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HUMAN NUTRITION

Science for Healthy Living

Third Edition

COVID-19
Content
Included

Tammy J. Stephenson
Megan R. Sanctuary
Caroline W. Passerello

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HUMAN NUTRITION

Science for Healthy Living

Third Edition

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**Mc
Graw
Hill**



HUMAN NUTRITION

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Brief Contents

Preface	xi
1	Introduction to Nutrition 1
2	Evaluating Nutrition Information 26
3	Basis of a Healthy Diet 48
4	Human Digestion, Absorption, and Transport 80
5	Carbohydrates: Sugars, Starches, and Fiber 110
6	Lipids: Triglycerides, Phospholipids, and Sterols 149
7	Proteins: Amino Acids 189
8	Metabolism 226
9	Vitamin Overview and Fat-Soluble Vitamins 266
10	Water-Soluble Vitamins 301
11	Water and Major Minerals 340
12	Trace Minerals 381
13	Obesity, Energy Balance, and Weight Management 414
14	Eating Disorders and Disordered Eating 449
15	Nutrition for Fitness and Sport 470
16	Pregnancy and Lactation 512
17	Infants, Children, and Adolescents 539
18	Nutrition for Older Adults 569
19	Food and Water Safety 592
20	Global Nutrition 625
Appendix A	English-Metric Conversions and Metric-to-Household Units A-3
Appendix B	Basic Chemistry Concepts A-5
Appendix C	Basic Anatomy and Physiology Concepts A-9
Appendix D	Chemical Structures: Amino Acids and Vitamins A-13
Appendix E	Vitamins Involved in Energy Metabolism A-19
Appendix F	Nutrition Assessment A-21
Appendix G	Daily Values Table A-31
Appendix H	Canada's Food Guide A-33
Appendix I	Food Composition Table A-35
Appendix J	DRI Tables A-105
Glossary	G-1
Index	I-1

About the Authors



©Tammy Stephenson

Tammy J. Stephenson, PhD, FAND received her BS in food science and human nutrition and PhD in nutritional sciences from the University of Kentucky.

She has taught a wide variety

of food, nutrition, and wellness courses, including introductory nutrition, to majors and nonmajors in the Department of Dietetics and Human Nutrition at the University of Kentucky for the past 20 years. Dr. Stephenson currently serves as Chair of the Department of Dietetics and Human Nutrition. She is also an active member of the Academy of Nutrition and Dietetics, having served as chair of the Nutrition Educators of Health Professionals practice group and being recognized as a Fellow of the Academy (FAND). She has published and presented on service learning, technology in teaching, student-centered learning, and other related topics. Dr. Stephenson has a passion for teaching engaging, interesting, and relevant nutrition courses and has been recognized through multiple teaching and mentoring awards at the university, state, and national levels. At the University of Kentucky, she has been recognized with both the Alumni Association's Great Teacher Award (2016) and the Provost Office's Outstanding Teacher Award (2015). Outside of the classroom, she enjoys running, doing yoga, gardening, cooking, watching her daughters play sports, and spending time with her family.

To Brian, Bailey, Kylie Mae, and Ansley

—Tammy Stephenson

Megan R. Sanctuary, MS, PhD, received her MS in molecular and integrative physiology from the University of Illinois at Urbana-Champaign and her PhD in nutritional biology from the University of California at Davis. She has

taught a wide variety of courses, including introductory nutrition, anatomy and physiology, and general biology. Dr. Sanctuary has published and presented in many areas of research, including the interactions among diet, the immune system, and the microbiota. She has a special interest in food as medicine, precision nutrition, and the effects of early nutrition on health and disease later in life. In her free time, she enjoys spending time with her family, reading, and doing yoga.



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To Maia, Maddox, and Eric

—Megan Sanctuary



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Caroline Passerello, MS, RDN, LDN, earned her BS degrees in psychology and clinical dietetics and her MS from the School of Health and Rehabilitation Sciences at the University of Pittsburgh. Caroline has experience running a nutrition consulting company and spent 8 years working in industry,

leading a retail dietitian program.

Caroline is a registered dietitian nutritionist and a full-time faculty member at the University of Pittsburgh in the Department of Sports Medicine and Nutrition. She teaches in the accelerated graduate-level Future Education Model; courses include Experiential Practice in the Community, Entrepreneurial Skills for Nutrition Professionals, Professional Development, Principles of Nutrition Education, and Introduction to Human Nutrition.

Caroline is active in her professional organization as a national spokesperson for the Academy of Nutrition and Dietetics. She has a specialty certificate in adult weight management and focuses her media interviews on nutrition education for consumers, healthful shopping, and children's nutrition. She is pursuing her doctor of education in health and physical activity in the School of Education at the University of Pittsburgh.

In her free time, Caroline enjoys being physically active with her family and bringing stress relief to others with her therapy pet, C.C.

To Henry, Luciana, MiMi, and Pop

–Caroline Passerello

For the third edition of *Human Nutrition: Science for Healthy Living*, we welcome Megan Sanctuary and Caroline Passerello to the authoring team! Both professors bring their areas of research expertise and professional practice to the content covered in the textbook. As well, both Dr. Sanctuary and Professor Passerello are experienced educators who teach introductory nutrition and provide valuable insight from their own teaching with the development of the third edition of the textbook.



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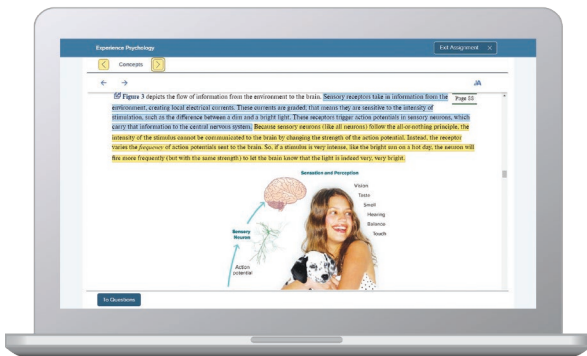
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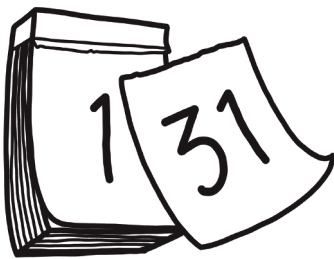
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"I really liked this app—it made it easy to study when you don't have your textbook in front of you."

- Jordan Cunningham,
Eastern Washington University



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Personalized Teaching and Learning Environment



vicushka/123RF

McGraw Hill NutritionCalc Plus

NutritionCalc Plus is a **powerful dietary analysis tool** featuring more than 30,000 foods from the reliable and accurate ESHA Research nutrient database, which is comprised of data from the latest USDA Standard Reference database, manufacturers' data, restaurant data, and data from literature sources. NutritionCalc Plus allows users to track food and activities, then analyze their choices with a robust selection of intuitive reports. The interface was updated to accommodate ADA requirements and modern mobile experience native to today's students.



Virtual Labs

VIRTUAL LABS

While the sciences are hands-on disciplines, instructors are now often being asked to deliver some of their lab components online, as full online replacements, supplements to prepare for in-person labs, or make-up labs.

These simulations help each student learn the practical and conceptual skills needed, then check for understanding and provide feedback. With adaptive pre-lab and post-lab assessment available, instructors can customize each assignment.

From the instructor's perspective, these simulations may be used in the lecture environment to help students visualize processes, such as digestion of starch and emulsification of lipids.

Dietary Analysis Case Studies in Connect®

One of the challenges instructors face with teaching nutrition classes is having time to grade individual dietary analysis projects. To help overcome this challenge, assign auto-graded dietary analysis case studies. These tools require students to use NutritionCalc Plus to analyze dietary data, generate reports, answer questions to apply their nutrition knowledge to real-world situations. These assignments were developed and reviewed by faculty who use such assignments in their own teaching. They are designed to be relevant, current, and interesting!



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Ava Ponce
22 year old, Female, 5'6", 145 lbs
Weight gain/loss: 0 lbs/week
Activity level: Active



McGraw Hill Create® is a self-service website that allows you to create customized course materials using McGraw Hill's comprehensive, cross-disciplinary content and digital products.

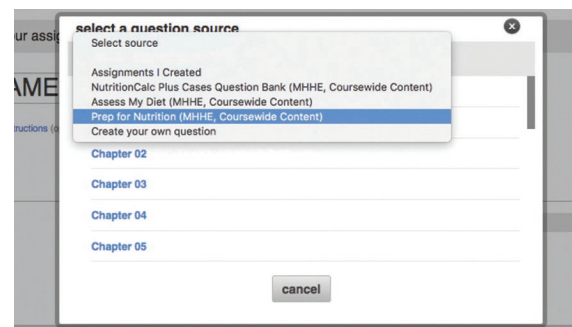


Tegrity in Connect is a tool that makes class time available 24/7 by automatically capturing every lecture. With a simple, one-click start-and-stop process, you capture all computer screens and corresponding audio in a format that is easy to search, frame by frame. Students can replay any part of any class with easy-to-use, browser-based viewing on a PC, Mac, or other mobile device.

Educators know that the more students can see, hear, and experience class resources, the better they learn. Tegrity's unique search feature helps students efficiently find what they need, when they need it, across an entire semester of class recordings. Help turn your students' study time into learning moments immediately supported by your lecture.

McGraw Hill Assess My Diet

Auto-graded personalized dietary analysis. Students are using NutritionCalc Plus to analyze their own dietary patterns. But how can instructors integrate that information into a meaningful learning experience? With Assess My Diet, instructors can now assign auto-graded, personalized dietary analysis questions within Connect. These questions refresh their memory on the functions and food sources of each nutrient and prompt the students to evaluate their own eating behaviors. Students can evaluate their own nutrient intakes compared to current Dietary Reference Intakes and demonstrate their ability to perform calculations on their own data, such as percent of calories from saturated fat. They can compare the nutrient density of their own food selections to see which of their food choices provides the most fiber or iron. A benefit of the Assess My Diet question bank is that it offers assignable content that is personalized to the students' data, yet it is still auto-graded. It saves time and keeps all assignments in one place.



Prep for Nutrition

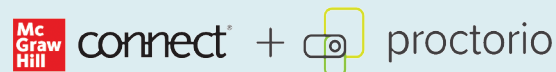
To help you level-set your classroom, we've created *Prep for Nutrition*. This question bank highlights a series of questions, including basic chemistry, biology, dietary analysis, mathematics, and student success, to give students a refresher on the skills needed to enter and be successful in their course! By having these foundational skills, you will feel more confident your students can begin class, ready to understand more complex concepts and topics. *Prep for Nutrition* is **course-wide for ALL nutrition titles** and can be found in the Question Bank drop-down within Connect.

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New remote proctoring and browser-locking capabilities, hosted by Proctorio within Connect, provide control of the assessment environment by enabling security options and verifying the identity of the student.

Seamlessly integrated within Connect, these services allow instructors to control students' assessment experience by restricting browser activity, recording students' activity, and verifying students are doing their own work.

Instant and detailed reporting gives instructors an at-a-glance view of potential academic integrity concerns, thereby avoiding personal bias and supporting evidence-based claims.



Welcome to *Human Nutrition: Science for Healthy Living*

Dear Students,

Welcome to the study of human nutrition! Before you begin your studies, it is important to understand that nutrition is a science that draws upon knowledge from other sciences, particularly biology, human anatomy and physiology, general chemistry, and biochemistry. The science of human nutrition also involves learning scientific information about foods and nutrients, as well as how this information is used to develop dietary recommendations for healthy people and nutritional therapies for those who are not healthy. By understanding the contents of this introductory nutrition textbook, you will be able to recognize the effects that people's food choices have on their health. In addition, you will appreciate the valuable role that registered dietitian nutritionists (RDNs) play as members of healthcare teams and will be well-prepared to take more advanced human nutrition courses, if you decide to become a dietitian or other professional in the medical field.

Human Nutrition: Science for Healthy Living has been developed by a team of nutrition educators who have extensive college teaching experience and a passion for teaching relevant, student-centered nutrition, biology, health, and wellness courses. Our goals with this textbook are to teach students the science of nutrition while also preparing future healthcare professionals and to make the study of introductory human nutrition enjoyable. Learning about any science can be challenging if the information is not presented in an appealing, interesting manner. We've made a distinct effort to write the content of this book in an understandable way and to provide clear descriptions of concepts that can be difficult to convey, such as the processes of digestion, absorption, and energy metabolism. To enhance your learning, numerous illustrations and photographs accompany the narrative. Such graphics enhance learning for all students, but especially for those who are "visual learners." By reviewing this Preface, you will learn about the features of this book and how to use them to facilitate your study of human nutrition.

We hope you will enjoy using this textbook!

Sammy J. Stephenson

Meg Stoltz

Carlini Passanillo

About the Cover: The cover of this edition reflects the "farm-to-table" theme that we have used for the first and second editions of *Human Nutrition*. For this third edition of the textbook, a new "Sustainability and Your Diet" feature is included in each chapter. A sustainable food system delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised.

