WARDLAW'S *Perspectives in*

NUTRITION

A FUNCTIONAL APPROACH

Third Edition

Carol Byrd-Bredbenner
Jacqueline Berning
Danita Kelley
Jaclyn M. Abbot

Mc Graw Hill

byr02421_fm_i-xxix.indd 1 2/10/21 12:33 AM

WARDLAW'S PERSPECTIVES IN NUTRITION: A FUNCTIONAL APPROACH, THIRD EDITION

Published by McGraw Hill LLC, 1325 Avenue of the Americas, New York, NY 10121. Copyright ©2022 by McGraw Hill LLC. All rights reserved. Printed in the United States of America. Previous editions ©2019, 2014, and 2013. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of McGraw Hill LLC, including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning.

Some ancillaries, including electronic and print components, may not be available to customers outside the United States.

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 LWI 26 25 24 23 22 21

ISBN 978-1-260-70242-2
MHID 1-260-70242-1

Portfolio Manager: *Lauren Vondra*
Product Developer: *Erin DeHeck*
Marketing Manager: *Tami Hodge*
Content Project Managers: *Jessica Portz/Rachael Hillebrand*
Buyer: *Susan K. Culbertson*
Design: *David W. Hash*
Content Licensing Specialist: *Abbey Jones*
Cover Image: *Inna Bigun/Shutterstock*
Compositor: *MPS Limited*

All credits appearing on page or at the end of the book are considered to be an extension of the copyright page.

Library of Congress Cataloging-in-Publication Data

Names: Byrd-Bredbenner, Carol, author. | Berning, Jacqueline R., author. | Kelley, Danita S., author. | Abbot, Jaclyn M., author.
Title: Wardlaw's perspectives in nutrition: a functional approach/Carol Byrd-Bredbenner, Jacqueline Berning, Danita Kelley, Jaclyn Abbot.
Other titles: Perspectives in nutrition
Description: Third edition. | New York, NY: McGraw Hill Education, [2022] | Includes bibliographical references and index.
Identifiers: LCCN 2020027607 | ISBN 9781260702422 (hardcover) | ISBN 9781260791235 (spiral bound)
Subjects: LCSH: Nutrition.
Classification: LCC QP141 .B995 2022 | DDC 612.3—dc23
LC record available at https://lccn.loc.gov/2020027607

The Internet addresses listed in the text were accurate at the time of publication. The inclusion of a website does not indicate an endorsement by the authors or McGraw Hill LLC, and McGraw Hill LLC does not guarantee the accuracy of the information presented at these sites.

mheducation.com/highered

Brief Contents

©Brand X Pictures/Getty Images RF

byr02421_fm_i-xxix.indd 3 2/10/21 12:33 AM

Meet the Author Team

Carol Byrd-Bredbenner, Ph.D., R.D., FAND, received her doctorate from Pennsylvania State University. Currently, she is Distinguished Professor in the Nutritional Sciences Department at Rutgers, The State University of New Jersey. She teaches a wide range of undergraduate and graduate nutrition courses. Her research interests focus on investigating environmental factors that affect dietary choices and health outcomes. Dr. Byrd-Bredbenner has authored numerous nutrition texts, journal articles, and computer software packages. She has received teaching awards from the American Dietetic Association (now called the Academy of Nutrition and Dietetics), Society for Nutrition Education, and U.S. Department of Agriculture. She was the recipient of the American Dietetic Association's Anita Owen Award for Innovative Nutrition Education Programs, American Society for Nutrition's Excellence in Nutrition Education Award, and Society for Nutrition Education and Behavior's Helen Denning Ullrich Award for Lifetime Excellence in Nutrition Education. She also was a Fellow of the United Nations, World Health Organization at the WHO Collaborating Center for Nutrition Education, University of Athens, Greece. She enjoys exploring food and culinary customs, traveling, diving, and gardening.

