CENGAGE

Understanding Normal & Clinical Nutrition

TWELFTH EDITION

Rolfes / Pinna / Whitney

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. 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 an absence of adequate exposure to 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	110	180	400	200	100	30	0.27	2	110	15	200	0.003	0.01	0.2	2
0.5–1	370	570	860	260	275	75	11	3	130	20	220	0.6	0.5	5.5	3
Children															
1–3	800	1500	2000	700	460	80	7	3	90	20	340	1.2	0.7	11	17
4–8	1000	1900	2300	1000	500	130	10	5	90	30	440	1.5	1.0	15	22
Males															
9–13	1200	2300	2500	1300	1250	240	8	8	120	40	700	1.9	2	25	34
14–18	1500	2300	3000	1300	1250	410	11	11	150	55	890	2.2	3	35	43
19–30	1500	2300	3400	1000	700	400	8	11	150	55	900	2.3	4	35	45
31–50	1500	2300	3400	1000	700	420	8	11	150	55	900	2.3	4	35	45
51–70	1500	2000	3400	1000	700	420	8	11	150	55	900	2.3	4	30	45
>70	1500	1800	3400	1200	700	420	8	11	150	55	900	2.3	4	30	45
Females															
9–13	1200	2300	2300	1300	1250	240	8	8	120	40	700	1.6	2	21	34
14–18	1500	2300	2300	1300	1250	360	15	9	150	55	890	1.6	3	24	43
19–30	1500	2300	2600	1000	700	310	18	8	150	55	900	1.8	3	25	45
31–50	1500	2300	2600	1000	700	320	18	8	150	55	900	1.8	3	25	45
51–70	1500	2000	2600	1200	700	320	8	8	150	55	900	1.8	3	20	45
>70	1500	1800	2600	1200	700	320	8	8	150	55	900	1.8	3	20	45
Pregnancy															
≤18	1500	2300	2600	1300	1250	400	27	12	220	60	1000	2.0	3	29	50
19–30	1500	2300	2900	1000	700	350	27	11	220	60	1000	2.0	3	30	50
31–50	1500	2300	2900	1000	700	360	27	11	220	60	1000	2.0	3	30	50
Lactation															
≤18	1500	2300	2500	1300	1250	360	10	13	290	70	1300	2.6	3	44	50
19–30	1500	2300	2800	1000	700	310	9	12	290	70	1300	2.6	3	45	50
31–50	1500	2300	2800	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 (IU/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)[d]	Chloride (mg/day)	Calcium (mg/day)	Phosphorus (mg/day)	Magnesium (mg/day)[e]	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	1200	2300	2500	3000	65	40	7	200	90	1000	2	1.3	300	3	0.2	—
4–8	1500	2900	2500	3000	110	40	12	300	150	3000	3	2.2	600	6	0.3	—
9–13	1800	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]There is no UL for sodium because evidence is insufficient to establish a risk from high intakes separate from the risk for chronic disease. Instead, Chronic Disease Risk Reduction (CDRR) intakes have been established and these values are listed here. Reducing high intakes to the CDRR (or lower) is expected to reduce chronic disease risk in a healthy population.
[e]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.

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To Ellie Whitney, my mentor, partner, and friend, with much appreciation for believing in me, sharing your wisdom, and giving me the opportunity to pursue a career more challenging and rewarding than any I could have imagined.

Sharon

In memory of my mother, Tina C. Pinna, who started me on the path to a nutrition career in my childhood years.

Kathryn

In memory of Gary Woodruff, the editor who first encouraged me to write.

Ellie

About the Authors

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 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 (RDN) and membership in the Academy of Nutrition and Dietetics.

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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.

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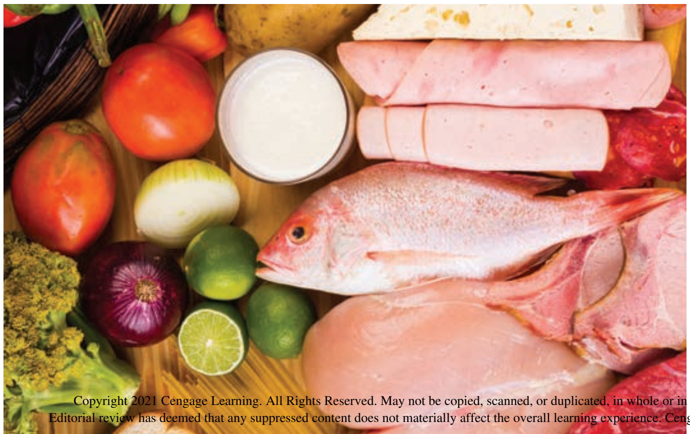
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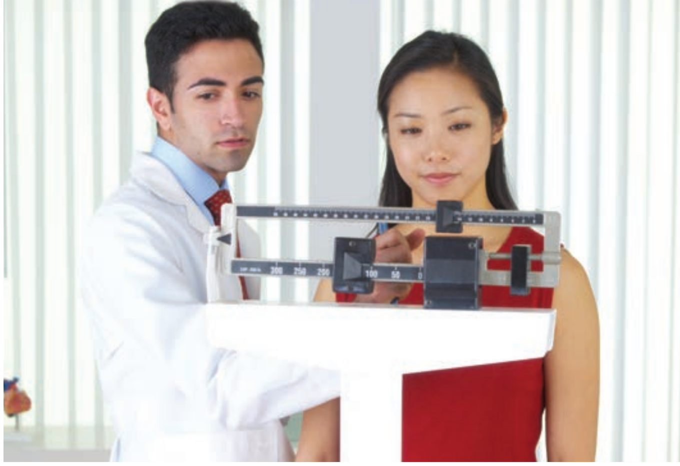
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Preface

As we launch this twelfth edition of *Understanding Normal and Clinical Nutrition*, nutrition research continues to uncover the many complex relationships between nutrition and health. Our goals for this edition are to incorporate these current research findings into the core information necessary for an introductory course in nutrition. As with previous editions, each chapter has been substantially updated and revised to include new topics as well as expand on existing topics. The chapters include practical information and valuable resources to help readers apply nutrition knowledge and skills to their daily lives and the clinical setting.

A main objective in writing this book has always been to share our enthusiasm about nutrition in a manner that motivates students to study and learn. Moreover, we seek to provide accurate information that is meaningful to the student or health professional. Students of nutrition often find the subject to be both fascinating and overwhelming; there are so many details to learn—new terms, new chemical structures, and new biological concepts. Taken one step at a time, however, the science of nutrition may seem less daunting and the facts more memorable. We hope that this book serves you well.

A Book Tour of This Edition

Understanding Normal and Clinical Nutrition presents updated, comprehensive coverage of the fundamentals of nutrition and nutrition therapy for an introductory nutrition course. The early chapters introduce the nutrients and their work in the body as well as recommendations about nutrition that are essential for maintaining health and preventing disease. The later chapters provide instruction in clinical nutrition—the pathophysiology and nutrition care for a wide range of medical conditions.

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, 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. 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 risks of weight loss and weight gain. Chapters 10, 11, 12, and 13 describe the vitamins, the minerals, and water—their roles in the body, deficiency and toxicity symptoms, and sources. Chapters 14, 15, and 16 complete the "normal" chapters by presenting the special nutrient needs of people through the life cycle—pregnancy and lactation; infancy, childhood, and adolescence; and adulthood and the later years.

The remaining "clinical" chapters of the book focus on the nutrition care of individuals with health problems. Chapter 17 explains how illnesses and their treatments influence nutrient needs and describes the process of nutrition assessment. Chapter 18 discusses how nutrition care is implemented and introduces the different types of therapeutic diets used in patient care. Chapter 19 explores the potential interactions between nutrients and medications and examines the benefits and risks associated with herbal products. Chapters 20 and 21 describe specialized methods for providing nutrients to people who are unable to consume a regular diet. Chapter 22 describes the inflammatory process and shows how metabolic and respiratory stress influence nutrient needs. Chapters 23 through 29 explore the pathology, medical treatment, and nutrition therapy for specific diseases, including gastrointestinal disorders, liver disease, diabetes mellitus, cardiovascular diseases, renal diseases, cancer, and HIV infection.

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. These definitions often include pronunciations and derivations to facilitate understanding. The glossary at the end of the book includes all defined terms.

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

CHAPTER OUTLINE & LEARNING OBJECTIVES

The opening page of each chapter provides a Chapter Outline & Learning Objectives that serves as an outline and directs readers to the main headings (and subheadings) within the chapter. Each main heading is followed by a Learning Objective for the content covered in that section. The Learning Objectives also appear within the text at the start of each main section as well as at the start of each Review It. After reading and studying the chapter, students should be able to demonstrate competency in the Learning Objectives.

Nutrition in Your Life/Nutrition in the Clinical Setting

Chapters 1 through 16 open with a paragraph called Nutrition in Your Life that introduces the chapter's content in a friendly and familiar way. Similarly, Chapters 17 through 29 open with a Nutrition in the Clinical Setting paragraph, which introduces real-life concerns associated with diseases or their treatments.

Clinical Portfolio

Chapters 17 through 29 finish with a Clinical Portfolio section, which enables readers to practice their clinical skills by addressing hypothetical clinical situations. Many of these assignments include instructions that use the Diet & Wellness Plus program. Such tools help students assess their current choices and make informed decisions about healthy options.

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 Normal and Clinical Nutrition* MindTap.

What's Online

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

> 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.

CASE STUDY

The clinical chapters include case studies that present problems and pose questions that allow readers to apply chapter material to hypothetical situations. Readers who successfully master these exercises will be better prepared to face real-life challenges that arise in the clinical setting.

Nutrition Assessment Checklist

The clinical chapters close with Nutrition Assessment Checklists that help readers evaluate how various disorders impair nutrition status. These sections highlight the medical, dietary, anthropometric, biochemical, and physical findings most relevant to patients with specific diseases.

DIET-DRUG Interactions

Most of the clinical chapters also include a section on Diet-Drug Interactions that presents the nutrition-related concerns associated with the medications commonly used to treat the disorders described in the chapter.

