People also tend to eat the kinds of foods eaten by those in their social circles, thus helping to explain why obesity seems to spread in social networks and weight loss is easier with a partner.[5]

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

Availability, Convenience, and Economy People often eat foods that are accessible, quick and easy to prepare, and within their financial means. Consumers who value convenience frequently eat out, bring home ready-to-eat meals, or have food delivered. Even when they venture into the kitchen, they want to prepare a meal in 15 to 20 minutes, using less than a half dozen ingredients—and those ingredients are often semiprepared foods, such as canned soups and frozen foods. Whether decisions based on convenience meet a person's nutrition needs depends on the choices made. Eating a banana or a candy bar may be equally convenient, but the fruit provides more vitamins and minerals and less sugar and fat.

Given the abundance of convenient food options, fewer adults are learning the cooking skills needed to prepare meals at home, which has its downside. People who are competent in their cooking skills and frequently eat their meals at home tend to make healthier food choices.[6] Not surprisingly, when eating out, consumers often choose low-cost fast-food outlets over more expensive fine-dining restaurants. Foods eaten away from home, especially fast-food meals, tend to be high in nutrients that Americans overconsume (saturated fat and sodium) and low in nutrients that Americans underconsume (calcium, fiber, and iron)—all of which can contribute to a variety of health problems.[7]

Unfortunately, healthful diets that include plenty of fruits, vegetables, fish, and nuts tend to cost a little more (about $1.50 per person per day more) than less healthful diets that feature meats, refined grains, and processed foods; also, milk is more expensive than soda.[8] Strategies to help consumers improve diet quality include reducing the price of fruits and vegetables, taxing processed foods, placing healthy options in strategic locations, and limiting discounts on less-healthy foods.[9]

Positive and Negative Associations People tend to like particular foods associated with happy occasions—such as hot dogs at ball games or cake and ice cream

ethnic foods: foods associated with particular cultural groups.

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

at birthday parties. By the same token, people can develop aversions to and dislike foods that they ate when they felt sick or that they were forced to eat in negative situations.[10] Similarly, children learn to like and dislike certain foods when their parents use foods as rewards or punishments. Negative experiences can have long-lasting influences on food preferences. More than 50 years after World War II, veterans who had experienced intense combat in the Pacific dislike Asian food significantly more than their peers who were not engaged in battle or those who fought elsewhere.

Emotions Emotions guide food choices and eating behaviors.[11] Some people cannot eat when they are emotionally upset. Others may eat in response to a variety of emotional stimuli—for example, to relieve boredom or depression or to calm anxiety. A lonely person may choose to eat rather than to call a friend. A person who has returned home from an exciting evening out may unwind with a late-night snack. These people may find emotional comfort, in part, because foods can influence the brain's chemistry and the mind's response. Carbohydrates and alcohol, for example, tend to calm, whereas proteins and caffeine are more likely to stimulate. Eating in response to emotions and stress can easily lead to overeating and obesity, but it may be helpful at times. For example, sharing food at times of bereavement serves both the giver's need to provide comfort and the receiver's need to be cared for and to interact with others as well as to take nourishment.

Values Food choices may reflect people's religious beliefs, political views, or environmental concerns. For example, some Christians forgo meat on Fridays during Lent (the period prior to Easter), Jewish law includes an extensive set of dietary rules that govern the use of foods derived from animals, and Muslims fast between sunrise and sunset during Ramadan (the ninth month of the Islamic calendar). Some vegetarians select foods based on their support for animal rights. A concerned consumer may boycott fruit picked by migrant workers who have been exploited. People may buy vegetables from local farmers to save the fuel and environmental costs of foods shipped long distances (see Photo 1-2). They may also select foods packaged in containers that can be reused or recycled. Some consumers accept or reject foods that have been irradiated, grown organically, or genetically modified, depending on their approval of these processes (see Chapter and Highlight 19 for a complete discussion).