The image on the cover shows a sandwich made with avocado, boiled eggs, pumpkin seeds, and edible viola flowers on whole grain bread. Several species in the *Viola* genus are safe for human consumption. Like most edible flowers, not all *Viola* species are safe for intake and, therefore, check before consuming any flower. Edible viola provide vitamins A and C and are a good source of antioxidants.



Preface

The authoring team had a vision of writing an interesting, engaging, and evidence-based introductory nutrition textbook that has a wide variety of pedagogical features to promote active learning. To that end, this third edition of *Human Nutrition: Science for Healthy Living* is learner-centered, easy to read, and richly illustrated with figures and images that clearly show physiological processes. Furthermore, the author team felt students and faculty would benefit from and value a textbook that was clinically oriented and provided ample opportunities for students to practice using their nutrition knowledge and critical thinking skills. *Human Nutrition: Science for Healthy Living* is the result of a team of authors with extensive teaching experience and who currently teach introductory nutrition to diverse student populations.

The clinical emphasis of the textbook is of particular relevance to those studying nutrition, dietetics, or other health science professions, including nursing. Specific real-life examples, current statistics, and scientific evidence from professional resources are provided to support nutrition concepts. Features designed to attract students' interest, such as *Sustainability and Your Diet*, *COVID-19*, *Did You Know?* and *Fresh Tips* boxes, provide up-to-date information on current and sometimes controversial topics, as well as practical recommendations for everyday healthy living.

Human Nutrition: Science for Healthy Living provides the framework for students to *learn* how nutrition information is often interrelated and to *apply* the science of nutrition to clinical situations. Furthermore, students apply key scientific principles and knowledge that they can translate into their own lives.

Features Designed Around Student-Centered Learning

Human Nutrition: Science for Healthy Living, 3e was written by authors who have extensive experience teaching introductory nutrition classes to both majors and nonmajors. The authors recognize the diverse learning needs of today's students and how the modern learning environment in higher education—large lecture classes, online classes, and flipped/hybrid classrooms—often challenge even the most experienced nutrition educators. The textbook and its supportive interactive materials are designed to help instructors create a learner-centered teaching environment that maximizes student engagement and knowledge acquisition. This current, evidence-based

introductory textbook has a wide variety of pedagogical features to promote active learning among students.

What's New in This Edition?

Human Nutrition: Science for Healthy Living, 3e has been updated throughout to reflect the *2020–2025 Dietary Guidelines for Americans* and associated changes to the MyPlate website and resources.

There are three new features included in the textbook: *COVID-19*, *Sustainability and Your Diet*, and *Culinary Medicine*.

The COVID-19 pandemic is addressed in relevant chapters throughout the textbook, highlighting the role of nutrition and lifestyle factors in coronavirus risk and treatment. Each *COVID-19* feature shares evidence-based and relevant content, such as the relationship between obesity and type 2 diabetes and COVID-19 risk and the role of vitamin D in preventing coronavirus. The *Sustainability and Your Diet* feature found in each chapter provides students with knowledge about sustainability and recommendations for making food and lifestyle choices to support a sustainable food system. Each chapter also includes a *Culinary Medicine* exercise that provides students with the opportunity to apply nutrition and food information to specific recommendations for preventing and treating disease. For example, how can a recipe high in sodium be modified for a person with hypertension who needs to limit sodium in her diet? Students will develop modified recipes that meet specific recommendations but also taste delicious.

For all chapters, numerous new and modern figures and photos have been added and updated to engage the reader and illustrate the content. Also, references have been updated to include the most current research and evidence-based practice recommendations. The following list provides some of the specific updates to each chapter.

- Chapter 1 has been updated based on the most current dietary recommendations. Table 1.2 has been updated for clarity. Figure 1.6 has been updated with the most current data, and the discussion of the relationship between diet and risk for chronic disease has been updated based on the most current research. A *COVID-19* feature has been added that discusses the virus being the third leading cause of death in the U.S. in 2020. Section 1.5, Factors that Influence Eating Habits, has been significantly revised and reorganized and now includes a *Sustainability and Your Diet* feature on sustainable food systems, including a new infographic on that topic.

- Chapter 2 has been reorganized to enhance the flow of the chapter. Section 2.2, Understanding the Scientific Method, has been completely revised based on student and instructor feedback. New examples are used throughout the chapter when discussing scientific studies. Section 2.3, Nutrition Information: Fact or Fiction, has been updated to reflect the fact that many consumers are now getting their information from online sources, including blogs.
- Chapter 3 has been significantly updated to reflect the *2020–2025 Dietary Guidelines for Americans*. Three new figures have been added and all content updated to reflect the most recent release of the *Dietary Guidelines*. As well, Figure 3.8 has been revised with new tools for estimating portion sizes. Figure 3.17 provides an example of a current Nutrition Facts panel with information related to the use of that panel. Section 3.6, Cultural Influences on Meal Planning, has been completely revised with new figures to reflect the diversity of dietary choices based on ethnicity and religious practices.
- Chapter 4 includes the most up-to-date information related to the health of the gastrointestinal tract. Section 4.7, Microbes in the Digestive Tract, has been expanded with a detailed discussion of the impact of gut microbiota on health and recommendations for optimizing gut health. The chapter includes new content on fermented foods and a *Sustainability and Your Diet* feature on food waste and the benefits of composting. Section 4.8, Common Digestive Disorders, has been reorganized and updated with the most current evidence-based recommendations for preventing and treating digestive disorders.
- Chapter 5 has been updated with the most current statistics and research on diabetes mellitus. New Figure 5.16 provides guidance on the management of diabetes. Section 5.8 includes new information on the relationship between carbohydrate intake and health, including metabolic syndrome, tooth decay, and digestive health. The basic information on simple carbohydrates has been re-written and streamlined with updates to several figures and tables. The new *Sustainability and Your Diet* feature focuses on the importance of bees as pollinators and the new *COVID-19* feature summarizes the relationship between type 2 diabetes and risk for coronavirus.
- Chapter 6 provides an updated and enhanced discussion of cardiovascular disease and dietary strategies to reduce a person’s risk for heart disease. The explanations of atherosclerosis and arteriosclerosis have been updated for clarity. The section on omega-3 fatty acids has been updated and includes a new *Sustainability and Your Diet* feature explaining the differences in omega-3 fatty acid content between grain-fed and grass-fed beef.
- Chapter 7 begins with a new case study for students to determine the protein needs of a healthy young adult and to make appropriate recommendations for consuming high-quality sources of protein. Table 7.3 has been updated with new food sources, and the section on protein quality has been revised significantly. Section 7.9, Food Hypersensitivity Disorders: Food Allergies, Food Intolerances, and Phenylketonuria, has been restructured with significant revisions based on the most current research available on these topics. This section now also includes the content on celiac disease, which has also been updated. Section 7.10, Plant-Based Diets, replaces the original section on “vegetarianism” to provide more broad information about the health effects of following a predominantly plant-based diet.
- Chapter 8 includes a new case study on energy drinks, exploring the role of B vitamins in energy metabolism. The chapter has been completely reorganized with major revisions to many of the figures. New Figure 8.9 provides a more clear and concise summary of the citric acid cycle. Also, the section on ketogenic diets has been updated with the most current research.
- Chapter 9 includes an update to Table 9.3, providing a summary of the fat-soluble vitamins. The chapter has been updated for clarity with a new *Did You Know?* feature on measuring skin carotenoid levels as an indicator of a person’s fruit and vegetable intake. For each of the vitamins, the most current research on the relationship between vitamin status and chronic disease risk is included. Tables 9.4, 9.6, 9.7, and 9.8 have been updated with new food sources of each vitamin.
- Chapter 10 includes an update to Table 10.1 based on the most current research available on each water-soluble vitamin. Tables 10.2, 10.3, 10.4, 10.5, 10.7, 10.9, and 10.10 have all been updated with new sample foods. A new *Sustainability and Your Diet* feature on vertical farming has been added. The statistics and content provided in Section 10.12, Diet and Cancer, have been updated based on the most current research.
- Chapter 11 includes a new *Sustainability and Your Diet* feature with recommendations to reduce a person’s water footprint, particularly when it comes to food production and choices. Figure 11.3 and Table 11.4 have both undergone significant revisions. All of the tables with examples of foods providing each mineral have been updated with new foods and beverages. The content in Sections 11.6 and 11.7, Sodium and Potassium respectively, have both been updated to reflect the most current (2019) Dietary Reference Intakes. New Table 11.11 provides the newest blood pressure levels and recommendations.

- Chapter 12 has been revised to include recommendations based on the most currently available research. Table 12.1, Summary of Trace Minerals, has been revised, and the tables with examples of foods providing each trace mineral have been updated. A new *Sustainability and Your Diet* feature addressing the mineral content of soil has been added and includes recommendations for optimizing the nutrient content of soil. As well, a new *COVID-19* feature provides information about the relationship between zinc intake, the immune system, and risk for COVID-19.
- Chapter 13 has been updated with the most current statistics on the prevalence of obesity (Figure 13.1), and new Figure 13.2 summarizes the health consequences of obesity. Section 13.2, Evaluating Health Using BMI and Body Composition, has been expanded with timely content on the use of body composition and BMI in evaluating health. Section 13.4, Factors That Influence Body Weight, has been significantly revised to include the most current research on the factors contributing to the obesity epidemic in the United States. New content on strategies to improve body composition are included, with an emphasis on mindfulness and intuitive eating practices. Section 13.6, Medical Treatment of Obesity, has also been updated with the most current evidence-based recommendations, including medications and surgical options for obesity treatment, when appropriate.
- Chapter 14 has undergone significant revision, with reorganization of the content and updates to all content. New information about the role of social media in disordered eating and eating disorders has been added. The content on diabulimia has been expanded, and new tables have been added with the common signs and symptoms of anorexia nervosa, bulimia nervosa, and binge eating disorder. A *Fresh Tips* feature with recommendations for approaching a friend or family member who has an eating disorder has been added. Figure 14.4 is a new figure that provides recommendations for alternative therapies for eating disorders.
- Chapter 15 has been updated based on the second edition (2018) of the U.S. Department of Health and Human Services *Physical Activity Guidelines for Americans*. Figure 15.4 has been updated and new information on physical activity trackers included. A new *Sustainability and Your Diet* feature focuses on active commuting as an option for many to improve health while being good for the environment. Table 15.3 has been revised to include new pre-event meal options for athletes. Section 15.10, Ergogenic Aids, has been updated with the most current research on athletes' use of ergogenic aids.
- Chapter 16 includes a new case study on recommendations for a preconception diet. Section 16.3, Nutrition and Lifestyle for a Healthy Pregnancy and Delivery, has been significantly revised based on current recommendations. A section on the developmental origins of disease has also been added. Figure 16.6 has been updated, and Section 16.6, Lactation and Breastfeeding, has been reorganized and significantly revised.
- Chapter 17 begins with a new case study on complementary foods to introduce during the weaning process. The content on nutritional needs during infancy and childhood has also been updated significantly based on the most current recommendations. Section 17.4, Adolescence, provides new insight into the diet quality of adolescents in the United States, and Section 17.5, Overweight and Obesity in Children, shares specific recommendations on preventing and managing obesity in this population.
- Chapter 18 has gone through a reorganization and updated with an emphasis on healthy aging. New Figure 18.2 summarizes the lifestyle characteristics of those living in the parts of the world where people live the longest. A new *Did You Know?* feature on telomeres and the factors contributing to accelerated aging has been added. Section 18.3, Nutrient Needs of Healthy Older Adults, has been updated based on current evidence-based recommendations and now includes a discussion of the MyPlate for Older Adults. A new *Fresh Tips* feature on physical activity recommendations to build muscle mass and reduce sarcopenia is now included as part of Section 18.4, Common Health Concerns of Older Adults.
- Chapter 19 has been updated with a new chapter opener case study introducing students to food-borne illnesses and practices to protect against such an illness. Section 19.5, Preventing Food-Borne Illnesses, has been updated to provide the most up-to-date expert recommendations and the content on food additives has been expanded. As well, a new *COVID-19* feature has been added providing Food and Drug Administration (FDA) guidance on food safety during the pandemic and preventing the spread of COVID-19.
- Chapter 20's content has been updated with the most current statistics and information regarding global nutrition and food insecurity. Tables 20.1 and 20.2 have undergone significant revisions to reflect updated global data. Section 20.3, Food Insecurity in the United States, has been updated, and a new *Sustainability and Your Diet* feature on food waste has been added. A new *COVID-19* feature addressing increased rates of food insecurity during the global pandemic has been added. The biotechnology content of the chapter has also been updated based on the most current research on this topic.

Features

Case Study—Each chapter begins with a case study addressing a realistic scenario. These high-interest scenarios engage students by showing how the chapter's content is relevant to their future professions and can be seen in a practical or clinical situation. Students are encouraged to consider the case study as they review the chapter. A suggested **Case Study Response** is provided at the end of the chapter to allow students to self-assess their understanding of the chapter's material and its applications.