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 supplemental 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 2019 *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). Appendix J presents the Healthy People 2020 nutrition-related objectives.

Appendix K provides examples of commercial enteral formulas commonly used in tube feedings or to supplement oral diets.

The Inside Covers The inside covers put commonly used information at your fingertips. The inside front covers (pages A–C) present the current nutrient recommendations. The inside back covers feature the Daily Values used on food labels plus a glossary of nutrient measures (page Y), and suggested weight ranges for various heights (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

- 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 15

- 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 16

- Added discussion about influence of obesity on the aging brain

Chapter 17

- Updated statistics as necessary
- Updated the table on nursing diagnoses

Chapter 18

- In the section on dietary modifications, added a paragraph about diet progression and added the term *diet progression* to the margin glossary
- In the highlight on food allergies, revised the sections on antibody blood testing and peanut allergy

Chapter 19

- Revised the tables related to herbal products
- In the highlight on Complementary and Alternative Medicine (CAM), modified some of the terminology used to describe CAM practices and modified the discussion on the use of CAM in the United States

Chapter 20

- Modified the table comparing tube feeding routes
- Revised the section on food safety guidelines
- In the highlight about inborn errors, modified the section on nutrition therapy for phenylketonuria

Chapter 23

- Updated statistics throughout the chapter
- Added some listings in the table on the National Dysphagia Diet
- Modified some material in the sections on gastritis, gastrectomy, and bariatric surgery; added a box showing the general dietary progression after bariatric surgery
- Moved the figure showing the sleeve gastrectomy procedure to Chapter 9

Chapter 24

- Revised the table of foods that increase intestinal gas
- Revised some information about nutrition therapies for acute pancreatitis and cystic fibrosis
- Modified some foods in the table of foods that worsen diarrhea; added some gluten sources to the table describing the gluten-free diet
- Updated statistics related to the location of inflammation in Crohn's disease
- Added a glossary definition for the term *toxic megacolon*
- In the highlight on probiotics, modified the sections about dietary sources of probiotics and safety concerns associated with the use of probiotics

Chapter 25

- Updated statistics throughout the chapter
- Shortened the paragraph on the nutrition treatment for hepatitis
- Revised several paragraphs in the section on the nutrition therapy for cirrhosis, including the table summarizing nutrition recommendations

Chapter 26

- Updated statistics throughout the chapter
- Updated the figure showing the change in diabetes prevalence over a 10-year period

- Revised paragraphs in the sections on diagnosis of diabetes, prevention of type 2 diabetes, dietary and exercise recommendations, and maintaining glycemic control during exercise
- Added a box showing the glycemic goals for pregnant women with diabetes

Chapter 27

- Updated statistics throughout the chapter
- Revised the "How To" on the treatment of high blood cholesterol according to latest guidelines
- Modified some paragraphs related to lifestyle management for cardiovascular disease
- Updated the box showing how blood pressure measurements are classified
- Updated the table on recommended lifestyle modifications for blood pressure reduction

Chapter 28

- Updated statistics throughout the chapter
- Revised the paragraph on malnutrition in chronic kidney disease and introduced the term *protein-energy wasting*
- Revised the table on dietary guidelines for chronic kidney disease
- In the highlight on dialysis, revised the description of the different types of hemodialysis

Chapter 29

- Updated statistics throughout the chapter
- Updated the table on nutrition-related factors that influence cancer risk
- Revised some nutrition recommendations for cancer and HIV infection
- Replaced the medication *didanosine* with *abacavir* in the diet-drug interactions feature

Student and Instructor Resources

Nutrition MindTap for Understanding Normal and Clinical Nutrition

MindTap is an outcomes-driven application that propels students from memorization to mastery. MindTap is the platform that gives you complete control of your course—to craft unique learning experiences that challenge students, build confidence and elevate performance. cengage.com/mindtap

Cengage Unlimited saved students over $60M in its first year. One subscription includes access to every Cengage online textbook and platform, along with study tools and resources that help students explore careers and gain the skills employers want. cengage.com/unlimited/instructor

Diet & Wellness Plus

Diet & Wellness Plus helps you gain a better understanding of how nutrition relates to your personal health goals. It enables you to track your diet and activity, generate reports, and analyze the nutritional value of the food you eat! It includes over 55,000 foods in the database, custom food and recipe features, the latest Dietary References, as well as your goal and actual percentages of essential nutrients, vitamins, and minerals. It also helps you to identify a problem behavior and make a positive change. After completing a Wellness Profile questionnaire, Diet & Wellness Plus will rate the level of concern for eight different areas of wellness, helping you determine the areas where you are most at risk. It then helps you put together a plan for positive change by helping you select a goal to work toward, complete with a reward for all your hard work. Diet & Wellness Plus is also available as an App that can accessed from the App dock in MindTap and can be used throughout the course for students to track their diet, activity, and behavior change.

Cognero Test Bank

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

- Author, edit, and manage test bank content from multiple Cengage Learning solutions
- Create multiple test versions in an instant
- Deliver tests from your learning management system (LMS), your classroom, or wherever you want

Instructor Companion Site

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

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.

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1
An Overview of Nutrition

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Nutrition in Your Life

Believe it or not, you have probably eaten at least 20,000 meals in your life. Without any conscious effort on your part, your body uses the nutrients from 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 that food habits affect health, they often choose foods for other reasons. After all, foods bring pleasures, traditions, and associations as well as nourishment. The challenge, then, is to combine favorite foods 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

LO1.1 Describe how various factors influence personal food choices.

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

Preferences As you might expect, the number one reason most people choose certain foods is taste—they like the flavor. Two widely shared preferences are for the sweetness of sugar and the savoriness of salt.[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 14).

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 food, more often. These marketing efforts pay off well, with sales exceeding $900 billion each year. In addition to building brand loyalty, food companies attract busy consumers with their promises of convenience.

Availability, Convenience, and Economy 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 9th month of the Islamic calendar). Some vegetarians select foods based on their support for animal rights. A concerned consumer may boycott fruit picked by migrant workers who have been exploited. People may buy vegetables from local farmers to 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.

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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.

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 discussions of eating disorders (Highlight 8) and dietary supplements commonly used by athletes.

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

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

LO 1.2 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.

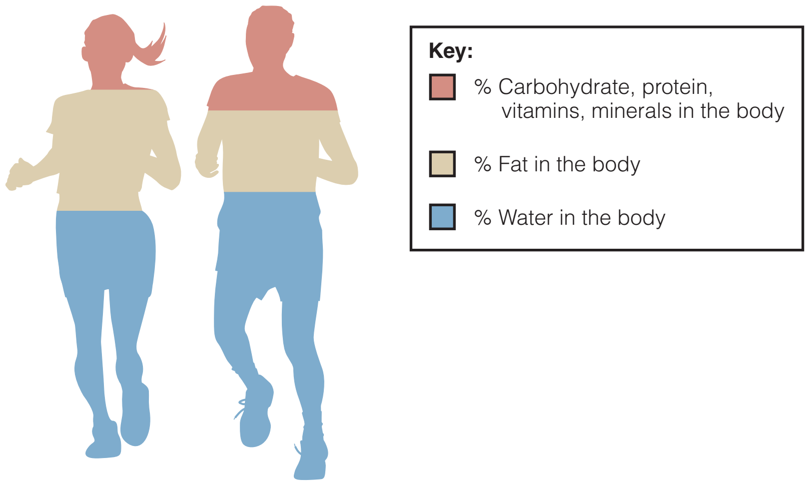
nutrients: chemical substances obtained from food and used in the body to provide energy, structural materials, and regulating agents to support growth, maintenance, and repair of the body's tissues. Nutrients may also reduce the risks of some diseases.

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. 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.

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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).

*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.

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

>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

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

Tarasyuk Igor/Shutterstock.com

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.

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

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

Stephen Barnes/Farming/Alamy Stock Photo

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,

>How To 1-2 Calculate the Energy Available from Foods

To calculate the energy available from a food, multiply the number of grams of carbohydrate, protein, and fat by 4, 4, and 9, respectively. Then add the results together. For example, 1 slice of bread with 1 tablespoon of peanut butter on it contains 16 grams carbohydrate, 7 grams protein, and 9 grams fat:

$$16 \text{ g carbohydrate} \times 4 \text{ kcal/g} = 64 \text{ kcal}$$
$$7 \text{ g protein} \times 4 \text{ kcal/g} = 28 \text{ kcal}$$
$$9 \text{ g fat} \times 9 \text{ kcal/g} = 81 \text{ kcal}$$
$$\text{Total} = 173 \text{ kcal}$$

From this information, you can calculate the percentage of kcalories each of the energy nutrients contributes to the total. To determine the percentage of kcalories from fat, for example, divide the 81 fat kcalories by the total 173 kcalories:

$$81 \text{ fat kcal} \div 173 \text{ total kcal} = 0.468$$
(rounded to 0.47)

Then multiply by 100 to get the percentage:

$$0.47 \times 100 = 47\%$$

Dietary recommendations that urge people to limit fat intake to 20 to 35 percent of kcalories refer to the day's total energy intake, not to individual foods. Still, if the proportion of fat in each food choice throughout a day exceeds 35 percent of kcalories, then the day's total surely will, too. Knowing that this snack provides 47 percent of its kcalories from fat alerts a person to the need to make lower-fat selections at other times that day.

> TRY IT Calculate the energy available from a bean burrito with cheese (55 grams carbohydrate, 15 grams protein, and 12 grams fat). Determine the percentage of kcalories from each of the energy nutrients.

and minerals as well as protein. Bread contains water, a trace of fat, a little protein, and some vitamins and minerals in addition to its carbohydrate. Only a few foods are exceptions to this rule, the common ones being sugar (pure carbohydrate) and oil (essentially pure fat).

Energy in the Body When the body uses carbohydrate, fat, or protein to fuel its activities, the bonds between the nutrient's atoms break. As the bonds break, they release energy. Some of this energy is released as heat, but some is used to send electrical impulses through the brain and nerves, to synthesize body compounds, and to move muscles. Thus the energy from food supports every activity from quiet thought to vigorous sports.