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

Nutrition Finally, of course, many consumers make food choices they believe are nutritious and healthy. Making healthy food choices 100 years ago was rather easy; the list of options was relatively short and markets sold mostly fresh, **whole foods**. Examples of whole foods include vegetables and legumes; fruits; seafood, meats, poultry, eggs, nuts, and seeds; milk; and whole grains. Today, tens of thousands of food items fill the shelves of super-grocery stores and most of those items are **processed foods.** Whether a processed food is a healthy choice depends, in part, on how extensively the food was processed. When changes are minimal, processing can provide an abundant, safe, convenient, affordable, and nutritious product.[12] Examples of minimally processed foods include frozen vegetables, fruit juices, smoked salmon, cheeses, and breads. The nutritional value diminishes, however, when changes are extensive, creating **ultra-processed foods**. Ultra-processed foods no longer resemble whole foods; they are made from substances

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> **PHOTO 1-2** To protect the environment, shop at local markets and reuse cloth shopping bags. To enhance your health, keep nutrition in mind when selecting foods.

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

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

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

that are typically used in food preparation, but not consumed as foods themselves (such as oils, fats, flours, refined starches, and sugars). These substances undergo further processing by adding a little, if any, processed foods, salt and other preservatives, and additives such as flavors and colors. Examples of ultra-processed foods include soft drinks, corn chips, fruit gummies, chicken nuggets, canned cheese spreads, and toaster pastries. Notably, these foods cannot be made in a home kitchen using common grocery ingredients. Dominating the global market, ultra-processed foods tend to be attractive, tasty, and cheap—as well as high in fat and sugar.[13] Consumers who want to make healthy food choices will select fewer ultra-processed foods and more whole foods and minimally processed foods.[14]

REVIEW IT Describe how various factors influence personal food choices.

A person selects foods for a variety of reasons. Whatever those reasons may be, food choices influence health. Individual food selections neither make nor break a diet's healthfulness, but the balance of foods selected over time can make an important difference to health.[15] For this reason, people are wise to think "nutrition" when making their food choices.

1.2 The Nutrients

LEARN IT Name the six major classes of nutrients and identify which are organic and which yield energy.

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

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> **PHOTO 1-3** Find pleasure in eating well. Enjoy foods that meet both your nutrient needs and dietary preferences.

Nutrients in Foods and in the Body

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

Nutrient Composition of Foods

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

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

Nutrient Composition of the Body

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

Chemical Composition of Nutrients

The simplest of the nutrients are the minerals. Each mineral is a chemical element; its atoms are all alike. As a result, its identity never changes. For example, iron may have different electrical charges, but the individual iron atoms remain the same when they are in a food, when a person eats the food, when the iron becomes part of a red blood cell, when the cell is broken

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

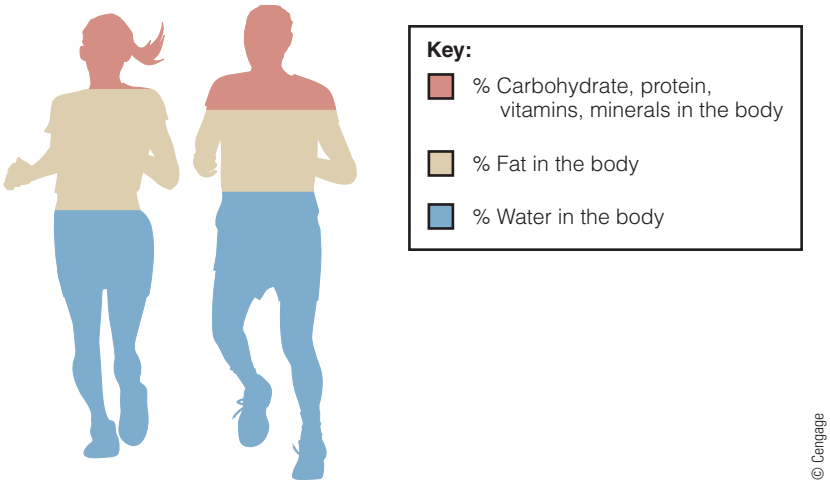
nutrients: chemical substances obtained from food and used in the body to provide energy, structural materials, and regulating agents to support growth, maintenance, and repair of the body's tissues. Nutrients may also reduce the risks of some diseases.

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

- **phyto** = plant

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

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



down, and when the iron is lost from the body by excretion. The next simplest nutrient is water, a compound made of two elements—hydrogen and oxygen. Minerals and water are **inorganic** nutrients—which means they do not contain carbon.