Quiz Yourself—This pretest, which is next to the **Case Study**, stimulates interest in reading the chapter. By taking the quiz, students may be surprised to learn how little or how much they know about the chapter's contents.

CASE STUDY RESPONSE

Vitamin D and bone health



Oleksandra Naumenko/Shutterstock

VITAMIN D IS NECESSARY FOR HEALTHY bones, including those of the spine. Vitamin D enhances absorption of phosphorus and calcium in the small intestine, two minerals necessary for bone growth and maintenance. When vitamin D is deficient, bones weaken, leading to osteomalacia. The weakening of the bones in the spine can lead to an abnormal curvature of the upper spine, which can be identified through monitoring changes in height over time.

Vitamin D is often called the "sunshine vitamin" because the sun can convert a substance in skin, 7-dehydrocholesterol, into active vitamin D. The amount of vitamin D made through sunlight exposure depends on a variety of factors, including where a person lives. Josette lives in northern Maine, a location with long winters. Her low blood vitamin D levels may be a result of her living north of the 33rd parallel and spending much of her day indoors.

Dairy foods are generally excellent sources of vitamin D. Low-fat milk, yogurt, and cheese are good options. Salmon, tuna, catfish, herring, and sardines are also rich in vitamin D. Some ready-to-eat cereals, bread, orange juice, and margarine have added vitamin D.

9 Vitamin Overview and Fat-Soluble Vitamins

CASE STUDY

Vitamin D and bone health

SEVENTY-YEAR-OLD JOSETTE LEARNED at her last physician's appointment that she is 2 inches shorter than she was 5 years ago. Her physician noted that Josette had developed curvature of her upper spine and recommended that she have additional testing to determine the cause. Additional testing revealed that Josette has low blood levels of vitamin D.

Josette has lived in northern Maine her entire life. After spending the past 30 years working outdoors, she has retired and now spends the majority of her day indoors.

- Describe the relationship between vitamin D and developing curvature of the upper spine.
- Explain to Josette how living in northern Maine may be contributing to her low blood levels of vitamin D.
- Recommend at least five vitamin D-rich foods for Josette to include in her diet.

The suggested "Case Study Response" can be found at the end of the chapter.

QUIZ Yourself

Can vitamins give a person more energy or reduce their chances for developing chronic disease? What happens if someone consumes too little or too much of a particular vitamin? Test your knowledge of vitamins by taking the following quiz. The answers are found at the end of the chapter.

1. Vitamins are a source of "quick" energy. T F
2. A deficiency of vitamin A can lead to rickets. T F
3. Vitamin D deficiencies are rare in the United States. T F
4. Vitamin E is an antioxidant. T F
5. Vitamin K is necessary for blood clotting. T F



Learning Outcomes—Each major section of a chapter opens with a list of learning outcomes. The **Learning Outcomes** help students prepare for reading the section and clarify the major concepts they are expected to learn. These measurable outcomes are further supported by assessment methods and study aids found within the chapters and within McGraw Hill Education's Connect[®].

Assess Your Progress—These review questions, which appear at the end of each major section within a chapter, apply to the section's learning outcomes and often involve critical thinking skills. Such questions enable students to test their knowledge and understanding of the information provided within that section.

7.9 Food Hypersensitivity Disorders: Food Allergies, Food Intolerances, and Phenylketonuria

LEARNING OUTCOMES

- 1 Describe the incidence, causes, and treatment of food allergies.
- 2 Explain the difference between a food allergy and a food intolerance, and provide examples of each condition.
- 3 Compare and contrast celiac disease and non-celiac gluten sensitivity, including differences in cause and diagnosis.
- 4 Explain the cause of phenylketonuria (PKU) and discuss diagnosis and treatment of the disorder.

ASSESS YOUR PROGRESS

- 28 Identify potential health effects of untreated, frequent gastroesophageal reflux disease (GERD)
- 29 What factors contribute to the development of gastric ulcers?
- 30 Explain the differences between constipation and diarrhea and the consequences if they are untreated.
- 31 What dietary and lifestyle recommendations would you provide to a person experiencing irritable bowel syndrome (IBS)?
- 32 Describe the differences between Crohn's disease and ulcerative colitis.

Fresh Tips—These practical suggestions help students apply the chapter’s content to their current situations. The *Fresh Tips* are also valuable for future healthcare professionals who want to provide useful health, food, and nutrition advice to their clients. Such features provide tips for including more fruits and vegetables in the diet, maintaining a healthy body weight and composition, reducing intake of added sugars, and keeping foods safe to eat.

DID YOU KNOW?

Physical activity trackers, often worn on the wrist, have become widely available and utilized as a tool to monitor and promote physical activity. Fitness trackers allow users to track daily physical activity as well as, in many cases, food intake, sleep, and heart rate. According to recent research, wearable trackers can be used not only as a tool to promote physical activity but also to improve well-being through new social experiences and boosting of self-esteem.^{16,17} Fitness tracker users should keep in mind that most trackers are not 100% accurate with step counts and distance traveled but rather provide an estimate of activity level.¹⁸

Haiyin Wang/Alamy



Did You Know?—This feature presents bits of information concerning topics that support the chapter’s content and are of interest to introductory nutrition students. Some of these features dispel beliefs about food and nutrition that are commonly held but inaccurate. Many of the features are based on the most current research on a topic, presenting the science in an informative, accurate, and interesting way.

Sustainability and Your Diet—A sustainable diet is one that promotes health and is good for the planet, today and in the future. This new feature provides students with knowledge about sustainability and recommendations for making food and lifestyle choices to support a sustainable food system.

COVID-19

Early evidence suggests a link between vitamin D deficiency and COVID-19 severity.⁴⁰ Such a link can be seen both in the United States and across the world. Those countries with higher rates of vitamin D deficiency have also seen more cases of COVID-19 and more serious health consequences, including hospitalization and death, from the infection. To optimize blood levels of vitamin D, consume recommended amounts in the diet and, when possible, spend time outdoors in the sunlight. Some individuals may also benefit from taking a vitamin D supplement, but they should talk with their healthcare provider first since vitamin D may interact with other supplements and medications.⁴¹

COVID-19—The *COVID-19* feature provides the latest information on the relationship between nutrition, lifestyle factors and risk for COVID-19. As well, the impact of the pandemic on food insecurity and food safety are addressed in this timely feature.

FRESH TIPS

Dietary strategies that are often recommended to control morning sickness include:

- Eating small, frequent meals every 2 to 3 hours.
- Drinking ginger tea or nibbling on dried ginger pieces.
- Choosing healthy snacks, including those that are high in protein, such as nuts or yogurt.
- Supplementing with low doses of vitamin B-6.^{10,11}



Toltek/Stock/Getty Images



SUSTAINABILITY AND YOUR DIET

When most people think of bees, they think of honey, frequently used as a sweetener. However, in addition to producing honey, bees are also important for pollination of much of the food we eat, including vegetables, fruits, and nuts.

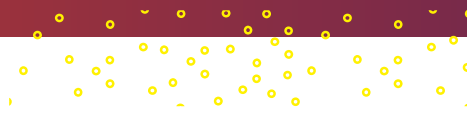
Experts estimate that bees help pollinate at least one-third of the plants used to produce food consumed around the world on a daily basis. According to the Food and Agriculture Organization (FAO) of the United Nations, 71 of the 100 crop species that provide 90% of the food around the world are pollinated by bees.² The accompanying image shows a honeybee getting pollen from a raspberry blossom.

Given the importance of bees in food production, keeping bees healthy is vital to a sustainable food system. Destruction of the bees’ natural habitat, pollution, climate change, and excess use of pesticides can all destroy local bee populations.³

To help keep the population healthy, the bees must have access to food and water that is contaminant free. Planting bee-friendly flowers and keeping water clean are two practices that help to sustain and grow bee colonies, important for both honey and the production of much of the food eaten around the world.



ZeroMinusOne/Stock/Getty Images



Each chapter ends with a *Case Study Response* and the following features.

Summary

SUMMARY

SECTION 13.1 Overweight and Obesity

- In the United States, overweight and obesity are widespread nutritional problems that have reached epidemic proportions. Overweight is characterized by higher than average body weight that is contributed by bone, muscle, body fat, and/or body water. Obesity is characterized by excessive and unhealthy amounts of body fat.

SECTION 13.2 Evaluating Health Using BMI and Body Composition

- Body mass index (BMI) is a health assessment tool based on the relationship between body weight and height that does not take body composition into account.

Critical Thinking—

These questions involve higher-level cognition skills, including applying, analyzing, synthesizing, and evaluating information.

Critical Thinking

1. Think about what you ate yesterday. Identify at least four factors that influenced your food and beverage choices. Of these factors, which was the most important to you? Explain why.
2. Consider your current eating habits. Does your diet have variety? Explain why your diet is or is not varied.
3. "Everything in moderation." Explain what this statement means in terms of your diet.
4. Consider your parents' and grandparents' health (or causes of death). Based on your family history, which chronic health conditions do you have a higher-than-average risk of developing?

If you were at risk of developing a chronic health condition that could be prevented by changing your diet, would you make the necessary changes at this stage of your life? Explain why or why not.

5. Eric spends about \$100 each month on purchases of dietary supplements, including protein powders, vitamin pills, and herbal extracts. He thinks it is necessary to take the products to achieve optimal health and prevent chronic illnesses. Based on the information in this chapter, what would you tell Eric about his use of the supplements?

Practice Test—This series of multiple-choice questions assesses students' comprehension and recall of the information presented in the chapter.

Practice Test

Select the best answer.

1. What is the AMDR for fat?
 - a. 10–35% of total kcal
 - b. 20–35% of total kcal
 - c. 30–45% of total kcal
 - d. 45–65% of total kcal
2. Which of the following statements is false?
 - a. RDAs are standards for daily intakes of certain nutrients.
 - b. RDAs meet the nutrient needs of nearly all healthy people.
 - c. RDAs contain a margin of safety.
 - d. RDAs are listed on food labels.
3. The Estimated Energy Requirement (EER)
 - a. has a margin of safety.
 - b. does not account for a person's height, weight, or physical activity level.
 - c. is based on the average daily energy needs of a healthy person.
 - d. reflects a person's actual daily energy needs.
11. Which of the following statements is false?
 - a. Each dietary pattern of the MyPlate guidelines includes a recommendation for daily fruit intake.
 - b. MyPlate can be individualized to meet a person's food preferences.
 - c. A major weakness of www.myplate.gov is the website's failure to emphasize the importance of regular physical activity.
 - d. A person can use MyPlate to evaluate his or her diet's nutritional adequacy.
12. Which of the following information is not provided by the Nutrition Facts panel (2020)?
 - a. Percentage of total calories from fat
 - b. Amount of total carbohydrate per serving
 - c. Serving size
 - d. Amount of total fat per serving
13. Daily Values are

References—Numbered references are provided at the end of each chapter.

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CULINARY MEDICINE



Foodcollection

Modifying Recipes for Healthy Living

Martin is a 16-year-old high school student who suspects that he may suffer from non-celiac gluten sensitivity (NCGS) because he experiences headaches, bloating, and “mental fog” after consuming wheat products. His diet is fairly high in gluten-containing foods; he normally eats cereal for breakfast, a sandwich at lunch, and his favorite pasta dish for dinner. Use the provided pasta recipe to answer the following questions.

1. Using diet analysis software, such as NutritionCalc Plus, enter the recipe information and evaluate the nutrition information. How many total kcal, grams of protein, grams of carbohydrate, and grams of fat are provided per serving of the pasta dish?
2. What suggestions do you have for your client to eliminate the gluten from the recipe?
3. What suggestions do you have for your client to ensure that the protein content of the recipe remains the same?
4. Develop a modified version of this recipe.
5. Use the diet analysis software to again evaluate the nutrition information. How do the total kcal, grams of protein, grams of carbohydrate, and grams of fat provided per serving of the dish compare to the original recipe?
6. OPTIONAL: Prepare both the original and the modified recipes. How does the gluten-free pasta taste, compared to wheat pasta? Have your friends see if they can figure out which dish is which!

Pesto Rigatoni

- 3 cups wheat linguini noodles
- 1/2 cup olive oil
- 1/2 cup pine nuts
- 1/2 cup parmesan cheese
- 1/2 cup red bell pepper
- 2 cups fresh basil leaves
- 2 cloves garlic

Makes 3 servings.

Culinary Medicine—*Culinary Medicine* combines knowledge of evidence-based dietary recommendations for optimizing health and preventing and treating disease with practical cooking guidance to make food tasty and appealing! This feature provides students with the opportunity to apply nutrition and food information to situations that commonly arise in clinical settings. Students modify an existing recipe to make it healthier, using information they have learned in the chapter. This feature allows students to apply their knowledge of culinary medicine to plan recipes that meet specific health guidelines, such as reducing the sodium content of a recipe for a person with high blood pressure.

PERSONAL Dietary Analysis

1. Record every food and beverage you eat over a 24-hour period. Recall how much you consumed and how it was prepared. Use the format shown in the sample (Table 3.16) to record your food and beverage intake.