If the body does not use these nutrients to fuel its current activities, it converts them into storage compounds (such as body fat), to be used between meals and overnight when fresh energy supplies run low. If more energy is consumed than expended, the result is an increase in energy stores and weight gain. Similarly, if less energy is consumed than expended, the result is a decrease in energy stores and weight loss.

When consumed in excess of energy needs, alcohol, too, can be converted to body fat and stored. When alcohol contributes a substantial portion of the energy in a person's diet, the harm it does far exceeds the problems of excess body fat. Highlight 7 describes the effects of alcohol on health and nutrition.

Other Roles of Energy-Yielding Nutrients In addition to providing energy, carbohydrates, fats, and proteins provide the raw materials for building the body's tissues and regulating its many activities. In fact, protein's role as an energy source is relatively minor compared with both the other two energy-yielding nutrients and its other roles. Proteins are found in structures such as the muscles and skin and help to regulate activities such as digestion and energy metabolism. Chapters 4, 5, and 6 present a full discussion on carbohydrates, fats, and proteins.

The Vitamins The **vitamins** are also organic, but they do not provide energy. Instead, they facilitate the release of energy from carbohydrate, fat, and protein and participate in numerous other activities throughout the body.

Each of the 13 vitamins has its own special roles to play.* One vitamin enables the eyes to see in dim light, another helps protect the lungs from air pollution, and still another helps make the sex hormones—among other things. When you cut yourself, one vitamin helps stop the bleeding and another helps repair the skin. Vitamins busily help replace old red blood cells and the lining of the digestive tract. Almost every action in the body requires the assistance of vitamins.

Vitamins can function only if they are intact, but because they are complex organic molecules, they are vulnerable to destruction by heat, light, and chemical agents. This is why the body handles them carefully, and why nutrition-wise cooks do, too. The strategies of cooking vegetables at moderate temperatures for short times and using small amounts of water help preserve the vitamins.

The Minerals In the body, some **minerals** are put together in orderly arrays in such structures as bones and teeth. Minerals are also found in the fluids of the body, which influences fluid balance and distribution. Whatever their roles, minerals do not yield energy.

Only 16 minerals are known to be essential in human nutrition.** Others are being studied to determine whether they play significant roles in the human body. Still other minerals, such as lead, are environmental contaminants that displace the nutrient minerals from their workplaces in the body, disrupting body functions. The problems caused by contaminant minerals are described in Chapter 13.

Because minerals are inorganic, they are indestructible and need not be handled with the special care that vitamins require. Minerals can, however, be bound by substances that interfere with the body's ability to absorb them. They can also be lost during food processing or during cooking when they leach into water that is discarded.

Water Water provides the environment in which nearly all the body's activities take place. It participates in many metabolic reactions and supplies the medium for transporting vital materials to cells and carrying waste products away from them. Water is discussed fully in Chapter 12, but it is mentioned in every chapter (see Photo 1-4). If you watch for it, you cannot help but be impressed by water's participation in all life processes.


frantic00/Shutterstock.com

> **PHOTO 1-4** Water is an essential nutrient and naturally carries varying amounts of several minerals.

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

Foods provide nutrients—substances that support the growth, maintenance, and repair of the body's tissues. The six classes of nutrients include:

- Carbohydrates
- Lipids (fats)
- Proteins
- Vitamins
- Minerals
- Water

Foods rich in the energy-yielding nutrients (carbohydrate, fat, and protein) provide the major materials for building the body's tissues and yield energy for the body's use or storage. Energy is measured in kcalories—a measure of heat energy. Vitamins, minerals, and water do not yield energy; instead they facilitate a variety of activities in the body.

*The water-soluble vitamins are vitamin C and the eight B vitamins: thiamin, riboflavin, niacin, vitamins B_6 and B_{12}, folate, biotin, and pantothenic acid (see Chapter 10). The fat-soluble vitamins are vitamins A, D, E, and K (see Chapter 11).

**The major minerals are calcium, phosphorus, potassium, sodium, chloride, magnesium, and sulfate (see Chapter 12). The trace minerals are iron, iodine, zinc, chromium, selenium, fluoride, molybdenum, copper, and manganese (see Chapter 13).

vitamins: organic, essential nutrients required in small amounts by the body for health. Vitamins regulate body processes that support growth and maintain life.

minerals: inorganic elements. Some minerals are essential nutrients required in small amounts by the body for health.

Without exaggeration, nutrients provide the physical and metabolic basis for nearly all that we are and all that we do. The next section introduces the science of nutrition with emphasis on the research methods scientists have used in uncovering the wonders of nutrition.

1.3 The Science of Nutrition

LO 1.3 Explain the scientific method and how scientists use various types of research studies and methods to acquire nutrition information.

The science of nutrition is the study of the nutrients and other substances in foods and the body's handling of them. Its foundation depends on several other sciences, including biology, biochemistry, and physiology. Nutrition is a relatively young science, but much has happened in its short life. And it is currently experiencing a tremendous growth spurt as scientists apply knowledge gained from sequencing the human **genome**. The integration of nutrition, genomics, and molecular biology has opened a whole new world of study called **nutritional genomics**—the science of how nutrients affect the activities of genes and how genes affect the interactions between diet and disease. Highlight 6 describes how nutritional genomics is shaping the science of nutrition, and examples of nutrient-gene interactions appear throughout later chapters.

Conducting Research

Consumers sometimes depend on personal experience or social media to gather information on nutrition. Such a personal account of an experience or event is known as an **anecdote** and is not accepted as reliable scientific information (see Glossary 1-1 for definitions of research terms). In contrast, researchers use the scientific method to guide their work (see Figure 1-3). As the figure shows, research always begins with a problem or a question. For example, "What foods or nutrients might protect against the common cold?" In search of an answer, scientists make an educated guess **(hypothesis)**, such as "foods rich in vitamin C reduce the number of common colds." Then they systematically conduct research studies to collect data that will test the hypothesis. Some examples of various types of research designs are presented in Figure 1-4 (p. 14). Because each type of study has strengths and weaknesses, some provide stronger evidence than others, as Figure 1-4 explains.

In attempting to discover whether a nutrient relieves symptoms or cures a disease, researchers deliberately manipulate one variable (for example, the amount of vitamin C in the diet) and measure any observed changes (perhaps the number of colds). As much as possible, all other conditions are held constant.

Controls

In studies examining the effectiveness of vitamin C, researchers typically divide the **subjects** into two groups. One group (the **experimental group**) receives a vitamin C supplement, and the other (the **control group**) does not. Researchers observe both groups to determine whether one group has fewer, milder, or shorter colds than the other.

In sorting subjects into two groups, researchers must ensure that each person has an equal chance of being assigned to either the experimental group or the control group. This is accomplished by **randomization**; that is, the subjects are chosen randomly from the same population by flipping a coin or some other method involving chance. Randomization helps to eliminate bias and ensure that the two groups are "equal" and that observed differences reflect the treatment and not other factors.[16]

Importantly, the two groups of subjects must be similar and must have the same track record with respect to colds to rule out the possibility that observed differences in the rate, severity, or duration of colds might have occurred anyway. If, for example, the control group would normally catch twice as many colds as the experimental group, then the findings prove nothing.

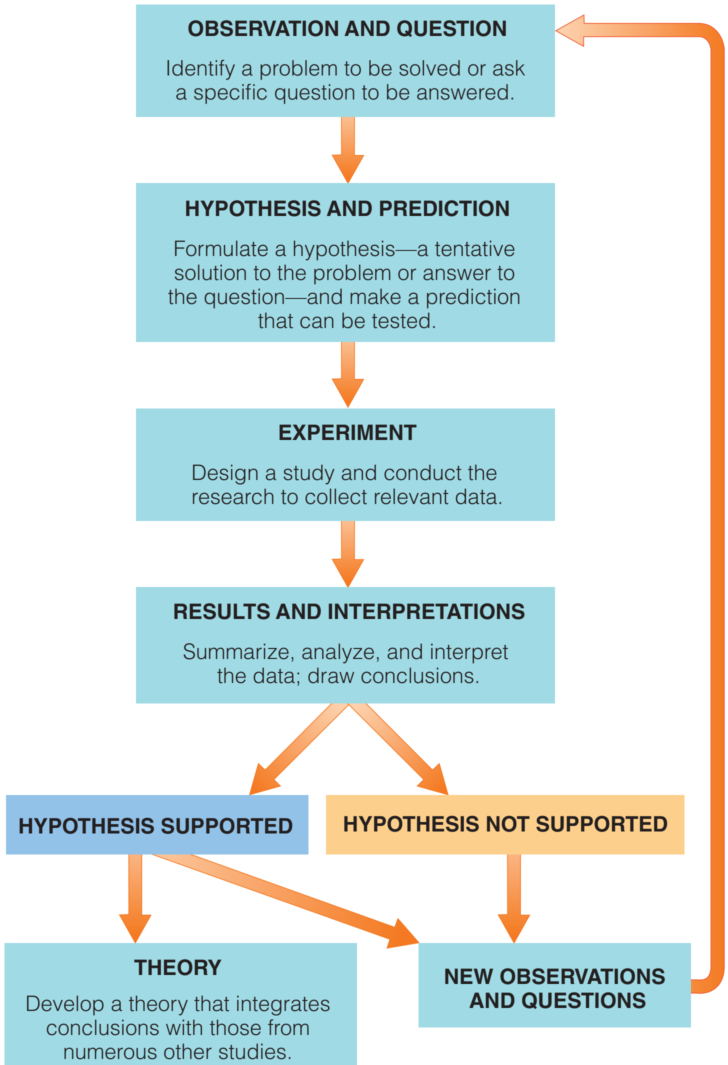
In experiments involving a nutrient, the diets of both groups must also be similar, especially with respect to the nutrient being studied. If those in the

genome (GEE-nome): the complete set of genetic material (DNA) in an organism or a cell. The study of genomes is called *genomics.*

nutritional genomics: the science of how nutrients affect the activities of genes (*nutrigenomics*) and how genes affect the activities of nutrients (*nutrigenetics*).