The other four classes of nutrients (carbohydrates, lipids, proteins, and vitamins) are more complex. In addition to hydrogen and oxygen, they all contain carbon, an element found in all living things; they are therefore called **organic** compounds (meaning, literally, "alive").* This chemical definition of *organic* differs from the agricultural definition. As Chapter 19 explains, organic farming refers to growing crops and raising livestock according to standards set by the US Department of Agriculture (USDA). Protein and some vitamins also contain nitrogen and may contain other elements such as sulfur as well.

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

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

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

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

Energy Measured in kCalories The energy released from carbohydrate, fat, and protein can be measured in **calories**—tiny units of energy so small that a single apple provides tens of thousands of them. To ease calculations, energy is expressed in 1000-calorie metric units known as kilocalories (shortened to **kcalories**, but

* Note that this definition of *organic* excludes coal, diamonds, and a few carbon-containing compounds that contain only a single carbon and no hydrogen, such as carbon dioxide (CO_2), calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$), and sodium cyanide (NaCN).

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

- **in** = not

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

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

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

- carbohydrate
- fat
- protein

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

TABLE 1-1 The Six Classes of Nutrients

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

commonly called "calories"). When you read in popular books or magazines that an apple provides "100 calories," it actually means 100 kcalories. This book uses the term *kcalorie* and its abbreviation *kcal* throughout, as do other scientific books and journals. How To 1-1 provides a few tips on "thinking metric."

Energy from Foods The amount of energy a food provides depends on how much carbohydrate, fat, and protein it contains. When completely broken down in the body, a gram of carbohydrate yields about 4 kcalories of energy; a gram of protein also yields 4 kcalories; and a gram of fat yields 9 kcalories (see Table 1-2).* How To 1-2 (p. 10) explains how to calculate the energy available from foods.

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

One other substance contributes energy—alcohol. Alcohol, however, is not considered a nutrient. Unlike the nutrients, alcohol does not sustain life. In fact, it interferes with the growth, maintenance, and repair of the body. Its only common

TABLE 1-2 kCalorie Values of Energy Nutrients

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

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

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

Gram for gram, ounce for ounce, and bite for bite, foods with a high energy density deliver more kcalories than foods with a low energy density. Both of these breakfast options provide 500 kcalories, but the cereal with milk, fruit salad, scrambled egg, turkey sausage, and toast with jam offers three times as much food as the doughnuts (based on weight); it has a lower energy density than the doughnuts. Selecting a variety of foods also helps ensure nutrient adequacy.

Matthew Farruggio

LOWER ENERGY DENSITY
This 450-gram breakfast delivers 500 kcalories, for an energy density of 1.1 (500 kcal ÷ 450 g = 1.1 kcal/g).

Matthew Farruggio

HIGHER ENERGY DENSITY
This 144-gram breakfast delivers 500 kcalories, for an energy density of 3.5 (500 kcal ÷ 144 g = 3.5 kcal/g).

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

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

>How To 1-1 Think Metric

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

Most food labels and many recipes provide dual measures, listing both household measures, such as cups, quarts, and teaspoons, and metric measures, such as milliliters, liters, and grams. This practice gives people an opportunity to gradually learn to "think metric."

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

The international unit for measuring food energy is the joule—the amount of energy expended when 1 kilogram is moved 1 meter by a force of 1 newton. The joule is thus a measure of *work* energy, whereas the kcalorie is a measure of *heat* energy. While many scientists and journals report their findings in kilojoules (kJ), many others, particularly those in the United States, use kcalories (kcal). To convert energy measures from kcalories to kilojoules, multiply by 4.2; to convert kilojoules to kcalories, multiply by 0.24. For example, a 50-kcalorie cookie provides 210 kilojoules:

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

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

Volume: Liters (L)

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

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A liter of liquid is approximately one US quart. (Four liters are only about 5 percent more than a gallon.)

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

Weight: Grams (g)

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

Length: Centimeters (cm)

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

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

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

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A 5-pound bag of potatoes weighs about 2 kilograms, and a 176-pound person weighs 80 kilograms. The height of a person 5 feet 10 inches tall (70 inches) is 178 centimeters.

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

characteristic with nutrients is that it yields energy (7 kcalories per gram) when metabolized in the body.

Most foods contain a mixture of the energy-yielding nutrients, vitamins, minerals, water, and other substances. For example, meat contains water, fat, vitamins,