McGraw Hill connect
Complete the Personal Dietary Analysis activity in Connect.

TABLE 3.16 Sample Food Record

Time of Day	Foods and Beverages	Food Preparation Description (e.g., Fried, Baked, Raw)	Estimated Amount Consumed
Breakfast—7 A.M.	Whole-grain ready-to-eat cereal	—	3/4 cup
Breakfast—7 A.M.	Fat-free milk	—	1 cup

2. Use NutritionCalc Plus to create a personal profile based on your age, sex, height, weight, and activity level. Then, use the “Intakes” option to enter your food and beverages.
3. Go to “Reports” and select “MyPlate Report.” Click on “View Report” to view the MyPlate analysis based on the 1-day food record.
4. Using Table 3.17, enter a minus sign (–) if your total intake is below the MyPlate recommendations and a plus sign (+) if it equals or exceeds the daily recommended amount for each food group.

TABLE 3.17 Rating Your Record

USDA Food Group	Actual Intake (from Question 3)	Recommended Intake (from Question 4)
Grains		
Vegetables		
Fruits		
Dairy		
Protein foods		

5. Evaluate the quality of your 24-hour food intake based on MyPlate guidelines.
 - a. Did your food intake meet MyPlate guidelines for all food groups? If it did not, list the food group(s) for which your intake(s) exceeded the recommendations. List food group(s) for which your intake(s) did not meet the guidelines.
 - b. Rate the overall quality of your general diet based on MyPlate on a scale of 1 to 5, with 1 being “poor” and 5 being “excellent.” Why did you give your diet this rating?
 - c. If your usual intake of nutrients does not meet or exceeds daily calorie and food group recommendations on a regular basis, describe how you could modify your diet to improve your intake.

Personal Dietary Analysis—Students can gain insight into their eating habits by completing this activity. Many of these activities can be completed with the use of a dietary analysis software program, such as NutritionCalc Plus.

Artwork and Photographs That Enhance Learning

Dimensional, full-color illustrations, some with numbered labels and explanatory text, help teach and/or show the progression of a complicated concept.

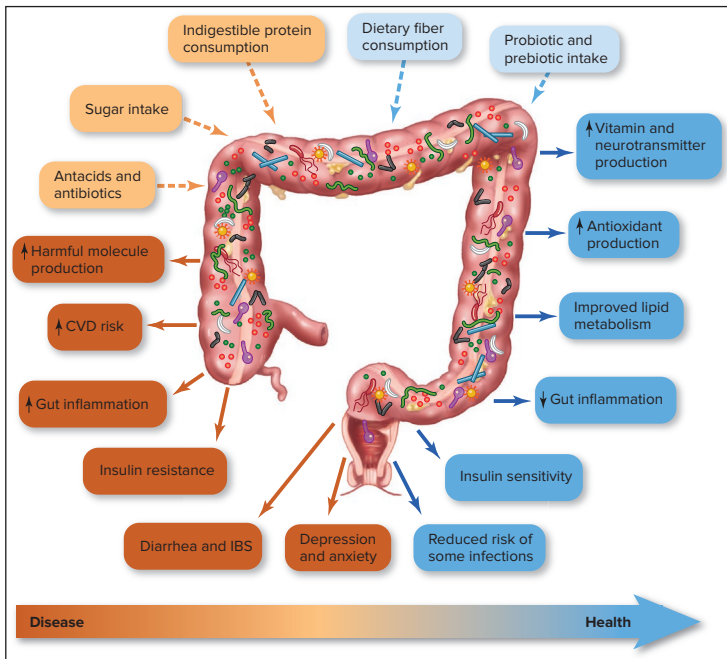


FIGURE 4.18 Gut microbiota in health and disease. Shutterstock / Netkoff

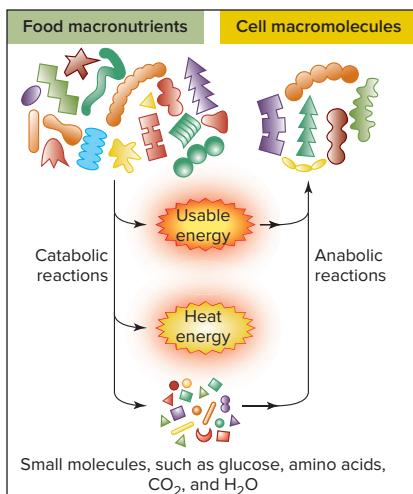


FIGURE 8.1 Metabolism. Energy released from catabolic reactions is used to fuel anabolic reactions in cells.

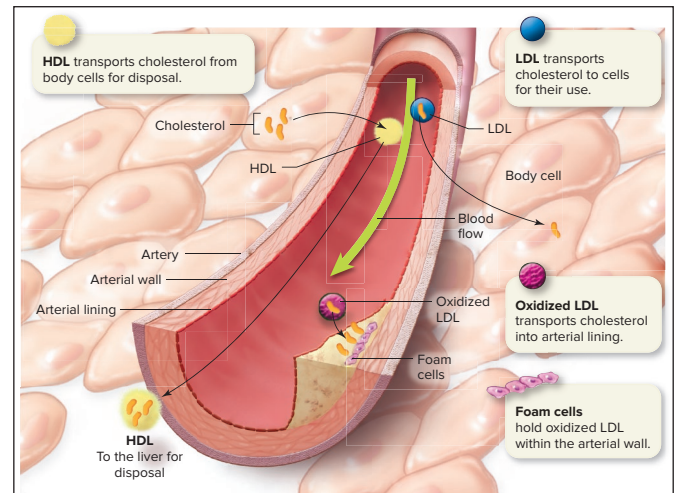


FIGURE 6.21 The role of HDL and LDL in lipid transport throughout the body. Oxidized LDL is taken up by macrophages, a type of immune system cell. Over time, the cholesterol-laden macrophages become “foam” cells that build up and contribute to atherosclerosis.

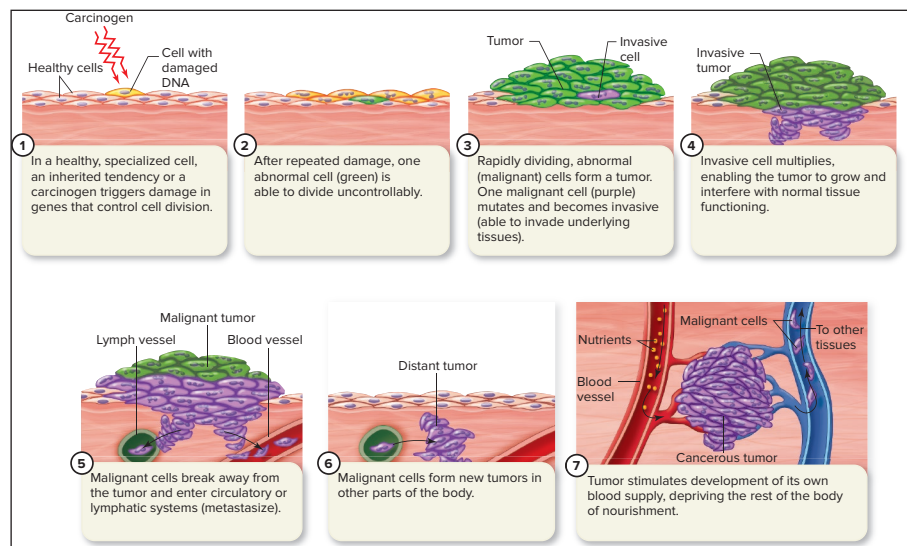
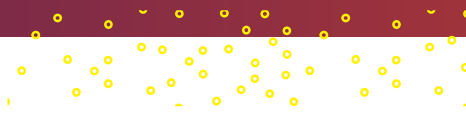


FIGURE 10.14 Cancer development and progression. Several steps are involved as a normal cell progresses into a cancer cell that multiplies out of control.



Numerous **high-quality photos** support the text and provide examples of nutrition-related medical conditions as well as microscopic views of clinical cases from the human body.

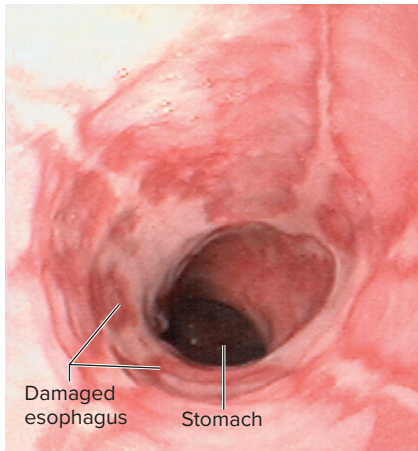


FIGURE 4.19 Acid reflux damage.
David M. Martin, M.D./Science Source



FIGURE 6.16 Gallstones.
Clinical Photography, Central Manchester University Hospitals NHS Foundation Trust, UK/Science Source



FIGURE 7.18 Skin patch testing for allergies.
©Science Photo Library/Getty Images

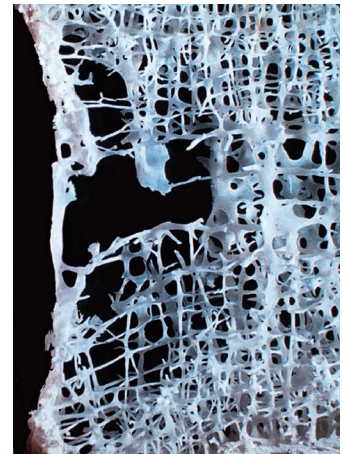


FIGURE 11.14 Bone tissue.
Michael Klein/Photolibrary/Getty Images



Shaiith/Shutterstock



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Our heartfelt thanks extend to everyone at McGraw Hill who worked on the development and production of this third edition of *Human Nutrition: Science for Healthy Living*. Developing such an innovative and superior nutrition majors' textbook was not an easy task, but our role as authors was made less challenging and more enjoyable by the talented and creative professionals who were assigned to the book. The book team consulted us when making important decisions that directly affected the textbook's features, layout, design, pedagogy, and even the cover. We appreciate their willingness to seek our input and consider us as valuable members of the team.

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Contents

Preface xi

1 Introduction to Nutrition 1

- 1.1 The Importance of Nutrition 2**
 - Why Study Nutrition? 2
 - How to Use This Textbook 2
- 1.2 The Nutrients 3**
 - The Six Classes of Nutrients 3
 - Nutrients: Elements 4
 - Nutrients: Essential and Conditionally Essential 5
 - Macronutrients and Micronutrients 6
 - Phytochemicals 6
- 1.3 Food as Fuel 7**
 - Direct Calorimetry 8
 - Calculating Food Energy 8
- 1.4 Does Diet Matter? 9**
 - Risk Factors 9
- 1.5 Factors That Influence Eating Habits 12**
 - Biological and Physiological Factors 12
 - Cognitive and Psychological Factors 13
 - Environmental Factors 13
 - Expert Advice Factors 13
- 1.6 Key Nutrition Concepts 15**
 - Concept 1: Most Foods Are Mixtures of Nutrients 15
 - Concept 2: Variety, Moderation, and Balance Can Help Ensure a Diet's Nutritional Adequacy 16
 - Concept 3: Food Is the Best Source of Nutrients 17
 - Concept 4: Foods and the Nutrients They Contain Are One of Many Components of Health 18
 - Concept 5: Malnutrition Includes Overnutrition as Well as *Undernutrition* 19
 - Concept 6: Nutrition Is a Dynamic Science 19
- Summary 20

2 Evaluating Nutrition Information 26

- 2.1 Dr. Goldberger's Discovery 27**
 - Identification of the Missing Dietary Substance 27
- 2.2 Understanding the Scientific Method 28**
 - An Introduction to the Scientific Method 28
 - Laboratory Research: Test Tube Studies 29
 - Laboratory Research: Animal Studies 30
 - Human Research: Observational Studies 32
 - Human Research: Experimental Studies 35
 - Self-Experimentation 36
 - Research Bias 37
 - Following Up with More Research 38
- 2.3 Nutrition Information: Fact or Fiction 39**
 - Conflicts and Controversies 39
 - Ask Questions 40
 - Look for Red Flags 40
 - Use the Internet Wisely 41
- Summary 43

3 Basis of a Healthy Diet 48

- 3.1 What Is a Nutrient Requirement? 49**
- 3.2 Dietary Reference Intakes: Nutrient and Calorie Standards 49**
 - Estimated Average Requirement 50
 - Estimated Energy Requirement 50
 - Recommended Dietary Allowances 50
 - Adequate Intakes 50
 - Tolerable Upper Intake Level 51
 - Acceptable Macronutrient Distribution Ranges 51
 - Applying Nutrient Standards 51
- 3.3 Major Food Groups 53**
 - Grains 53
 - Dairy Foods 54
 - Protein Foods 55

Fruits 55
Vegetables 55
Oils 55

3.4 U.S. Dietary Guidelines 56

Applying the 2020–2025 *Dietary Guidelines for Americans* 57

3.5 Food Guides for Dietary Planning 58

MyPlate 58
Other Menu-Planning Tools 63

3.6 Cultural Influences on Meal Planning 63

Hispanic Diet 64
Native American Indian Diets 64
African Heritage Diets 64
Southern European Diet 65
Asian Diet 65
Religious Influences 66