> FIGURE 1-3 The Scientific Method

Research scientists follow the scientific method. Note that most research generates new questions, not final answers. Thus, the sequence begins anew, and research continues in a somewhat cyclical way.



GLOSSARY 1-1
RESEARCH TERMS

anecdote: a personal account of an experience or event; not reliable scientific information.

blind experiment: an experiment in which the subjects do not know whether they are members of the experimental group or the control group.

control group: a group of individuals similar in all possible respects to the experimental group except for the treatment. Ideally, the control group receives a placebo while the experimental group receives a real treatment.

correlation (CORE-ee-LAY-shun): the simultaneous increase, decrease, or change in two variables. If A increases as B increases, or if A decreases as B decreases, the correlation is *positive.* (This does not mean that A causes B or vice versa.) If A increases as B decreases, or if A decreases as B increases, the correlation is *negative.* (This does not mean that A prevents B or vice versa.) Some third factor may account for both A and B.

double-blind experiment: an experiment in which neither the subjects nor the researchers know which subjects are members of the experimental group and which are serving as control subjects, until after the experiment is over.

experimental group: a group of individuals similar in all possible respects to the control group except for the treatment. The experimental group receives the real treatment.

hypothesis (hi-POTH-eh-sis): an unproven statement that tentatively explains the relationships between two or more variables.

peer review: a process in which a panel of scientists rigorously evaluates a research study to ensure that the scientific method was followed.

placebo (pla-SEE-bo): an inert, harmless medication given to provide comfort and hope; a sham treatment used in controlled research studies.

placebo effect: a change that occurs in response to expectations about the effectiveness of a treatment that actually has no pharmaceutical effects.

randomization (RAN-dom-ih-ZAY-shun): a process of choosing the members of the experimental and control groups without bias.

replication (REP-lih-KAY-shun): repeating an experiment and getting the same results.

subjects: the people or animals participating in a research project.

theory: a tentative explanation that integrates many diverse findings to further the understanding of a defined topic.

validity (va-LID-ih-tee): having the quality of being founded on fact or evidence.

variables: factors that change. A variable may depend on another variable (for example, a child's height depends on his age), or it may be independent (for example, a child's height does not depend on the color of her eyes). Sometimes both variables correlate with a third variable (a child's height and eye color both depend on genetics).

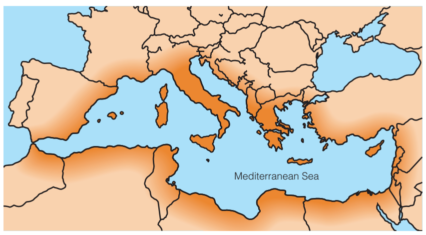
> FIGURE 1-4 Examples of Research Designs

EPIDEMIOLOGICAL STUDIES research the incidence, distribution, and control of diseases in a population. Epidemiological studies include cross-sectional, case-control, and cohort studies.

Strengths:
- Can narrow down the list of possible causes
- Can raise questions to pursue through other research

Weaknesses:
- Cannot control variables that may influence the development or the prevention of a disease
- Cannot prove cause and effect

CROSS-SECTIONAL STUDIES



Researchers observe how much and what kinds of foods a group of people eat and how healthy those people are. Their findings identify factors that might influence the incidence of a disease in various populations.

Example. Many people in the Mediterranean region drink more wine, eat more fat from olive oil, and yet have a lower incidence of heart disease than northern Europeans and North Americans.

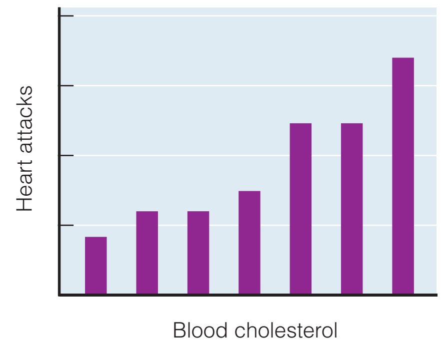
CASE–CONTROL STUDIES

Lester V. Bergman/Corbis Documentary/Getty Images

Researchers compare people who do and do not have a given condition such as a disease, closely matching them in age, sex, and other key variables so that differences in other factors will stand out. These differences may account for the condition in the group that has it.

Example. People with goiter lack iodine in their diets.

COHORT STUDIES



Researchers analyze data collected from a selected group of people (a cohort) at intervals over a certain period of time.

Example. Data collected periodically over the past several decades from more than 5000 people randomly selected from the town of Framingham, Massachusetts, in 1948 have revealed that the risk of heart attack increases as blood cholesterol increases.

EXPERIMENTAL STUDIES test cause-and-effect relationships between variables. Experimental studies include laboratory-based studies—on animals or in test tubes (in vitro)—and human intervention (or clinical) trials.

Strengths:
- Can control conditions (for the most part)
- Can determine effects of a variable
- Can apply some findings on human beings to some groups of human beings

Weaknesses:
- Cannot apply results from test tubes or animals to human beings
- Cannot generalize findings on human beings to all human beings
- Cannot use certain treatments for clinical or ethical reasons

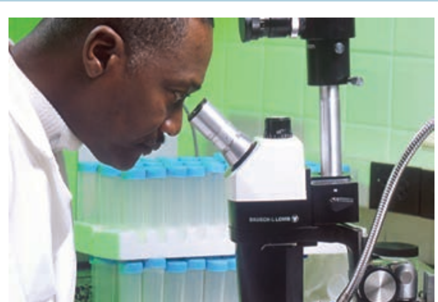
LABORATORY-BASED ANIMAL STUDIES

Remi BENALI/Gamma-Rapho/Getty Images

Researchers feed animals special diets that provide or omit specific nutrients and then observe any changes in health. Such studies test possible disease causes and treatments in a laboratory where conditions can be controlled.

Example. Mice fed a high-fat diet eat less food than mice given a lower-fat diet, so they receive the same number of kcalories—but the mice eating the high-fat diet become obese.

LABORATORY-BASED IN VITRO STUDIES



Source: USDA Agricultural Research Service

Researchers examine the effects of a specific variable on a tissue, cell, or molecule isolated from a living organism.

Example. Laboratory studies find that fish oils inhibit the growth and activity of the bacteria implicated in ulcer formation.

HUMAN INTERVENTION (OR CLINICAL) TRIALS

David Buffington/Stockbyte/Getty Images

Researchers ask people to adopt a new behavior (for example, eat a citrus fruit, take a vitamin C supplement, or exercise daily). These trials help determine the effectiveness of such interventions on the development or prevention of disease.

Example. Heart disease risk factors improve when men drink fresh-squeezed orange juice daily for 2 months compared with those on a diet low in vitamin C—even when both groups follow a diet high in saturated fat.

experimental group are receiving less vitamin C from their usual diet, then any effects of the supplement may not be apparent.

Sample Size To ensure that chance variation between the two groups does not influence the results, the groups must be large. For example, if one member of a group of five catches a bad cold, he will pull the whole group's average toward bad colds; but if one member of a group of 500 catches a bad cold, she will not unduly affect the group average. Statistical methods are used to determine whether differences between groups of various sizes support a hypothesis.

Placebos If people who take vitamin C for colds *believe* it will cure them, their chances of recovery may improve. Taking pills believed to be beneficial may shorten the duration and lessen the severity of illness regardless of whether the pills contain active ingredients. This phenomenon, the result of expectations, is known as the **placebo effect**. In experiments designed to determine vitamin C's effect on colds, this mind-body effect must be rigorously controlled. Severity of symptoms is often a subjective measure, and people who believe they are receiving treatment may report less severe symptoms.

One way experimenters control for the placebo effect is to give pills to all participants. Those in the experimental group, for example, receive pills containing vitamin C, and those in the control group receive a **placebo**—pills of similar appearance and taste containing an inactive ingredient. This way, the expectations of the two groups will be equal. It is not necessary to convince all subjects that they are receiving vitamin C, but the extent of belief or nonbelief must be the same in both groups. A study conducted under these conditions is called a **blind experiment**—that is, the subjects do not know (are blind to) whether they are members of the experimental group (receiving treatment) or the control group (receiving the placebo).

Double Blind When both the subjects and the researchers do not know which subjects are in which group, the study is called a **double-blind experiment**. Being fallible human beings and having an emotional and sometimes financial investment in a successful outcome, researchers might record and interpret results with a bias in the expected direction. To prevent such bias, the pills are coded by a third party, who does not reveal to the experimenters which subjects are in which group until all results have been recorded.

Analyzing Research Findings

Research findings must be analyzed and interpreted with an awareness of each study's limitations. Scientists must be cautious about drawing any conclusions until they have accumulated a body of evidence from multiple studies that have used various types of research designs. As evidence accumulates, scientists begin to develop a **theory** that integrates the various findings and explains the complex relationships.

Correlations and Causes Researchers often examine the relationships between two or more **variables**—for example, daily vitamin C intake and the number of colds or the duration and severity of cold symptoms. Importantly, researchers must be able to observe, measure, or verify the variables selected. Findings sometimes suggest no **correlation** between variables (regardless of the amount of vitamin C consumed, the number of colds remains the same). Other times, studies find either a **positive correlation** (the more vitamin C, the more colds) or a **negative correlation** (the more vitamin C, the fewer colds). Notice that in a positive correlation, both variables change in the same direction, regardless of whether the direction is "more" or "less"—"the more vitamin C, the more colds" is a positive correlation, just as is "the less vitamin C, the fewer colds." In a negative correlation, the two variables change in opposite directions: "the less vitamin C, the more colds" or "the more vitamin C, the fewer colds." Also notice that a positive correlation does not necessarily reflect a desired outcome, nor does a negative correlation always reflect an undesirable outcome.