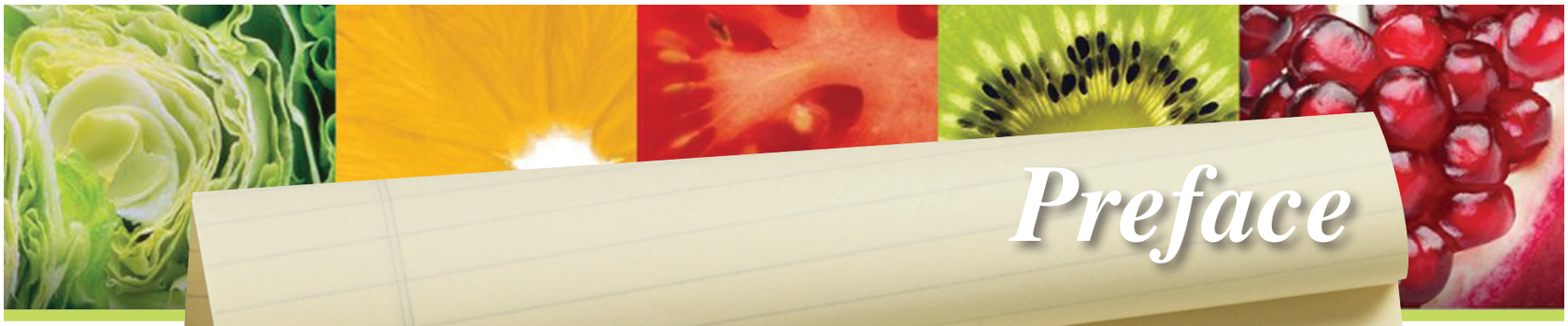
Jacqueline R. Berning, Ph.D., R.D., CSSD, earned her doctorate in nutrition from Colorado State University in Fort Collins, Colorado. She is currently Professor and Chair of the Health Science Department at the University of Colorado at Colorado Springs (UCCS), where she has won numerous teaching awards. Dr. Berning is published in the area of sports dietetics and was the sport dietitian for the Denver Broncos for over 25 years, Cleveland Indians for 18 years, and Colorado Rockies for 10 years. Currently, she is the sport dietitian for UCCS athletics and U.S. Lacrosse. She is active in the Academy of Nutrition and Dietetics, where she served as Chair of the Program Planning Committee for FNCE and is currently Chair of the Appeals Committee. In 2014, Dr. Berning was awarded the Mary Abbot Hess Award for Culinary Events for teaching the University of Colorado football team how to grocery shop and cook. Additionally, she served 6 years as an ADA spokesperson and is former Chair of the Sports, Cardiovascular, and Wellness Nutritionists dietetics practice group. She enjoys walking, hiking, and gardening.

©Clinton Lewis

Danita Saxon Kelley, Ph.D., R.D., earned her doctorate in nutritional sciences from the University of Kentucky. She serves as Associate Dean of the College of Health and Human Services and is a Professor in the Family and Consumer Sciences Department at Western Kentucky University. Previously, Dr. Kelley was Director of the Didactic Program in Dietetics at Western Kentucky University. She is a Past President of the Board of Directors for the Kentucky Academy of Nutrition and Dietetics. Her scholarly work has focused on adolescents' eating patterns, the communication skills of dietetic students, histaminergic activity and regulation of food intake, and dietary restriction effects on the antioxidant defense system. She has received awards for teaching from the Kentucky Academy of Nutrition and Dietetics and the Dietetic Educators of Practitioners of the Academy of Nutrition and Dietetics. She enjoys singing, walking her dog, cheering for her family in water-ski competitions, and watching her children participate in athletic and musical endeavors.

Jaclyn Maurer Abbot, Ph.D., R.D., earned her doctorate in nutritional sciences at the University of Arizona. She is a Registered Dietitian Nutritionist and adjunct lecturer in the Nutritional Sciences Department at Rutgers, The State University of New Jersey. She teaches online undergraduate courses in nutrition and health and introductory sports nutrition. Her research focuses on nutrition communication and health promotion on an array of topics, including safe food handling, nutrition for optimizing fitness performance, nutrition knowledge and behavior, and disease prevention. She has delivered her research findings via formal classroom teaching, outreach programming, and peer-reviewed journals. She enjoys running, coaching youth sports, and spending time with her husband and 3 young children.

byr02421_fm_i-xxix.indd 4 2/10/21 12:33 AM



Preface

Welcome to the Third Edition of Wardlaw's Perspectives in Nutrition: A Functional Approach

Wardlaw's Perspectives in Nutrition: A Functional Approach has the richly deserved reputation of providing an accurate, current, in-depth, and thoughtful introduction to the dynamic field of nutrition. We have endeavored to build upon this tradition of excellence by enriching this edition for both students and instructors by organizing the presentation of vitamins and minerals around key functions. Our passion for nutrition, our genuine desire to promote student learning, and our commitment to scientific accuracy, coupled with constructive comments from instructors and students, guided us in this effort. Our primary goal has been to maintain the strengths and philosophy that have been the hallmark of this book yet continue to enhance the accessibility of the science content and the application of materials for today's students.

Nutrition profoundly affects all of our lives every day. For the authors, as well as many other educators, researchers, and clinicians, this is the compelling reason for devoting our careers to this dynamic field. The rapid pace of nutrition research and provocative (and sometimes controversial) findings challenge us all to stay abreast of the latest research and understand its implications for health. We invite you to share with us topics that you believe deserve greater or less attention in the next edition.