3.7 Food and Dietary Supplement Labels 66

Daily Values 67
Nutrition Facts Panel 67
Health Claims 69
Structure/Function Claims 69
Nutrient Content Claims 69
Other Descriptive Labeling Terms 70
Dietary Supplement Labels 70
Organic Food 72

Summary 74

4 Human Digestion, Absorption, and Transport 80

4.1 Overview of the Digestive System 81

Layers of the Wall of the GI Tract 81
Sphincters Control the Flow of GI Contents 81
Mechanical and Chemical Digestion 82

4.2 The Mouth 83

Salivary Glands 83
Taste Buds 83
Disorders of Taste and Smell 84

4.3 The Esophagus 85

Peristalsis 85

4.4 The Stomach 86

Secretions of the Stomach 87
Digestion in the Stomach 88

4.5 The Small Intestine 89

Accessory Organs: The Liver, Gallbladder, and Pancreas 90

Digestion in the Small Intestine 90
Nutrient Absorption and Transport 92
Bioavailability of Nutrients 93

4.6 The Large Intestine 94

Functions of the Large Intestine 94

4.7 Microbes in the Digestive Tract 96

Actions of Intestinal Bacteria 96
Probiotics and Prebiotics 97
Fecal Microbiota Transplantation 98

4.8 Common Digestive Tract Disorders 99

Gastroesophageal Reflux 100
Vomiting 100
Gastric Ulcer 101
Constipation 102
Diarrhea 102
Irritable Bowel Syndrome 103
Inflammatory Bowel Disease 103
Diverticulosis and Diverticulitis 104

Summary 105

5 Carbohydrates: Sugars, Starches, and Fiber 110

5.1 Introducing Carbohydrates 111

5.2 Simple Carbohydrates 112

Monosaccharides 112
Disaccharides 113
What Is High-Fructose Corn Syrup? 114
Nutritive Sweeteners 115
Alternative Sweeteners 116

5.3 Complex Carbohydrates 118

Oligosaccharides 118
Starch and Glycogen 118
Fiber 119

5.4 Carbohydrate Consumption Patterns 121

Added Sugar Consumption 122

5.5 Carbohydrates: Digestion and Absorption 123

Carbohydrate Digestion 123
Carbohydrate Absorption 124
Fiber 124

5.6 Maintaining Normal Blood Glucose Levels 125

Metabolism of Glucose 126

5.7	Diabetes Mellitus	127
	What Is Diabetes?	127
	Testing for Diabetes	130
	Controlling Diabetes	130
	Can Diabetes Be Prevented?	133
	What Is Hypoglycemia?	133
5.8	Carbohydrates and Health	134
	Are Carbohydrates Fattening?	134
	Metabolic Syndrome	135
	Tooth Decay (Dental Caries)	136
	Lactose Intolerance	136
	Does Sugar Cause Hyperactivity?	137
	Fiber and Health	138
	Summary	140

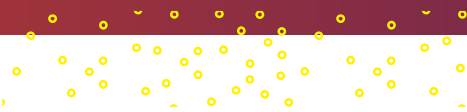
6 Lipids: Triglycerides, Phospholipids, and Sterols 149

6.1	Introducing Lipids	150
	Classes of Lipids	150
	Major Functions of Lipids	150
6.2	Fatty Acids	151
	Saturation	151
	Omega Fatty Acids	151
	Essential Fatty Acids	152
	What Are Trans Fats?	153
6.3	Triglycerides	155
	Triglycerides in Foods	155
6.4	Phospholipids	157
6.5	Cholesterol and Other Sterols	158
	Plant Sterols and Stanols	159
6.6	Lipid Digestion, Absorption, and Transport	160
	Lipid Digestion	160
	Lipid Absorption	162
	Lipid Transportation	163
	Enterohepatic Circulation of Bile	165
	Lipid Storage Diseases	166
6.7	Lipid Consumption Patterns	167
6.8	Lipids and Cardiovascular Disease	168
	From Atherosclerosis to Cardiovascular Disease	168
	CVD: Major Risk Factors	170
	Assessing Risk of Atherosclerosis	173

6.9	Reducing Risk of Atherosclerosis: Dietary Changes	175
	What About Omega-6 and Omega-3 Fats?	175
	What About Dietary Cholesterol?	176
	Food Selection and Preparation	177
	Other Dietary Modifications	178
	Weight Loss and Physical Activity	178
	What If Lifestyle Changes Do Not Work?	179
	Summary	180

7 Proteins: Amino Acids 189

7.1	Introducing Proteins	190
	Major Functions of Protein in the Body	190
7.2	Amino Acids	191
	Essential Amino Acids	191
	Derivatives of Amino Acids	192
7.3	Protein Synthesis and Structure	192
	Protein Structure	193
	Protein Denaturation	194
7.4	Protein in Foods	195
	Protein Quality and Completeness	196
7.5	Protein Digestion, Absorption, and Transport	196
	Protein Digestion	197
	Protein Absorption and Transport	197
7.6	Protein Metabolism	198
	Amino Acid Metabolism: Transamination and Deamination	198
	Nitrogen Balance	200
7.7	Meeting Protein Needs	201
	RDA for Protein	202
	Protein Complementation	202
	High Protein Intake	203
7.8	Protein Undernutrition	206
	Protein Deficiency	207
7.9	Food Hypersensitivity Disorders: Food Allergies, Food Intolerances, and Phenylketonuria	208
	Food Allergies	209
	Celiac Disease	209
	Non-celiac Gluten Sensitivity	211
	Planning a Gluten-Free Diet	211
	Food Intolerances	212
	Phenylketonuria	212



- 7.10 Plant-Based Diets 213**
 - Health Effects of a Plant-Based Diet 213
 - Important Nutritional Considerations for Plant-Based Diets 214
 - Plant-Based Menu Planning 215
- 7.11 Nutritional Genomics 216**
 - Personalized Nutrition 217
 - The Future of Nutritional Genomics 217
- Summary 217

- 8.8 Managing Fuel in the Body 250**
 - Metabolic Responses to an Overnight Fast 250
 - Metabolic Responses to Starvation 250
 - Obesity and Insulin Resistance 251
- 8.9 Putting the Metabolism Puzzle Together 252**
- 8.10 Alcohol as an Energy Source 254**
 - Alcohol Absorption 255
 - Alcohol Metabolism 255
 - Effects of Alcohol on the Body 258
 - Alcohol Use Disorder 260
 - Caffeinated Alcoholic Beverages 261
- Summary 261

8 Metabolism 226

- 8.1 Fueling the Body 227**
 - What Is Energy? 227
- 8.2 Energy Metabolism 228**
 - The Roles of Enzymes and Coenzymes 228
 - Adenosine Triphosphate 229
 - Mitochondria: The Powerhouse of the Cell 230
- 8.3 Obtaining Energy from Carbohydrates 230**
 - Carbohydrate Catabolism 230
 - Glycogenolysis 235
 - Alternative Sources of Glucose 236
 - Carbohydrate Catabolism: Putting the Puzzle Together 236
- 8.4 Obtaining Energy from Fat 237**
 - Beta-Oxidation: Fatty Acids to Acetyl CoA 238
 - What Is Ketogenesis? 240
 - Fat Catabolism: Putting the Puzzle Together 241
- 8.5 Obtaining Energy from Protein 243**
 - Preparing Amino Acids for Catabolism: Removing Nitrogen 243
 - Using Amino Acids for Energy 243
 - Protein Catabolism: Putting the Puzzle Together 243
- 8.6 Energy Storage 244**
 - Storing Triglycerides 244
 - Storing Glucose 245
 - When Amino Acids Are in Excess 245
 - Wasting Excess Energy 246
- 8.7 Hormonal Responses to Changing Energy Needs 247**
 - Insulin: Anabolic Metabolism 248
 - Glucagon, Cortisol, and Epinephrine: Catabolic Metabolism 248
 - Thyroid Hormone: Adaptation to Changing Conditions 250

9 Vitamin Overview and Fat-Soluble Vitamins 266

- 9.1 Introducing Vitamins 267**
- 9.2 Vitamins: The Basics 267**
 - Classifying Vitamins 268
 - Roles of Vitamins 269
 - Sources of Vitamins 271
 - Vitamin Absorption 272
 - Deficiency and Toxicity of Vitamins 272
 - Preserving the Vitamin Content of Foods 274
- 9.3 An Overview of Fat-Soluble Vitamins 275**
- 9.4 Vitamin A 276**
 - Classifying Forms of Vitamin A 276
 - Functions of Vitamin A 277
 - Food Sources of Vitamin A 279
 - Carotenoids 279
 - Dietary Adequacy 280
 - Vitamin A and Chronic Disease 281
- 9.5 Vitamin D 282**
 - Classifying Forms of Vitamin D 282
 - Functions of Vitamin D 283
 - Food Sources of Vitamin D 284
 - Dietary Adequacy 286
- 9.6 Vitamin E 287**
 - Classifying Forms of Vitamin E 287
 - Functions of Vitamin E 288
 - Food Sources of Vitamin E 288
 - Dietary Adequacy 288
 - Vitamin E and Chronic Disease 289
- 9.7 Vitamin K 290**
 - Digestion and Absorption of Vitamin K 290
 - Functions of Vitamin K 291
 - Food Sources of Vitamin K 291

Dietary Adequacy 292
Vitamin K and Osteoporosis 292

9.8 Cystic Fibrosis and Fat-Soluble Vitamins 293

What Is Cystic Fibrosis? 293
Symptoms and Diagnosis 293
Treatment 294
Summary 295

10 Water-Soluble Vitamins 301

10.1 Introducing Water-Soluble Vitamins 302

Water-Soluble Vitamins: Basic Concepts 302
Water-Soluble Vitamins as Coenzymes 302

10.2 Thiamin 304

Functions of Thiamin 304
Food Sources of Thiamin 305

10.3 Riboflavin 306

Food Sources of Riboflavin 307
Dietary Adequacy 307

10.4 Niacin 308

Food Sources of Niacin 308
Dietary Adequacy 309

10.5 Pantothenic Acid 310

Food Sources of Pantothenic Acid 310
Dietary Adequacy 310

10.6 Biotin 311

Food Sources of Biotin 311
Dietary Adequacy 312

10.7 Vitamin B-6 312

Food Sources of Vitamin B-6 312
Dietary Adequacy 313

10.8 Folate 314

Sources of Folate 314
Digestion and Absorption of Folate 315
Dietary Adequacy 316

10.9 Vitamin B-12 319

Food Sources of Vitamin B-12 319
Digestion and Absorption of Vitamin B-12 320
Dietary Adequacy 320

10.10 Vitamin C 322

Functions of Vitamin C 322
Food Sources of Vitamin C 323
Dietary Adequacy 323

10.11 Vitamin-Like Compounds 325

Choline 326
Carnitine 327

Inositol 327
Taurine 328
Lipoic Acid 328

10.12 Diet and Cancer 328

What Is Cancer? 328
What Causes Cells to Become Cancerous? 330
The Role of Diet in Cancer Development 331
Diet and Cancer Prevention 331
Reducing the Risk 332
Summary 332

11 Water and Major Minerals 340

11.1 Water 341

Water and Body Composition 341
Functions of Water 341
Water and Membrane Transport 341
Water Distribution: Intracellular and Extracellular Water 342
Sources of Water 343

11.2 Water Balance and Hydration 344

Water Balance 344
Hydration Status 346

11.3 Minerals: The Basics 348

Functions of Minerals 349
Sources of Minerals 349
Major Minerals 351

11.4 Calcium 353

Maintaining Normal Blood Calcium Levels 354
Sources of Calcium 354
Calcium Absorption 356
Dietary Adequacy 357
Calcium, Heart Disease, and Weight Control 360

11.5 Phosphorus 360

Food Sources of Phosphorus 361
Dietary Adequacy 361

11.6 Sodium 363

Food Sources of Sodium 363
Dietary Adequacy 363
Sodium and Hypertension 364

11.7 Potassium 367

Sources of Potassium 367
Dietary Adequacy 367

11.8 Magnesium 369
Sources of Magnesium 369
Dietary Adequacy 371

11.9 Chloride 371
Food Sources of Chloride 372
Dietary Adequacy 372

11.10 Sulfur 373
Summary 373

12 Trace Minerals 381

12.1 What Is a Trace Mineral? 382

12.2 Iron 383
Food Sources of Iron 384
Iron Absorption, Storage, and
Transport 385
Dietary Adequacy 387

12.3 Iodine 391
Function of Iodine 392
Sources of Iodine 392
Iodine Absorption 392
Dietary Adequacy 392

12.4 Zinc 394
Functions of Zinc 394
Sources of Zinc 395
Dietary Adequacy 396

12.5 Selenium 397
Functions of Selenium 397
Sources of Selenium 398
Dietary Adequacy 399
Selenium and Health 399

12.6 Fluoride 399
Functions of Fluoride 400
Sources of Fluoride 400
Dietary Adequacy 401

12.7 Chromium 402
Function of Chromium 402
Sources of Chromium 402
Dietary Adequacy 402

**12.8 Copper, Manganese, and
Molybdenum 403**
Copper 404
Manganese 405
Molybdenum 405

**12.9 Possible Essential
Minerals 406**
Arsenic in Food 406
Summary 408

13 Obesity, Energy Balance, and Weight Management 414

13.1 Overweight and Obesity 415
Prevalence of Obesity 415
Health Consequences of Obesity 416
Economic Consequences of Obesity 417