Correlational evidence proves only that variables are associated, not that one is the cause of the other. To actually prove that A causes B, scientists have to find evidence of the *mechanism*—that is, an explanation of how A might cause B.

Cautious Conclusions When researchers record and analyze the results of their experiments, they must exercise caution in their interpretation of the findings. For example, in an epidemiological study, scientists may use a specific segment of the population—say, men 18 to 30 years old. When the scientists draw conclusions, they are careful not to generalize the findings to older men or women of any age. Similarly, animals may provide a suitable model for some human studies but scientists must be cautious in applying animal findings to human beings.[17] Conclusions from any one research study are always tentative and take into account findings from studies conducted by other scientists as well. As evidence accumulates, scientists gain confidence about drawing conclusions and making recommendations. Even then, their statements are worded cautiously, such as "A diet high in fruits and vegetables *may* protect against *some* cancers."

Publishing Research

The findings from a research study are submitted to a board of reviewers composed of other scientists who rigorously evaluate the study to ensure that the scientific method was followed—a process known as **peer review**. The reviewers critique the study's hypothesis, methodology, statistical significance, and conclusions. They also note the funding source, recognizing that financial support and other conflicts of interest may bias scientific conclusions.[18] If the reviewers consider the conclusions to be well supported by the evidence—that is, if the research has **validity**—they endorse the work for publication in a scientific journal where others can read it. This raises an important point regarding information found on the Internet: much gets published without the rigorous scrutiny of peer review. Consequently, readers must assume greater responsibility for examining the data and conclusions presented. Highlight 1 offers guidance in determining whether Internet information is reliable. Table 1-3 describes the parts of a typical research article.

Even when a new finding is published or released to the media, it is still only preliminary and not very meaningful by itself. Other scientists will need to confirm or disprove the findings through **replication** and reanalysis.[19] To be accepted into the body of nutrition knowledge, findings must stand up to rigorous, repeated testing in experiments conducted by other researchers. What we "know" in nutrition results from years of research findings. Communicating the latest finding in its proper context without distorting or oversimplifying the message is a challenge for scientists and journalists alike.[20] For a helpful scientific overview of topics in nutrition, look for review articles in scholarly journals such as *Nutrition Reviews*. Reviews may be either a **systematic review**, which provides a qualitative summary of the evidence or a **meta-analysis**, which provides a quantitative summary.[21]

With each report from scientists, the field of nutrition changes a little—each finding contributes another piece to the whole body of knowledge (see Photo 1-5). People who know how science works understand that single findings, like single

> **PHOTO 1-5** Knowledge about the nutrients and their effects on health comes from scientific studies.

systematic review: a critical and integrative summary of evidence gathered from multiple selected studies to answer a specific question and develop a *qualitative* review.

meta-analysis: an objective and statistical summary of evidence gathered from multiple selected studies to develop a *quantitative* review; often derived from a systematic review.

TABLE 1-3 Parts of a Typical Research Article

- *Abstract:* The abstract provides a brief overview of the article.
- *Introduction:* The introduction clearly states the purpose of the current study and provides a comprehensive review of the relevant literature.
- *Methodology:* The methodology section defines key terms and describes the study design, subjects, and procedures used in conducting the study.
- *Results:* The results report the findings and may include tables and figures that summarize the information.
- *Discussion*: The discussion draws tentative conclusions that are supported by the data and reflect the original purpose as stated in the introduction. Usually, it answers a few questions and raises several more.
- *References*: The references reflect the investigator's knowledge of the subject and should include an extensive list of relevant studies.

frames in a movie, are just small parts of a larger story. Over years, nutrition knowledge gradually changes, and dietary recommendations change to reflect the current understanding of scientific research. Highlight 5 provides a detailed look at how dietary fat recommendations have evolved over the past several decades as researchers have uncovered the relationships between the various kinds of fat and their roles in supporting or harming health.

> **REVIEW IT** Explain the scientific method and how scientists use various types of research studies and methods to acquire nutrition information.
> Scientists learn about nutrition by conducting experiments that follow the protocol of scientific research. In designing their studies, researchers randomly assign control and experimental groups, seek large sample sizes, provide placebos, and remain blind to treatments. Their findings must be reviewed and replicated by other scientists before being accepted as valid.

The characteristics of well-designed research have enabled scientists to study the actions of nutrients in the body. Such research has laid the foundation for quantifying how much of each nutrient the body needs.

1.4 Dietary Reference Intakes

LO 1.4 Define the four categories of the DRI and explain their purposes.

Using the results of thousands of research studies, nutrition experts have produced a set of standards that define the amounts of energy, nutrients, and other dietary components that best support health. These recommendations are called **Dietary Reference Intakes (DRI)**, and they reflect the collaborative efforts of researchers in both the United States and Canada.* The inside front cover provides a handy reference for DRI values.

Establishing Nutrient Recommendations The DRI Committee consists of highly qualified scientists who base their estimates of nutrient needs on careful examination and interpretation of scientific evidence. These recommendations apply to healthy people and may not be appropriate for people with diseases that increase or decrease nutrient needs. The next several paragraphs introduce the four categories of the DRI, explain their purposes, and discuss specific aspects of how the committee goes about establishing these values:

- Estimated Average Requirements (EAR)
- Recommended Dietary Allowances (RDA)
- Adequate Intakes (AI)
- Tolerable Upper Intake Levels (UL)

Estimated Average Requirements (EAR) The committee reviews hundreds of research studies to determine the **requirement** for a nutrient—how much is needed in the diet. The committee selects a specific criterion for each nutrient based on its roles in supporting various activities in the body and in reducing disease risks.

An examination of all the available data reveals that each person's body is unique and has its own set of requirements. Men differ from women, and needs change as people grow from infancy through old age. For this reason, the committee clusters its recommendations for people into groups based on sex and age. Even so, the exact requirements for people of the same sex and age are likely to be different. Person A might need 40 units of a particular nutrient each day; person B might need 35; and person C might need 57. Looking at enough people might reveal that their individual requirements fall into a symmetrical distribution, with most near the midpoint and only a few at the extremes (see the left side of Figure 1-5, p. 18). Using this information, the committee determines an **Estimated Average Requirement (EAR)**

*The DRI reports are produced by the Food and Nutrition Board, Institute of Medicine of the National Academies, with active involvement of scientists from the United States and Canada.

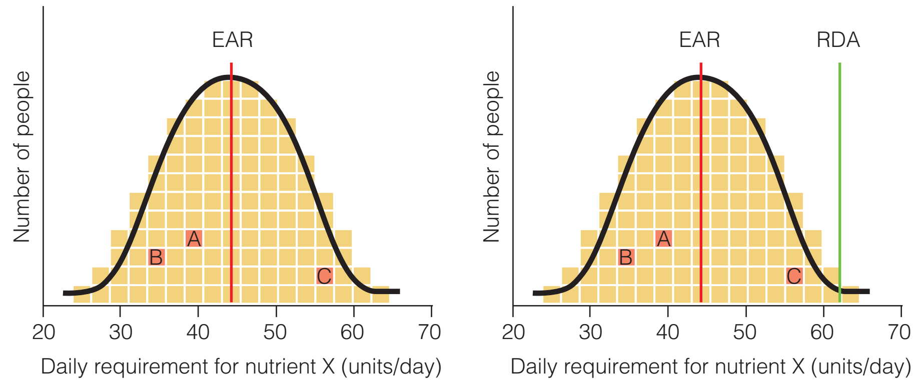
Dietary Reference Intakes (DRI): a set of nutrient intake values for healthy people in the United States and Canada. These values are used for planning and assessing diets and include:
- Estimated Average Requirements (EAR)
- Recommended Dietary Allowances (RDA)
- Adequate Intakes (AI)
- Tolerable Upper Intake Levels (UL)

requirement: the lowest continuing intake of a nutrient that will maintain a specified criterion of adequacy.

Estimated Average Requirement (EAR): the average daily amount of a nutrient that will maintain a specific biochemical or physiological function in half the healthy people of a given age and sex group.

> **FIGURE 1-5 Estimated Average Requirements (EAR) and Recommended Dietary Allowances (RDA) Compared**

Each square in the graphs below represents a person with unique nutritional requirements. (The text discusses three of these people—A, B, and C.) Some people require only a small amount of nutrient X and some require a lot. Most people, however, fall somewhere in the middle.



The Estimated Average Requirement (EAR) for a nutrient is the amount that meets the needs of about half of the population (shown here by the red line).

The Recommended Dietary Allowance (RDA) for a nutrient (shown here in green) is set well above the EAR, meeting the needs of about 98% of the population.

for each nutrient—the average amount that appears sufficient for half of the population. In Figure 1-5, the EAR is shown as 45 units.

Recommended Dietary Allowances (RDA) Once a nutrient *requirement* is established, the committee must decide what intake to *recommend* for everybody—the **Recommended Dietary Allowance (RDA)**. As you can see by the distribution in Figure 1-5, the EAR (shown in the figure as 45 units) is probably closest to everyone's need. If people consumed exactly the average requirement of a given nutrient each day, however, approximately half of the population would develop deficiencies of that nutrient—in Figure 1-5, for example, person C would be among them. Recommendations are therefore set greater than the EAR to meet the needs of most healthy people.

Small amounts greater than the daily requirement do no harm, whereas amounts less than the requirement may lead to health problems. When people's nutrient intakes are consistently **deficient** (less than the requirement), their nutrient stores decline, and over time this decline leads to poor health and deficiency symptoms. Therefore, to ensure that the nutrient RDA meet the needs of as many people as possible, the RDA are set near the top end of the range of the population's estimated requirements.

In this example, a reasonable RDA might be 63 units a day (see the right side of Figure 1-5). Such a point can be calculated mathematically so that the needs of about 98 percent of a population are included. Almost everybody—including person C, whose needs were more substantial than the average—would consume enough of the nutrient if they met this dietary goal. Relatively few people's requirements would exceed this recommendation, and even then, they wouldn't exceed it by much. Notice that Figure 1-5 illustrates how the EAR meets the needs of about half of the population, whereas the RDA meets the needs of about 98 percent of the population.

Adequate Intakes (AI) For some nutrients, such as vitamin K, there is insufficient scientific evidence to determine an EAR (which is needed to set an RDA). In these cases, the committee establishes an **Adequate Intake (AI)** instead of an RDA. An AI reflects the average amount of a nutrient that a group of healthy people consumes. Like the RDA, the AI may be used as a nutrient intake goal for individuals.

Although both the RDA and the AI serve as nutrient intake goals for individuals, their differences are noteworthy. An RDA for a given nutrient is based on enough scientific evidence to expect that the needs of almost all healthy people will be

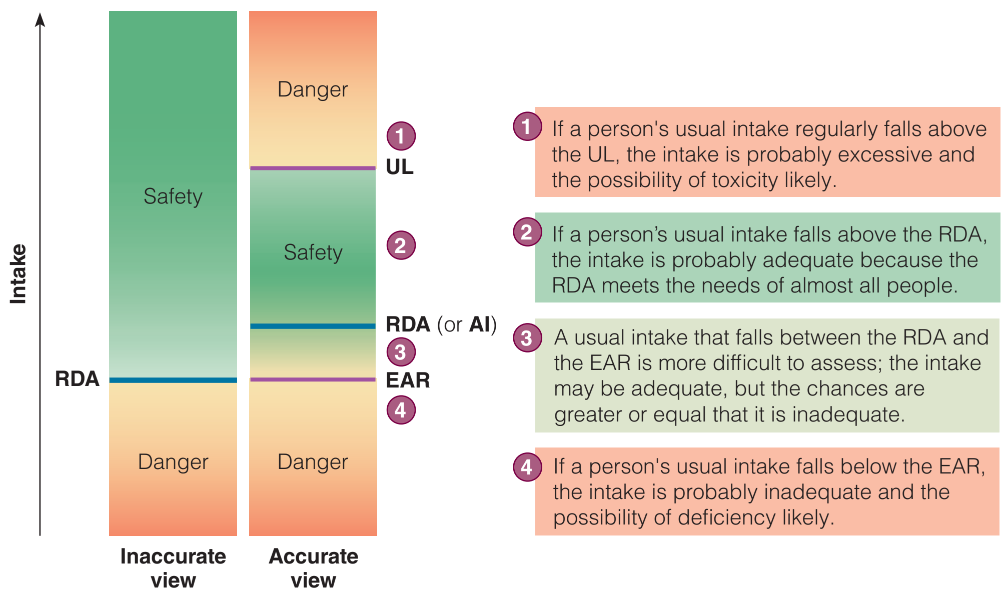
Recommended Dietary Allowance (RDA): the average daily amount of a nutrient considered adequate to meet the known nutrient needs of practically all healthy people; a goal for dietary intake by individuals.

deficient: inadequate; a nutrient amount that fails to meet the body's needs and eventually results in deficiency symptoms.

Adequate Intake (AI): the average daily amount of a nutrient that appears sufficient to maintain a specified criterion; a value used as a guide for nutrient intake when an RDA cannot be determined.

> **FIGURE 1-6 Inaccurate versus Accurate View of Nutrient Intakes**

The RDA (or AI) for a given nutrient represents a point that lies within a range of appropriate and reasonable intakes between toxicity and deficiency. Both of these recommendations are high enough to provide reserves in times of short-term dietary inadequacies, but not so high as to approach toxicity. Nutrient intakes above or below this range may be equally harmful.



met. An AI, on the other hand, must rely more heavily on scientific judgments because sufficient evidence is lacking. For this reason, AI values are more tentative than RDA values. The inside front cover (pp. A-B) identifies which nutrients have an RDA and which have an AI. Later chapters present the RDA and AI values for vitamins and minerals.

Tolerable Upper Intake Levels (UL) As mentioned earlier, the recommended intakes for nutrients are generous, yet they may not be sufficient for every individual for every nutrient. Nevertheless, it is probably best not to exceed these recommendations by very much or very often. Individual tolerances for high doses of nutrients vary, and somewhere greater than the recommended intake is a point beyond which a nutrient is likely to become toxic. This point is known as the **Tolerable Upper Intake Level (UL)**. It is naïve—and inaccurate—to think of recommendations as minimum amounts. A more accurate view is to see a person's nutrient needs as falling within a range, with marginal and danger zones at each end for intakes that are either inadequate or excessive (see Figure 1-6).

Paying attention to the UL is particularly useful in guarding against the overconsumption of nutrients, which may occur when people use large-dose dietary supplements and fortified foods regularly. Later chapters discuss the dangers associated with excessively high intakes of vitamins and minerals, and the inside front cover (p. C) presents tables of the UL for selected nutrients.

Establishing Energy Recommendations

In contrast to the RDA and AI values for nutrients, the recommendation for energy is not generous. Excess energy cannot be readily excreted and is eventually stored as body fat. These reserves may be beneficial when food is scarce, but they can also lead to obesity and its associated health consequences.

Estimated Energy Requirement (EER) The energy recommendation—called the **Estimated Energy Requirement (EER)**—represents the average dietary energy intake (kcalories per day) that will maintain energy balance in a person who has a healthy body weight and level of physical activity. Balance is key to the energy recommendation. Enough food energy is needed to sustain a healthy and active life.

Tolerable Upper Intake Level (UL): the maximum daily amount of a nutrient that appears safe for most healthy people and beyond which there is an increased risk of adverse health effects.

Estimated Energy Requirement (EER): the average dietary energy intake that maintains energy balance and good health in a person of a given age, sex, weight, height, and level of physical activity.

Because *any* amount in excess of energy needs will result in weight gain, no UL for energy has been determined.

Acceptable Macronutrient Distribution Ranges (AMDR) People don't eat energy directly; they derive energy from foods containing carbohydrates, fats, and proteins. Each of these three energy-yielding nutrients contributes to the total energy intake, and those contributions vary in relation to one another. The DRI committee has determined that the composition of a diet that provides adequate energy and nutrients and reduces the risk of chronic diseases is:

- 45 to 65 percent kcalories from carbohydrate
- 20 to 35 percent kcalories from fat
- 10 to 35 percent kcalories from protein

These values are known as **Acceptable Macronutrient Distribution Ranges (AMDR)**. Figure 1-7 illustrates that diets with varying amounts of carbohydrate, fat, and protein can all fall within the AMDR and when the contribution of any of the energy nutrients increases or decreases, the contribution of the others shifts as well.

Using Nutrient Recommendations

Although the intent of nutrient recommendations seems simple, they are the subject of much misunderstanding and controversy (see Photo 1-6). Perhaps the following facts will help put them in perspective:

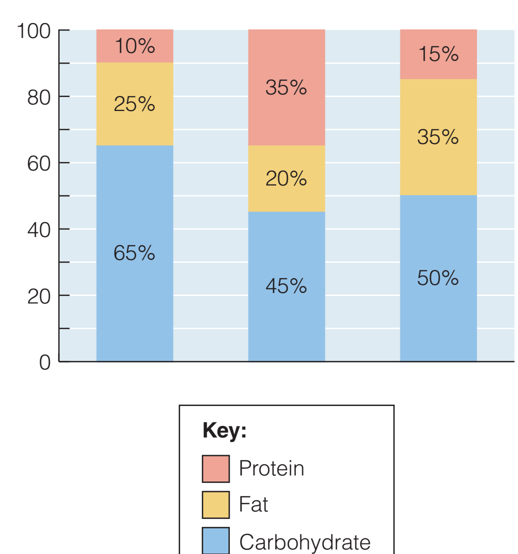
1. Estimates of adequate energy and nutrient intakes apply to *healthy* people. They need to be adjusted for malnourished people or those with medical problems who may require supplemented or restricted dietary intakes.
2. *Recommendations* are not minimum requirements, nor are they necessarily optimal intakes for all individuals. Recommendations target most of the people and cannot account for individual variations in nutrient needs.
3. Most nutrient goals are intended to be met through diets composed of a variety of *foods* whenever possible. Excess intakes of vitamins and minerals are unlikely when they come from foods. Using dietary supplements to meet nutrient goals raises the risks of toxicity.

Photodisc/Getty Images

> **PHOTO 1-6** The DRI "alphabet soup" of nutrient intake standards makes sense when you learn their purposes.

> **FIGURE 1-7** **Energy Nutrient Contributions to the Total**

The three energy nutrients—carbohydrate, fat, and protein—all contribute to the total energy (kcalorie) intake. Each of these three bars illustrates percentages that fall within the Acceptable Macronutrient Distribution Ranges (AMDR). Notice that whenever the percentage of any one of them increases or decreases, the percentages from the others change as well.



Acceptable Macronutrient Distribution Ranges (AMDR): ranges of intakes for the energy nutrients that provide adequate energy and nutrients and reduce the risk of chronic diseases.

4. Recommendations apply to *average* daily intakes. Trying to meet the recommendations for every nutrient every day is difficult and unnecessary. The length of time over which a person's intake can deviate from the average without risk of deficiency or toxicity varies for each nutrient, depending on how the body uses and stores the nutrient. For most nutrients (such as thiamin and vitamin C), deprivation would lead to rapid development of deficiency symptoms (within days or weeks); for others (such as vitamin A and vitamin B_{12}), deficiencies would develop more slowly (over months or years).
5. Each of the DRI categories serves a unique purpose. For example, the EAR are most appropriately used to develop and evaluate nutrition programs for *groups* such as schoolchildren or military personnel. The RDA (or AI if an RDA is not available) can be used to set goals for *individuals*. The UL serve as a reminder to keep nutrient intakes less than amounts that increase the risk of toxicity—not a common problem when nutrients derive from foods, but a real possibility for some nutrients if supplements are used regularly.

With these understandings, professionals can use the DRI for a variety of purposes.[22]

Comparing Nutrient Recommendations More than 80 nations have published nutrient standards similar to those used in the United States. Slight differences may be apparent, reflecting differences both in the interpretation of the data from which the standards were derived and in the food habits and physical activities of the populations they serve.