**13.2 Evaluating Health Using BMI and Body
Composition 417**
Body Mass Index 417
Body Composition and Fat Distribution 418
How Much Body Fat Is Healthy? 421

13.3 Energy Intake and Expenditure 423
Energy Expenditure 423
Estimating Total Energy Expenditure 425
Measuring Energy Expenditure 426
Energy Balance 427
Beyond Energy Balance 428

13.4 Factors That Influence Body Weight 428
Genetic Factors 429
Physiological Factors: Regulation of Adipose
Tissue 429
Physiological Factors: Regulation of Eating
Behavior 430

**13.5 Strategies to Improve Body
Composition 433**
Dietary Considerations 433
Optimizing Eating Behaviors 435
Physical Activity Recommendations 436
Other Factors 437
Recommended Weight-Loss Practices 438

13.6 Medical Treatment of Obesity 440
Weight-Loss Medications 440
Bariatric Surgical Procedures 440
Summary 442

14 Eating Disorders and Disordered Eating 449

**14.1 Introduction to Eating Disorders and
Disordered Eating 450**
Continuum of Eating Behaviors 450
Major Types of Eating Disorders 450
Factors Contributing to Eating
Disorders 452

14.2 Anorexia Nervosa 453
Signs and Symptoms 453

Diagnosis 454
Physiological Consequences 454

14.3 Bulimia Nervosa 455
Signs and Symptoms 455
Health Risks 456

14.4 Binge Eating Disorder 456
Prevalence and Health Risks 457

14.5 Other Specified or Unspecified Feeding or Eating Disorders 457
Night Eating Syndrome 458
Unspecified Feeding or Eating Disorders 458

14.6 Female Athlete Triad 460
Health Consequences of the Female Athlete Triad 460

14.7 Prevention and Treatment of Eating Disorders 461
Preventing Eating Disorders 461
Treating Eating Disorders 462
Summary 465

15 Nutrition for Fitness and Sport 470

15.1 Physical Activity and Health 471
What Is Physical Activity? 471
Health Benefits of Regular Physical Activity 471
Physical Activity Habits of Americans 471
Physical Activity Pyramid 472

15.2 Physical Activity Guidelines 474
Determining the Intensity of Physical Activity 475
Aerobic Training 476
Muscle-Strengthening Activities 477
Developing a Physical Fitness Plan 477
Components of an Enduring Fitness Plan 478

15.3 Energy Systems for Exercising Muscles 479
Energy Metabolism During Exercise 479
Aerobic Capacity 482
Fat or Carbohydrate for Fueling Exercise? 483

15.4 Basics of Sports Nutrition 484
Energy Needs 484

15.5 Carbohydrate Needs of Athletes 485
Carbohydrate Needs 485
Pre-event Meals and Snacks 486

Consuming Carbohydrates During Events 488
Consuming Carbohydrates During Exercise Recovery 488

15.6 Fat Needs of Athletes 489
Fats Utilization During Exercise 489
Fat Needs 489

15.7 Protein Needs of Athletes 490
Protein Intake of Athletes 490
Importance of Protein for Physical Activity 490
Protein Recommendations for Athletes 491
Protein Supplements for Athletes 492

15.8 Micronutrient Needs of Athletes 494
Antioxidant Vitamins 494
Iron 495
Calcium and Vitamin D 495

15.9 Fluid and Electrolyte Needs of Athletes 496
Fluid Recommendations 497
Heat-Related Illness 497
Replenishing Fluids 498
Hyponatremia 500

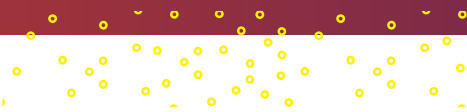
15.10 Ergogenic Aids 500
What Is an Ergogenic Aid? 501
Safety and Effectiveness of Ergogenic Aids 504
Summary 505

16 Pregnancy and Lactation 512

16.1 Preparing for Pregnancy: Nutrition Concerns 513
The Preconception Period 513
Nutritional Considerations in Fertility 513

16.2 Physiology of Pregnancy 515
The First Trimester 515
The Second and Third Trimesters 516
Common Signs and Symptoms of Pregnancy 516
Changes to Maternal Tissues During Pregnancy 517
Gastrointestinal Disturbances During Pregnancy 519

16.3 Nutrition and Lifestyle for a Healthy Pregnancy and Delivery 520
Energy, Protein, and Essential Fatty Acid Needs 520
Vitamin and Mineral Needs 521
Developmental Origins of Disease 522
Physical Activity During Pregnancy 523



16.4 Limiting Toxin Exposure During Pregnancy 524

- Alcohol 524
- Tobacco 524
- Foods and Beverages of Concern 525
- Environmental Toxins 525
- Medication Use During Pregnancy 525

16.5 Health Conditions During Pregnancy 527

- Diabetes in Pregnancy 527
- Swelling and Hypertension in Pregnancy 527
- Anemia of Pregnancy 528
- Effects of Maternal Health on Birth Outcomes 528

16.6 Lactation and Breastfeeding 529

- Trends in Breastfeeding 529
- Physiology of Milk Production and Lactation 530
- Stages of Lactation 530
- Recommendation for the Duration of Breastfeeding 531
- Dietary Planning for Lactating Women 531
- Benefits and Challenges of Breastfeeding 532

Summary 533

17 Infants, Children, and Adolescents 539

17.1 Infancy: Birth to 12 Months 540

- Reflexes 541
- Developmental Milestones 541
- Nutrition During Infancy 542
- Complementary Foods 546
- Physiological Readiness for Weaning 547

17.2 Toddlers and Preschool-Age Children 549

- Growth and Development 550
- Nutrition for Toddlers and Preschoolers 550
- Diet-Related Concerns 551
- Special Supplemental Nutrition Assistance Program for Women, Infants, and Children 552

17.3 School-Age Children 553

- Nutritional Concerns 553
- Planning Nutritionally Adequate Meals and Snacks 554
- School Lunches 554

17.4 Adolescence 554

- Growth and Development 555

- Nutrition During Adolescence 556
- Nutrition-Related Concerns of Adolescents 557

17.5 Overweight and Obesity in Children and Adolescents 558

- Defining Obesity in Children 558
- Health Problems Associated with Childhood Obesity 559
- Childhood Obesity: Contributing Factors 559
- Childhood Obesity: Prevention 561
- Childhood Obesity: Treatment 562
- Summary 563

18 Nutrition for Older Adults 569

18.1 Older Adults 570

- Defining Older Adult 570
- What Is Life Expectancy? 570
- Theories on Aging 571

18.2 Physiological Aspects of Normal Aging 573

18.3 Nutrient Needs of Healthy Older Adults 574

- Energy 574
- Macronutrients 575
- Water 575
- Vitamin D 575
- Vitamin B-12 576
- Calcium 576
- Sodium and Potassium 576

18.4 Common Health Concerns of Older Adults 577

- Weight Loss 577
- Obesity 577
- Diseases and Conditions That Affect Vision 578
- The Aging Digestive Tract 580
- Arthritis 581
- Depression 581
- Heart Failure 582
- Polypharmacy and Food-Drug Interaction 582

18.5 Dementia 583

- Alzheimer's Disease 584
- Vascular Dementia 584
- Parkinson's Disease 584
- Risk Factors for Age-Related Dementia 584

18.6 Food Insecurity Among Older Adults 585

- Food and Nutrition Programs for Community-Residing Older Adults 586
- Administration for Community Living's Nutrition Program 586
- Summary 587

19 Food and Water Safety 592

- 19.1 Protecting the Food Supply 593**
 - Key Federal Food Safety Agencies 593
 - State and Local Health Departments 594
- 19.2 Pathogens in Food 594**
 - Sources of Pathogens 595
 - Potentially Hazardous Foods 596
- 19.3 Food-Borne Illness 597**
 - Causes of Food-Borne Illness 597
 - High-Risk Populations 598
- 19.4 Common Food-Borne Pathogens 599**
 - Bacteria 599
 - Viruses 600
 - Protozoa and Parasitic Worms 601
 - Toxins 602
 - Prions 602
- 19.5 Preventing Food-Borne Illnesses 603**
 - Food Selection 603
 - Food Preparation 604
 - Raw Fish 607
 - Ground Meats, Poultry, and Cooked Fish 607
 - Storing and Reheating Food 607
 - Check Your Steps Program 608
- 19.6 Food Preservation 609**
 - Food Preservation Techniques 610
 - Canned Foods 611
 - Irradiation 611
- 19.7 Food Additives 612**
 - Intentional Food Additives 612
 - Food Safety Legislation: Food Additives 612
 - Unintentional Food Additives 613
- 19.8 Public Water Supply and Safety 616**
 - Comparing Bottled and Tap Water 617
- 19.9 Preparing for Disasters 618**
 - Emergency Water Supply 618
 - Emergency Food Supply 619
- Summary 620

20 Global Nutrition 625

- 20.1 Malnutrition: A Worldwide Concern 626**
 - Chronic Undernutrition 626
 - Factors That Contribute to Undernutrition 626
 - Consequences of Chronic Undernutrition 627
- 20.2 Undernutrition: Common Micronutrient Deficiencies 630**
 - Vitamin A 630
 - Iron 630
 - Iodine 631
 - Zinc 631
- 20.3 Food Insecurity in the United States 632**
 - Hunger in the United States 632
 - Improving Food Access 633
 - Major U.S. Food Assistance Programs 634
 - Taking Action Against Food Insecurity 636
- 20.4 Preventing and Treating Undernutrition 638**
 - Biotechnology 639
 - Fortification of Foods 639
 - Sustainable Living Practices 640
 - Summary 641
- Appendix A English-Metric Conversions and Metric-to-Household Units A-3
- Appendix B Basic Chemistry Concepts A-5
- Appendix C Basic Anatomy and Physiology Concepts A-9
- Appendix D Chemical Structures: Amino Acids and Vitamins A-13
- Appendix E Vitamins Involved in Energy Metabolism A-19
- Appendix F Nutrition Assessment A-21
- Appendix G Daily Values Table A-31
- Appendix H Canada's Food Guide A-33
- Appendix I Food Composition Table A-35
- Appendix J DRI Tables A-105
- Glossary G-1
- Index I-1

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1 Introduction to Nutrition

CASE STUDY

Healthy eating while on campus

EACH CHAPTER IN THE TEXTBOOK is introduced with a real-life application “Case Study” that describes a person’s background, including his or her health and food choices. Begin by reviewing the case study and writing down potential responses to the case study questions. Then, after reading and studying the chapter, review your initial answers and make changes, if necessary. Compare your responses with the suggested responses to the case study that are provided at the end of each chapter.

Jorge has become concerned about his eating practices since he started college last month. He lives in a residence hall that has an all-you-can-eat dining facility in the basement and the Student Union is nearby.

After moving in, Jorge began a daily routine of eating a fast-food breakfast sandwich, large chocolate chip muffin, and sugar-sweetened coffee at the Student Union before his 10 A.M. class. Between classes he would drink sugary soft drinks and then eat three slices of pizza or a couple of hamburgers and a large portion of French fries in the dining facility at night. He knows he should eat more nutritious foods, but he thinks he does not have enough time to eat fresh salads or fresh fruit. Jorge wants your advice concerning how he can improve his food choices.

- Consider Jorge’s current eating practices. Do his food choices reflect a nutritionally adequate pattern?
- What steps can Jorge take to improve his eating practices?

The suggested “Case Study Response” can be found at the end of the chapter.

QUIZ Yourself

Each chapter of this textbook begins with “Quiz Yourself,” a brief true-or-false quiz to test your knowledge of the material covered in the chapter. Before reading Chapter 1, test your basic nutrition knowledge by taking the following quiz. The answers are found at the end of this chapter.

1. There are five classes of nutrients: carbohydrates, lipids, proteins, vitamins, and water. __T__F
2. Vitamins and minerals are sources of energy. __T__F
3. Heart disease is the leading cause of death in the United States. __T__F
4. Most foods are mixtures of just two nutrients. __T__F
5. The Food and Drug Administration regulates the safety and effectiveness of dietary supplements that are sold in the United States. __T__F



1.1 The Importance of Nutrition

LEARNING OUTCOMES

- 1 Explain why it is important to study nutrition.
- 2 Describe Americans' current food-consumption practices and how they compare to dietary recommendations.

Many college students do not pay much attention to the foods they consume regularly, possibly because they are healthy now and they think poor health is unlikely to affect them until later in life. Why should you focus more on what and how much you eat? What is nutrition? In this textbook, we will provide a framework for understanding nutrition and making healthy food choices.

Why Study Nutrition?

Food is a basic human need for survival: people become hungry and search for something to eat when their bodies need **nutrients**, the life-sustaining substances in food. Nutrients are necessary for the growth, maintenance, and repair of the body's cells. **Nutrition** is the scientific study of nutrients and how the body uses them.

Humans have the instinctive ability to select safe and appropriate foods. However, environmental cues and food processing can trick the body's innate sense of what is edible and healthy. To eat well, people need to learn about the nutritional value of foods and the effects that their **diet**, their usual pattern of food choices, can have on health.

Simply having information about nutrients and their importance to good health may not be enough for people to change ingrained food-related behaviors and purchase healthier foods. A person must also be motivated to make such changes. Some people strive to improve their diets because they want to lose or gain weight and/or improve their body composition. Others are so concerned about their health that they are motivated to change their eating habits in specific ways, such as by eating fewer salty foods or more fruits and vegetables.

What People Eat in America

According to average food consumption trends, Americans are consuming above the recommendations for added fats and oils, added sugars and sweeteners, high-fat protein foods, and grains and below the recommendations for vegetables, dairy products, and fruit.¹ Americans' access to ultra-processed foods continues to increase, which is in part responsible for the current problem of overweight yet undernourished individuals. Raw foods often undergo some form of processing, such as refining, canning, freezing, or cooking, before they are eaten. Processing can make a food more nutritious, safer to eat, and less likely to spoil. However, some forms of processing remove nutrients that were naturally in the food and/or add unhealthy amounts of sodium, sugar, and "solid" fat to foods.²

Public health experts are concerned with Americans' eating habits, because many serious diseases, including obesity and type 2 diabetes, are associated with certain dietary practices. Over the past 30 years, these health conditions have become increasingly more common, not only in North America but also among populations of other countries. People may be able to live longer, healthier lives by improving the nutritional quality of their diets.

How to Use This Textbook

Every major section of a chapter begins with a set of "Learning Outcomes" and ends with "Assess Your Progress" questions for you to evaluate your knowledge of the material. Key terms that you need to know when learning about nutrition are displayed in bold type within the narrative. The terms and their definitions are in the margins, but you can also look up the definitions in the glossary.

nutrients life-sustaining substances in food

nutrition scientific study of nutrients and how the body uses them

diet a person's usual pattern of food choices

At the end of each chapter, you will find a summary of key points; a set of “Critical Thinking” questions; and “Practice Test,” a group of multiple-choice questions that check your understanding of the material in the chapter. Answers to the “Practice Test” questions are provided at the end of the test. A “Culinary Medicine” activity in which you modify a recipe to accommodate a client’s specific dietary needs is also included at the end of each chapter. Many chapters also include a “Personal Dietary Analysis” assignment based on your own dietary habits.

ASSESS YOUR PROGRESS

- 1 Why is it important to learn about nutrition?
- 2 Which foods do Americans tend to consume in amounts that are higher than recommended?

1.2 The Nutrients

LEARNING OUTCOMES

- 1 List the six classes of nutrients, and identify major roles of each class of nutrient in the body.
- 2 Describe the key features of an essential nutrient.
- 3 Categorize nutrients based on whether they are essential and their designation as a micronutrient or macronutrient.
- 4 Identify rich food sources of phytochemicals.

To understand nutrition, you need to learn about and use information from biology, anatomy, physiology, and chemistry. This chapter introduces the nutrients and their general functions. Chapter 4 focuses on the structures and functions of the human digestive system. Appendices B and C provide brief reviews of basic chemistry and physiology concepts that form the foundation for understanding the science of nutrition.

The Six Classes of Nutrients

There are six classes of nutrients: carbohydrates, lipids (such as fats and oils), proteins, vitamins, minerals, and water. Both food and the human body are comprised of these nutrients. Although the percentage varies with age and sex, about 50 to 70% of the body’s total weight is water. On average, healthy young men and women have similar amounts of vitamins, minerals, and carbohydrates in their bodies, but young women have less water and protein, and considerably more fat (Fig. 1.1). Bodies with high fat content tend to have less water in them than bodies with less fat since there is more water in lean tissues.

Each nutrient typically has more than one physiological role, or function, in the body (Table 1.1). In general, the body uses certain nutrients for energy, growth and development, and regulation of processes, including the repair and maintenance of cells. Cells do not need food to survive, but they need the nutrients in food to carry out their



FIGURE 1.1 Comparing body composition. This figure presents the approximate percentages of nutrients that constitute the bodies of a healthy man and woman. Note that the amount of vitamins in the human body is so small that it is not shown. Andres Rodriguez/Alamy; Pepsco Studio/Shutterstock

TABLE 1.1 Nutrients

Nutrient Class	Major Functions
Carbohydrates	<ul style="list-style-type: none"> • Major source of energy (most forms) • Maintenance of normal blood glucose levels • Elimination of solid waste from gastrointestinal tract (fiber)
Lipids	<ul style="list-style-type: none"> • Major source of energy • Cellular development, physical growth and development • Regulation of body processes (certain hormones, for example) • Growth and development of the brain • Absorption of fat-soluble vitamins
Proteins	<ul style="list-style-type: none"> • Formation of structural components, such as muscle fibers, and functional components, such as enzymes • Cellular development, growth, and maintenance • Regulation of body processes (certain hormones, for example) • Transportation of substances within the blood • Energy (normally a minor source)
Vitamins	<ul style="list-style-type: none"> • Regulation of body processes • Immune function • Production and maintenance of cells • Protection against agents that can damage cellular components
Minerals	<ul style="list-style-type: none"> • Regulation of body processes, including fluid balance and energy metabolism • Formation of certain chemical messengers • Formation of structural and functional components of various substances and tissues • Cellular development, growth, and maintenance
Water	<ul style="list-style-type: none"> • Maintenance of fluid balance • Regulation of body temperature • Elimination of wastes • Transportation of substances • Participation in many chemical reactions

metabolism total of all the chemical processes that occur in living cells

metabolic activities. **Metabolism** is the total of all the chemical processes that occur in living cells, including the chemical reactions involved in breaking down large molecules into smaller molecules (supplying energy), building larger molecules (such as proteins and long-chain fats) from smaller molecules, and eliminating waste products.

element substance that cannot be separated into simpler substances by ordinary chemical or physical means

Nutrients: Elements

Nutrients are sources of elements that the body needs to carry out its activities (Table 1.2). An **element** is a substance, such as carbon and oxygen, that cannot

TABLE 1.2 Elements in Nutrients

Nutrient Class	Elements*						
	Carbon	Hydrogen	Nitrogen	Oxygen	Phosphorus	Sulfur	Others
Carbohydrates	✓	✓		✓			
Lipids	✓	✓	X	✓	X		
Proteins	✓	✓	✓	✓		X	
Vitamins	✓	✓	X	✓	X	X	Cobalt
Minerals					X	X	Sodium, magnesium, potassium, calcium, chromium, iron, copper, zinc, iodine, and others
Water		✓		✓			

*Not every element listed may be a component of a particular nutrient in each class.

✓ All nutrients in this class contain this element.

X Some nutrients in the class, but not all, contain this element.

be separated into simpler substances by ordinary chemical or physical means. Elements are the basic substances that make up all things, including life forms such as human beings. Almost 98% of the human body (by weight) is composed of only five elements: oxygen, carbon, hydrogen, nitrogen, and calcium (Fig. 1.2).³ Several elements, such as calcium, are minerals that the body needs for a variety of functions. In Figure 1.2, the mineral elements are highlighted in green.

In chemistry, the term **organic** refers to compounds that contain carbon. Carbohydrates, lipids, proteins, and vitamins are organic nutrients because they contain carbon. **Inorganic** nutrients, such as minerals and water, are substances that do not contain carbon.

Nutrients: Essential and Conditionally Essential

All nutrients are important for health, but the body can use the “raw materials” from food to synthesize (make) many nutrients, such as cholesterol and some types of fats (lipids). The remaining nutrients, about 50 of them, are dietary essentials. An **essential nutrient** must be supplied by food because the body does not synthesize the nutrient or make enough to meet its needs. Water is the most essential nutrient because the body can survive for only a few days without it.

Nutrition scientists use the following factors to help determine whether a nutrient is essential:

- If the nutrient is missing from the diet, a deficiency disease occurs as a result. A **deficiency disease** is a state of health characterized by certain abnormal physiological changes. Changes that are observable or measurable are **signs** of disease. Disease signs include rashes, failure to grow properly, and elevated blood pressure. **Symptoms** are subjective complaints of ill health that may be difficult to observe or measure, such as dizziness, fatigue, and headache.
- When the missing nutrient is added to the diet, the abnormal physiological changes are corrected. As a result, signs and symptoms of the deficiency disorder resolve as normal functioning is restored and the condition is cured.
- After scientists identify the nutrient’s specific roles in the body, they can explain why the abnormalities occurred when the substance was missing from the diet.

To test an adult male human’s need for vitamin C, for example, scientists would have the subject avoid consuming foods or vitamin supplements that contain the vitamin. When the amount of vitamin C in the subject’s white blood cells (leukocytes) became too low for them to function normally, the person would develop physical signs of scurvy, the vitamin C deficiency disease. When the person brushed his teeth, his gums would bleed from the pressure of the toothbrush (Fig. 1.3). If he cut himself, the wound would heal slowly or not at all.

If the scientists began to feed foods that contain vitamin C to the subject again, the man’s deficiency signs and symptoms would disappear within a few days, because his body was recovering. Chapter 10 provides information about the physiological roles of vitamin C. One of those roles is maintaining *collagen*, the protein in the body that holds cells together, including the cells that form tiny blood vessels in skin. Collagen is also needed to produce scar tissue for wound healing. When the vitamin is lacking, the tiniest blood vessels in the gums begin to leak blood where they are compressed, and even minor cuts have difficulty healing. Thus, vitamin C meets all the required features of an essential nutrient. Table 1.3 lists nutrients that are generally considered to be essential.

Some nutrients that are normally nonessential can become essential under certain conditions, such as in metabolic disorders or serious diseases, and during prenatal (before birth) development. In these conditions, **conditionally essential nutrients** may be made by the body but in amounts that are inadequate and must

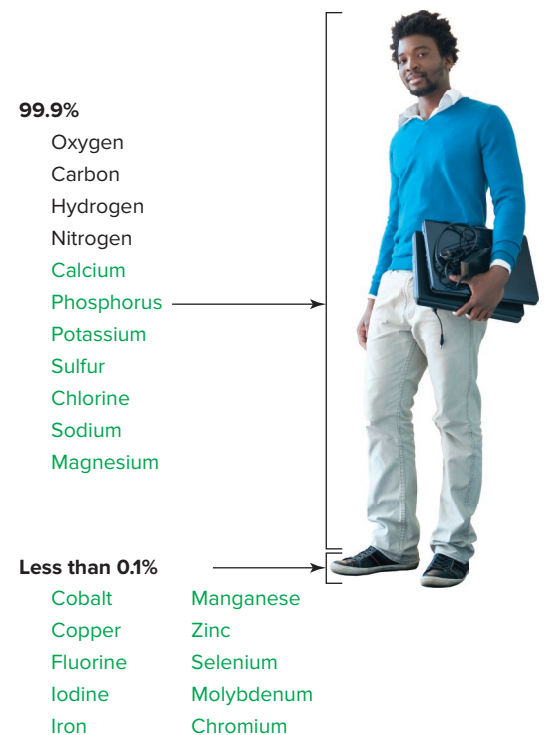


FIGURE 1.2 Nutrient-related elements in the human body. Minerals are highlighted in green; calcium is the most plentiful mineral element in the body.

Eric Audras/Getty Images

organic (chemistry) refers to compounds that contain carbon

inorganic (chemistry) refers to substances that do not contain carbon

essential nutrient nutrient that must be supplied by food

deficiency disease state of health characterized by certain abnormal physiological changes that occur when the body lacks a nutrient

signs physical changes associated with a disease state that are observable or measurable

symptoms subjective complaints of ill health that may be difficult to observe or measure

conditionally essential nutrients nutrients that are normally not essential but become essential under certain conditions, such as during a serious illness



FIGURE 1.3 Sign of scurvy.

Source: Centers for Disease Control

TABLE 1.3 Essential Nutrients for Humans

Carbohydrates	Proteins (Amino Acids*)	Lipids	Vitamins	Minerals	Water
Glucose [§]	The following amino acids are generally recognized as essential: Histidine Leucine Isoleucine Lysine Methionine Phenylalanine Threonine Tryptophan Valine	Fats that contain: Linoleic acid Alpha-linolenic acid	A Thiamin Riboflavin Niacin Pantothenic acid Biotin Folate B-6 B-12 C D [†] E K Choline [‡]	Major minerals: Calcium Chloride Magnesium Phosphorus Potassium Sodium Sulfur Trace minerals: Chromium Copper Iodine Iron Manganese Molybdenum Selenium Zinc	Water

*Amino acids are the basic units that make up proteins.