Many countries use the recommendations developed by two international groups: FAO (Food and Agriculture Organization) and WHO (World Health Organization). The FAO/WHO nutrient recommendations are considered sufficient to maintain health in nearly all healthy people worldwide and are provided in Appendix I.

REVIEW IT Define the four categories of the DRI and explain their purposes.
The Dietary Reference Intakes (DRI) are a set of nutrient intake values that can be used to plan and evaluate diets for healthy people. The Estimated Average Requirement (EAR) defines the amount of a nutrient that supports a specific function in the body for half of the population. The Recommended Dietary Allowance (RDA) is based on the Estimated Average Requirement and establishes a goal for dietary intake that will meet the needs of about 98 percent of the population. An Adequate Intake (AI) serves a similar purpose when an RDA cannot be determined. The Estimated Energy Requirement (EER) defines the average amount of energy intake needed to maintain energy balance, and the Acceptable Macronutrient Distribution Ranges (AMDR) define the proportions contributed by carbohydrate, fat, and protein to a healthy diet. The Tolerable Upper Intake Level (UL) establishes the highest amount that appears safe for regular consumption.

1.5 Nutrition Assessment

LO 1.5 Explain how the four assessment methods are used to detect energy and nutrient deficiencies and excesses.

What happens when a person doesn't consume enough or consumes too much of a specific nutrient or energy? If the deficiency or excess is significant over time, the person experiences symptoms of **malnutrition**. With a deficiency of energy, the person may display the symptoms of **undernutrition** by becoming extremely thin, losing muscle tissue, and becoming prone to infection and disease. With a deficiency of a nutrient, the person may experience skin rashes, depression, hair loss, bleeding gums, muscle spasms, night blindness, or other symptoms. Similarly, over time, regular intakes in excess of needs may also have adverse effects. With an excess of energy, the person may become obese and vulnerable to diseases associated with **overnutrition**, such as heart disease and diabetes. With a sudden nutrient overdose, the person may experience hot flashes, yellowing skin, a rapid heart rate, low blood pressure, or other symptoms.

Malnutrition symptoms—such as diarrhea, skin rashes, and fatigue—are easy to miss because they resemble the symptoms of other diseases. But a person who

malnutrition: any condition caused by excess or deficient food energy or nutrient intake or by an imbalance of nutrients.
- **mal** = bad

undernutrition: deficient energy or nutrients.

overnutrition: excess energy or nutrients.

has learned how to use assessment techniques to detect malnutrition can identify when these conditions are caused by poor nutrition and can recommend steps to correct it. This discussion presents the basics of nutrition assessment; many more details are offered in later chapters and in Appendix E.

Nutrition Assessment of Individuals

To prepare a **nutrition assessment**, a trained health care professional uses:

- Historical information
- Anthropometric measurements
- Physical examinations
- Laboratory tests

Each of these methods involves collecting data in various ways and interpreting each finding in relation to the others to create a total picture.[23]

Historical Information One step in evaluating nutrition status is to obtain information about a person's history with respect to health status, socioeconomic status, drug use, and diet. The **health history** reflects a person's medical record and may reveal a disease that interferes with the person's ability to eat or the body's use of nutrients. The person's family history of major diseases is also noteworthy, especially for conditions such as heart disease that have a genetic tendency to run in families. Economic circumstances may show a financial inability to buy foods or inadequate kitchen facilities in which to prepare them. Social factors such as marital status, ethnic background, and educational level also influence food choices and nutrition status. A **drug history**, including all prescribed and over-the-counter medications, may highlight possible interactions that lead to nutrient deficiencies (as described in Chapter 19). A **diet history** that examines a person's intake of foods, beverages, and dietary supplements may reveal either excess or inadequate intakes of nutrients or energy.

To take a diet history, the assessor collects data about the foods a person eats. The data may be collected by recording the foods the person has eaten over a period of 24 hours, 3 days, or a week or more or by asking what foods the person typically eats and how much of each. The days in the record must be fairly typical of the person's diet, and portion sizes must be recorded accurately. To determine the amounts of nutrients consumed, the assessor usually enters the foods and their portion sizes into a computer using a diet analysis program. The assessor then compares the calculated nutrient intakes with the DRI to determine the probability of adequacy. Alternatively, the diet history might be compared against standards such as the USDA Food Patterns or *Dietary Guidelines for Americans* (described in Chapter 2).

An estimate of energy and nutrient intakes from a diet history, when combined with information from other assessment results, can help confirm or rule out the *possibility* of suspected nutrition problems. A sufficient intake of a nutrient does not guarantee adequacy, and an insufficient intake does not always indicate a deficiency. Such findings, however, warn of possible problems.

Anthropometric Measurements A second technique that may help reveal nutrition problems is taking **anthropometric** measures such as height and weight. The assessor compares a person's measurements with standards specific for sex and age or with previous measures on the same individual. (Chapter 8 presents information on body weight and its standards; Chapter 15 and Appendix E include growth charts for children.)

Measurements taken periodically and compared with previous measurements reveal patterns and indicate trends in a person's overall nutrition status, but they provide little information about specific nutrients. Instead, measurements out of line with expectations may reveal such problems as growth failure in children, wasting or swelling of body tissues in adults, and obesity—conditions that may reflect energy or nutrient deficiencies or excesses.

nutrition assessment: a comprehensive analysis of a person's nutrition status that uses health, socioeconomic, drug, and diet histories; anthropometric measurements; physical examinations; and laboratory tests.

health history: an account of a client's current and past health status and disease risks.

drug history: a record of all the drugs, over-the-counter and prescribed, that a person takes routinely.

diet history: a record of eating behaviors and the foods a person eats.

anthropometric (AN-throw-poe-MET-rick): relating to measurement of the physical characteristics of the body, such as height and weight.

- **anthropos** = human
- **metric** = measuring

Physical Examinations A third nutrition assessment technique is a physical examination looking for clues to poor nutrition status. Visual inspection of the hair, eyes, skin, posture, tongue, and fingernails can provide such clues (see Photo 1-7). In addition, information gathered from an interview can help identify physical symptoms. The examination requires skill because many physical signs and symptoms reflect more than one nutrient deficiency or toxicity—or even nonnutrition conditions. Like the other assessment techniques, a physical examination alone does not yield firm conclusions. Instead, physical examinations reveal possible imbalances that must be confirmed by other assessment techniques, or they confirm results from other assessment measures.

Laboratory Tests A fourth way to detect a developing deficiency, imbalance, or toxicity is to take samples of blood or urine, analyze them in the laboratory, and compare the results with normal values for a similar population. Laboratory tests are most useful in uncovering early signs of malnutrition before symptoms appear. In addition, they can confirm suspicions raised by other assessment methods.

Iron, for Example The mineral iron can be used to illustrate the stages in the development of a nutrient deficiency and the assessment techniques useful in detecting them. The **overt**, or outward, signs of an iron deficiency appear at the end of a long sequence of events. Figure 1-8 describes what happens in the body as a nutrient deficiency progresses and shows which assessment methods can reveal those changes.

First, the body has too little iron—either because iron is lacking in the person's diet (a **primary deficiency**) or because the person's body doesn't absorb enough, excretes too much, or uses iron inefficiently (a **secondary deficiency**). A diet history provides clues to primary deficiencies; a health history provides clues to secondary deficiencies.

Next, the body begins to use up its stores of iron. At this stage, the deficiency might be described as a **subclinical deficiency**. It exists as a **covert** condition, and although it might be detected by laboratory tests, outward signs are not yet apparent.

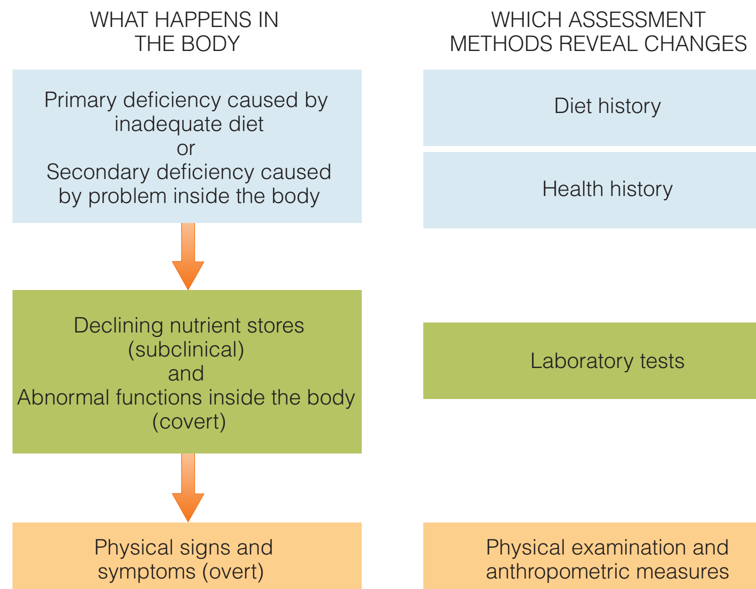
Finally, the body's iron stores are exhausted. Now, it cannot make enough iron-containing red blood cells to replace those that are aging and dying. Iron is needed in red blood cells to carry oxygen to all the body's tissues. When iron is lacking, fewer red blood cells are made, the new ones are pale and small, and every part of the body feels the effects of oxygen shortage. At this point in time, the overt symptoms of deficiency appear—weakness, fatigue, pallor, and headaches, reflecting the iron-deficient state of the blood. A physical examination and interview will reveal these symptoms.