[†]The body makes vitamin D after exposure to sunlight, but a dietary source of the nutrient is often necessary.

[‡]The body makes choline but may not make enough to meet needs. Choline is classified as a vitamin-like compound.

[§]The body can make glucose without carbohydrates during periods of starvation.

^{||}The body can produce vitamin K and biotin from bacteria in the intestines, but a dietary source of these nutrients is often necessary.

macronutrients nutrients that the body needs in large amounts

micronutrients nutrients that the body needs in very small amounts

phytochemicals substances in plants that are not nutrients but may have healthful benefits

be supplemented by the diet. Chapter 7 discusses some amino acids that are conditionally essential. Amino acids are the nitrogen-containing compounds that make up protein molecules.

Macronutrients and Micronutrients

So far, we have organized nutrients based on their chemical composition and essentiality. A third way to classify nutrients is based on amounts that the body needs. Carbohydrates, fats, and proteins are **macronutrients** because the body requires relatively large amounts of these nutrients daily (*macro* = large). Vitamins and minerals are **micronutrients** because the body needs very small amounts of them to function properly (*micro* = small).

In general, a serving of food supplies grams (g) of carbohydrate, fat, and protein and milligram (mg) or microgram (μg) quantities of vitamins and minerals. For example, a serving of a vanilla ice cream cone (1/2 cup scoop in a sugar cone) provides about 24 g of carbohydrate, 8 g of fat, 3 g of protein, 88 mg of calcium, and 145 mg of potassium.

Macronutrients supply energy for cells, whereas micronutrients are not sources of energy. Although the body requires large amounts of water, this nutrient does not provide energy and is not usually classified as a macronutrient.

Phytochemicals

Plants make hundreds of substances called **phytochemicals** (*phyto* = plant), which are not nutrients (nonnutrients), yet they may have health benefits. The stimulant caffeine, for example, is a phytochemical made by coffee plants. Beta-carotene is a phytochemical in many fruits and vegetables that the body can convert to vitamin A. Table 1.4 identifies rich food sources of several phytochemicals that scientists are studying. The table indicates some effects of the phytochemicals on the body, including possible health benefits.

Not all phytochemicals have beneficial effects on the body. Some phytochemicals, such as nicotine in tobacco leaves, ricin in castor beans, and oxalic acid in rhubarb leaves, are toxic or can interfere with the absorption of nutrients.



Most foods are mixtures of nutrients. An ice cream cone is a rich source of carbohydrate and fat, but this dessert also contributes some protein, calcium, and potassium to diets.

M. Unal Ozmen/Shutterstock

Information about several phytochemicals that have known effects on human health is woven into the chapters of this textbook where appropriate.

TABLE 1.4 Phytochemicals of Scientific Interest

Classification and Examples	Biological Effects/Possible Health Benefits	Rich Food Sources
Carotenoids Alpha-carotene, beta-carotene, lutein, lycopene, zeaxanthin	May reduce risk of certain cancers and macular degeneration (a major cause of blindness in the United States)	Orange, red, yellow fruits and vegetables; egg yolks
Phenolics	Antioxidant activity; may inhibit cancer growth and reduce risk of heart disease	
Quercetin		Apples, tea, red wine, onions, olives, raspberries, cocoa
Catechins		Green and black tea, chocolate, plums, apples, berries, pecans
Anthocyanins		Red, blue, or purple fruits and vegetables
Resveratrol		Red wine, purple grapes and grape juice, dark chocolate, cocoa
Isoflavonoids		Soybeans and other legumes
Tannins		Tea, coffee, chocolate, blueberries, grapes, persimmons
Monoterpenes		Oranges, lemons, grapefruit, cherries
Organosulfides Isothiocyanates, indoles, allylic sulfur compounds	Antioxidant effects; may improve immune system functioning and reduce the risk of heart disease	Garlic, onions, leeks, cruciferous vegetables (broccoli, cauliflower, cabbage, kale, bok choy, collard and mustard greens)
Alkaloids Caffeine	Stimulant effects	Coffee, tea, “energy drinks,” kola nuts, cocoa
Capsaicinoids Capsaicin	May provide some pain relief	Chili peppers

ASSESS YOUR PROGRESS

- 3 List the six major classes of nutrients and identify at least one physiological role for each class.
- 4 Explain the meaning of organic in the context of chemical compounds.
- 5 What are three key factors that determine whether a substance is an essential nutrient?
- 6 Distinguish between macronutrients and micronutrients, and provide examples of each.
- 7 List at least three foods that are rich sources of phytochemicals.

1.3 Food as Fuel

LEARNING OUTCOMES

- 1 Distinguish between a calorie and a kilocalorie.
- 2 Estimate the amount of energy (kcal) in a serving of food based on the grams of carbohydrate, protein, fat, and alcohol present.

Most foods are sources of biological fuels because they provide energy for cells. The human body uses energy while running, sitting, studying, and even sleeping. Every cell in the body needs energy to carry out its various activities. Therefore, people need to consume energy-containing foods to survive.

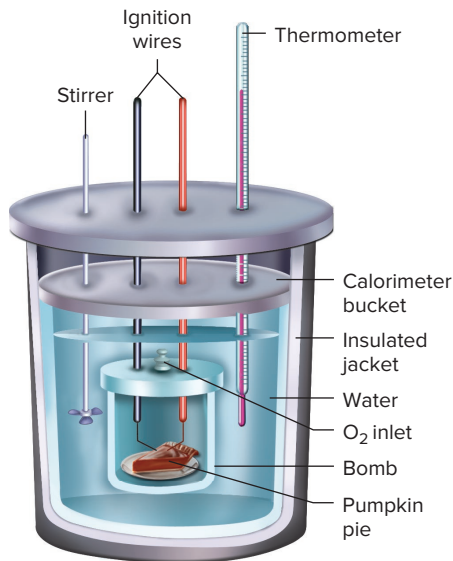


FIGURE 1.4 Bomb calorimeter.

calorie amount of heat necessary to raise the temperature of 1 g (1 ml) of water 1° Celsius (C)

kilocalorie (kcal) or Calorie the heat energy needed to raise the temperature of 1000 g (1 liter) of water 1° Celsius (C)

bomb calorimeter device used to measure the calories in a sample of food

A **calorie** is the amount of heat (a form of energy) necessary to raise the temperature of 1 g (1 ml) of water 1° Celsius (C). A calorie is such a small unit of measurement that the amount of energy in food is reported in 1000-calorie units called kilocalories or Calories. Thus, a **kilocalorie (kcal)**, or **Calorie**, is the heat energy needed to raise the temperature of 1000 g (1 liter) of water 1° Celsius (C). A small apple, for example, supplies 40,000 calories, 40 kcal, or 40 Calories. If no number of kilocalories is specified, it is appropriate to use *calories*. In this textbook, the term *calories* is interchangeable with *food energy* or simply *energy*. Appendix I is a food composition table that lists the energy and nutrient contents of many commonly consumed foods and beverages.

Direct Calorimetry

The calorie content of a food or beverage can be determined through direct calorimetry, which involves placing a specific amount of food in a **bomb calorimeter** (*kal-oh-rim'-eh-ter*). As shown in Figure 1.4, the “bomb” is a small chamber surrounded by a jacket of water. An electrical spark ignites the food, and under the conditions inside the bomb, the food burns completely. As the food burns, it releases energy in the form of heat, which raises the temperature of the water in the surrounding chamber. A thermometer measures the increased water temperature, and scientists use this information to determine the number of calories in the food.

Compared to the human body, a bomb calorimeter is much more efficient at using the energy-yielding nutrients in foods as fuel. Therefore, scientists must correct for this difference in efficiency when developing food composition tables, such as the one in Appendix I.

Calculating Food Energy

Consumers can calculate the number of kcal in their diets by knowing the amounts of macronutrients and the nonnutrient alcohol in their foods and beverages. A gram of carbohydrate and a gram of protein each supply about 4 kcal; a gram of fat provides about 9 kcal (Fig. 1.5). Alcohol is not a nutrient because the human body does not need the chemical to survive. Alcohol, however, is a source of energy; a gram of pure alcohol supplies 7 kcal. Chapter 8 discusses alcohol, including its metabolism and effects on health.

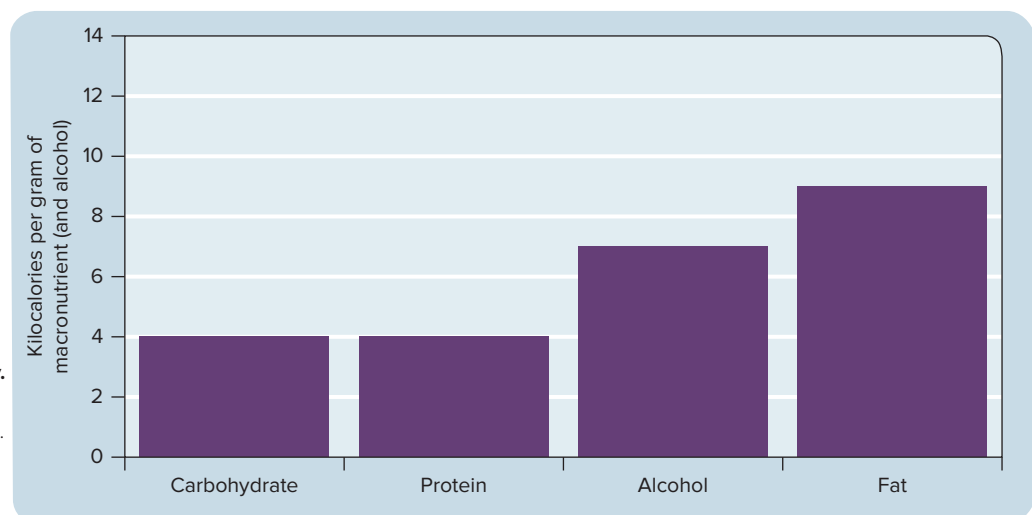


FIGURE 1.5 Energy sources for the body. Macronutrients and alcohol supply our bodies with energy in the form of calories.

Elena Schweitzer/Stock/360/Getty Images; D. Hurst/Alamy; Hurst Photo/Shutterstock; Torbjorn Lagerwall/Alamy Stock Photo

Let us use the ice cream cone mentioned earlier as an example for estimating the caloric content of a food. The ice cream cone contains about 24 g of carbohydrate, 8 g of fat, and 3 g of protein. To estimate the number of kcal provided in a serving of this food,

STEP 1: Determine how many kcal are provided by each type of macronutrient.

$$\begin{array}{rcl} 24 \text{ g carbohydrate} & \times & 4 \text{ kcal/g carbohydrate} & = & 96 \text{ kcal} \\ 8 \text{ g fat} & \times & 9 \text{ kcal/g fat} & = & 72 \text{ kcal} \\ 3 \text{ g protein} & \times & 4 \text{ kcal/g protein} & = & 12 \text{ kcal} \end{array}$$

STEP 2: Add the individual kcal from carbohydrate, fat, and protein together to estimate the total kcal per serving of the food.

$$\begin{array}{l} \text{Total kcal} = 96 \text{ kcal (carbohydrate)} + 72 \text{ kcal (fat)} + 12 \text{ kcal} \\ \text{(protein)} = 180 \text{ kcal} \end{array}$$

This food provides approximately 180 kcal per serving.

ASSESS YOUR PROGRESS

- 8 What is the difference between a calorie and a kilocalorie?
- 9 A slice of whole-wheat bread supplies approximately 13 g of carbohydrate, 1 g of fat, 3 g of protein, and 11 g of water. Based on this information, estimate the number of kilocalories provided in a slice of the bread.
- 10 An alcoholic beverage contains 4 g of carbohydrate and 10 g of alcohol. In this drink, how many kilocalories are provided by the alcohol?

1.4 Does Diet Matter?

LEARNING OUTCOMES

- 1 List the 10 leading causes of death in the United States.
- 2 Describe lifestyle factors that contribute to many of the leading causes of death in the United States.
- 3 Explain the purpose of the Healthy People initiative.

In the beginning of this chapter, we mentioned that public health officials are concerned about the impact that poor food choices can have on the health of Americans. The graph shown in Figure 1.6 shows the 10 leading causes of deaths in the United States and the approximate percentages of deaths that were attributed to each of them in 2017. Note that heart disease was the leading cause of death and cancer was the second leading cause of death. In 2017, these two diseases accounted for almost half of all deaths.⁴ Also note that several of the leading causes of death are diet-related and responsible for the premature (early) deaths of thousands of adult Americans.

Risk Factors

Heart disease, diabetes, and cancer are chronic diseases. **Chronic** diseases are long-term conditions that usually take many years to develop and have complex causes. A **risk factor** is an attribute, a characteristic, or an exposure that increases a person's chances of developing a chronic disease. For example, genetic background or family history is an important risk factor for heart disease. If your grandfather had a heart attack before he was 55 years old and your mother is being treated

chronic long term

risk factor attribute, characteristic, or exposure that increases a person's chances of developing a chronic disease