Nutrition Assessment of Populations

To assess a population's nutrition status, researchers conduct surveys using techniques similar to those used on

> **FIGURE 1-8 Stages in the Development of a Nutrient Deficiency**

Internal changes precede outward signs of deficiencies. Outward signs of sickness, however, need not appear before a person takes corrective measures. Laboratory tests can help determine nutrient status in the early stages.




massimofusaro/Shutterstock.com

> **PHOTO 1-7** A peek inside the mouth provides clues to a person's nutrition status. An inflamed tongue may indicate a deficiency of one of the B vitamins, and mottled teeth may reveal fluoride toxicity, for example.

overt (oh-VERT): out in the open and easy to observe.
- **ouvrir** = to open

primary deficiency: a nutrient deficiency caused by inadequate dietary intake of a nutrient.

secondary deficiency: a nutrient deficiency caused by something other than an inadequate intake, such as a disease condition or drug interaction that reduces absorption, accelerates use, hastens excretion, or destroys the nutrient.

subclinical deficiency: a deficiency in the early stages, before the outward signs have appeared.

covert (KOH-vert): hidden, as if under covers.
- **couvrir** = to cover


Monkey Business Images/Shutterstock.com

> **PHOTO 1-8** National surveys provide valuable information about the kinds of foods people eat.

individuals. The data collected are then used by various agencies for numerous purposes, including the development of national health goals.

National Nutrition Surveys National nutrition surveys gather information about the population's dietary, nutritional, and related health status. One survey collects data on the kinds and amounts of foods people eat.* Another survey examines the people themselves, using anthropometric measurements, physical examinations, and laboratory tests.** The data provide valuable information on several nutrition-related conditions, such as growth impairments, heart disease, and nutrient deficiencies. National nutrition surveys often oversample high-risk groups (low-income families, pregnant women, adolescents, the elderly, African Americans, and Mexican Americans) to obtain an accurate estimate of their health and nutrition status.

The resulting wealth of information from the national nutrition surveys is used for a variety of purposes (see Photo 1-8). For example, Congress uses this information to establish public policy on nutrition education, food assistance programs, and the regulation of the food supply. Scientists use the information to establish research priorities. The food industry uses these data to guide decisions in public relations and product development. The DRI and other major reports that examine the relationships between diet and health depend on information collected from these nutrition surveys. These data also provide the basis for developing and monitoring national health goals.

National Health Goals The **Healthy People** program sets priorities and guides policies that "increase the quality and years of healthy life" and "eliminate health disparities." At the start of each decade, the program sets goals for improving the nation's health during the next ten years. Nutrition is one of many topic areas, each with numerous objectives. Appendix J lists the nutrition and weight status objectives for 2020, as well as nutrition-related objectives from other topic areas.

Progress in meeting the 2020 goals is mixed. The objective to meet physical activity and muscle-strengthening guidelines has been achieved, but the objective to eat more fruits and vegetables showed no improvement.[24] Trends in overweight and obesity actually worsened. Clearly, "what we eat in America" must change if we hope to meet the Healthy People goals.

National Trends What do we eat in America and how has it changed over the past 45 years? The short answer to both questions is "a lot." We eat more meals away from home, particularly at fast-food restaurants. We eat larger portions. We drink more sweetened beverages and eat more energy-dense, nutrient-poor foods such as candy and chips. We snack frequently. As a result of these dietary habits, our energy intake has risen and, consequently, so has the incidence of overweight and obesity. Overweight and obesity, in turn, profoundly influence our health—as the next section explains.

REVIEW IT Explain how the four assessment methods are used to detect energy and nutrient deficiencies and excesses.

People become malnourished when they get too little or too much energy or nutrients. Deficiencies, excesses, and imbalances of nutrients lead to malnutrition diseases. To detect malnutrition in individuals, health care professionals use a combination of four nutrition assessment methods. Reviewing historical information on diet and health may suggest a possible nutrition problem. Laboratory tests may detect a possible nutrition problem in its earliest stages, whereas anthropometric measurements and physical examinations pick up on the problem only after it causes symptoms. National surveys use similar assessment methods to measure people's food consumption and to evaluate the nutrition status of populations.

Healthy People: a national public health initiative under the jurisdiction of the US Department of Health and Human Services (DHHS) that identifies the most significant preventable threats to health and focuses efforts to eliminate them.

*This survey is called *What We Eat in America*.
**This survey is known as the National Health and Nutrition Examination Survey (NHANES).

1.6 Diet and Health

LO 1.6 Identify several risk factors and explain their relationships to chronic diseases.

Foods play a vital role in supporting health. Early nutrition research focused on identifying the nutrients in foods that would prevent such common diseases as rickets (the vitamin D–deficiency disease) and scurvy (the vitamin C–deficiency disease). With this knowledge, developed countries have successfully defended against nutrient deficiency diseases. World hunger and nutrient deficiency diseases still pose a major health threat in developing countries, however, but not because of a lack of nutrition knowledge. More recently, nutrition research has focused on obesity and chronic diseases associated with energy and nutrient excesses.[25] Chronic diseases are responsible for 7 out of 10 deaths among US adults and account for more than 85 percent of US health care costs.[26] Once thought to be "rich countries' problems," overconsumption of unhealthy foods and chronic diseases have escalated worldwide in recent decades.[27]

Chronic Diseases Table 1-4 lists the 10 leading causes of death in the United States. These "causes" are stated as if a single condition such as heart disease caused death, but most chronic diseases arise from multiple factors over many years. A person who died of heart disease may have been overweight, had high blood pressure, been a cigarette smoker, and spent years eating a diet high in saturated fat and getting too little exercise.

Of course, not all people who die of heart disease fit this description, nor do all people with these characteristics die of heart disease. People who are overweight might die from the complications of diabetes instead, or those who smoke might die of cancer. They might even die from something totally unrelated to any of these factors, such as an automobile accident. Still, statistical studies have shown that certain conditions and behaviors are linked to certain diseases.

Table 1-4 highlights four of the top seven causes of death as having a link with diet. Notice that these four diseases—heart disease, cancers, strokes, and diabetes—account for more than half of the deaths each year.

TABLE 1-4 Leading Causes of Death in the United States

	Percentage of Total Deaths
1. **Heart disease**	23.5
2. **Cancers**	22.5
3. Chronic lung diseases	5.7
4. Accidents	5.0
5. **Strokes**	5.0
6. Alzheimer's disease	3.3
7. **Diabetes mellitus**	2.9
8. Pneumonia and influenza	2.2
9. Kidney disease	1.8
10. Suicide	1.6

NOTE: The diseases highlighted in bold have relationships with diet.

SOURCE: J. Q. Xu and coauthors, Deaths: Final data for 2013, *National Vital Statistics Reports* 64 (Hyattsville, MD: National Center for Health Statistics, 2016).

Risk Factors for Chronic Diseases Factors that increase or reduce the *risk* of developing chronic diseases can be identified by analyzing statistical data. A strong association between a **risk factor** and a disease means that when the factor is present, the *likelihood* of developing the disease increases. It does not mean that all people with the risk factor will develop the disease. Similarly, a lack of risk factors does not guarantee freedom from a given disease. On the average, though, the more risk factors in a person's life, the greater that person's chances of developing the disease. Conversely, the fewer risk factors in a person's life, the better the chances for good health.

Risk Factors Persist Risk factors tend to persist over time. Without intervention, a young adult with high blood pressure will most likely continue to have high blood pressure as an older adult, for example. Thus, to minimize the damage, early intervention is most effective.

Risk Factors Cluster Risk factors tend to cluster. For example, a person who is obese may be physically inactive, have high blood pressure, and have high blood cholesterol—all risk factors associated with heart disease. Multiple risk factors act synergistically to increase the risk of disease dramatically. Intervention that focuses on one risk factor often benefits the others as well. For example, physical activity can help reduce weight. Physical activity and weight loss will, in turn, help lower blood pressure and blood cholesterol (see Photo 1-9).

Jacek Chabraszewski/Shutterstock.com

> **PHOTO 1-9** Physical activity can be both fun and beneficial.

risk factor: a condition or behavior associated with an elevated frequency of a disease but not proved to be causal. Leading risk factors for chronic diseases include obesity, cigarette smoking, high blood pressure, high blood cholesterol, physical inactivity, and a diet high in added fats and low in vegetables, fruits, and whole grains.

Risk Factors in Perspective The most prominent risk factor—contributing to one of every five deaths each year in the United States—is tobacco use, followed

TABLE 1-5 Factors Contributing to Deaths in the United States

Factors	Percentage of Deaths
Tobacco	18
Poor diet/inactivity	15
Alcohol	4
Microbial agents	3
Toxic agents	2
Motor vehicles	2
Firearms	1
Sexual behavior	<1
Illicit drugs	<1

SOURCE: A. H. Mokdad and coauthors, Actual causes of death in the United States, 2000, *Journal of the American Medical Association* 291 (2004): 1238–1245, with corrections from *Journal of the American Medical Association* 293 (2005): 298.

closely by diet and activity patterns, and then alcohol use (see Table 1-5). Risk factors such as smoking, poor dietary habits, physical inactivity, and alcohol consumption are personal behaviors that can be changed. Decisions to not smoke, to eat a well-balanced diet, to engage in regular physical activity, and to drink alcohol in moderation (if at all) improve the likelihood that a person will enjoy good health. Other risk factors, such as genetics, sex, and age, also play important roles in the development of chronic diseases, but they cannot be changed. Health recommendations acknowledge the influence of such factors on the development of disease, but they must focus on the factors that are changeable.

Health Behaviors in the United States Despite evidence linking certain behaviors with chronic diseases, many Americans continue to engage in unhealthy behaviors. An estimated 35 percent of US adults consume more than moderate amounts of alcohol; 20 percent smoke cigarettes; 50 percent are physically inactive; 60 percent are either overweight or obese; and 30 percent obtain 7 hours or less of sleep per day.[28] For those who do not smoke or drink alcohol excessively, the one choice that can influence chronic disease risks more than any other is diet.[29]

REVIEW IT Identify several risk factors and explain their relationships to chronic diseases.

Diet has no influence on some diseases but is linked closely to others. Other life choices, such as engaging in physical activity and using tobacco or alcohol, also affect health for the better or worse.

The next several chapters provide many more details about nutrients and how they support health. Whenever appropriate, the discussion shows how diet influences each of today's major diseases. Dietary recommendations appear again and again, as each nutrient's relationships with health are explored. Most people who follow the recommendations will benefit and can enjoy good health into their later years.

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