To your health!

Carol Byrd-Bredbenner
Jacqueline Berning
Danita Kelley
Jaclyn Maurer Abbot

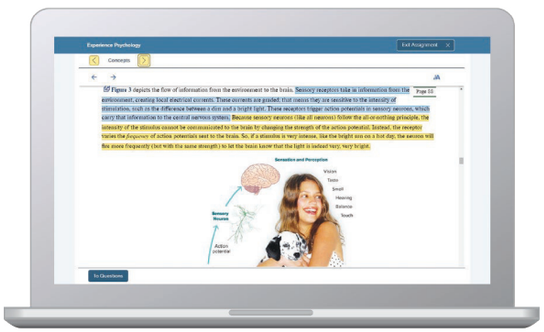
byr02421_fm_i-xxix.indd 5 2/10/21 12:33 AM

Instructors: Student Success Starts with You

Tools to enhance your unique voice

Want to build your own course? No problem. Prefer to use our turnkey, prebuilt course? Easy. Want to make changes throughout the semester? Sure. And you'll save time with Connect's auto-grading too.

65%
Less Time Grading



Laptop: McGraw Hill; Woman/dog: George Doyle/Getty Images

Study made personal

Incorporate adaptive study resources like SmartBook® 2.0 into your course and help your students be better prepared in less time. Learn more about the powerful personalized learning experience available in SmartBook 2.0 at **www.mheducation.com/highered/connect/smartbook**

Affordable solutions, added value

Make technology work for you with LMS integration for single sign-on access, mobile access to the digital textbook, and reports to quickly show you how each of your students is doing. And with our Inclusive Access program you can provide all these tools at a discount to your students. Ask your McGraw Hill representative for more information.

Padlock: Jobalou/Getty Images

Solutions for your challenges

A product isn't a solution. Real solutions are affordable, reliable, and come with training and ongoing support when you need it and how you want it. Visit **www.supportateverystep.com** for videos and resources both you and your students can use throughout the semester.

Checkmark: Jobalou/Getty Images

SUPPORT AT every step

Students: Get Learning that Fits You

Effective tools for efficient studying

Connect is designed to make you more productive with simple, flexible, intuitive tools that maximize your study time and meet your individual learning needs. Get learning that works for you with Connect.

Study anytime, anywhere

Download the free ReadAnywhere app and access your online eBook or SmartBook 2.0 assignments when it's convenient, even if you're offline. And since the app automatically syncs with your eBook and SmartBook 2.0 assignments in Connect, all of your work is available every time you open it. Find out more at **www.mheducation.com/readanywhere**

> ***"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

Calendar: owattaphotos/Getty Images

Everything you need in one place

Your Connect course has everything you need—whether reading on your digital eBook or completing assignments for class, Connect makes it easy to get your work done.

Learning for everyone

McGraw Hill works directly with Accessibility Services Departments and faculty to meet the learning needs of all students. Please contact your Accessibility Services Office and ask them to email accessibility@mheducation.com, or visit **www.mheducation.com/about/accessibility** for more information.

Top: Jenner Images/Getty Images, Left: Hero Images/Getty Images, Right: Hero Images/Getty Images

Connecting Instructors and Students to Additional Digital Resources

Saves students and instructors time while improving performance

McGraw Hill Campus

McGraw Hill Campus integrates all of your digital products from McGraw Hill with your school's Learning Management System for quick and easy access to best-in-class content and learning tools.

Dietary Analysis Tools

NutritionCalc Plus is a powerful dietary analysis tool featuring more than 30,000 foods from the 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. This tool is provided complimentary in Connect with *Perspectives in Nutrition*.

Dietary Analysis Case Studies 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, and 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!

Assess My Diet 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.

Presentation tools allow you to customize your lectures

Enhanced Lecture Presentations Contain lecture outlines, art, photos, and tables. Fully customizable, adapted for ADA compliance, complete, and ready to use—these presentations will streamline your work and let you spend less time preparing for lecture!

Editable Art Fully editable (labels and leaders) line art from the text

Animations Over 50 animations bring key concepts to life, available for instructors *and* students.

Digital Lecture Capture

Tegrity® is a fully automated lecture capture solution used in traditional, hybrid, "flipped classes" and online courses to record lessons, lectures, and skills.

Virtual Labs and Lab Simulations

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.

Connecting Students to Today's Nutrition

Our Intended Audience

This textbook was developed for students pursuing nutrition and health science careers as well as those wanting a better understanding of how nutrition affects their lives. Because this course often attracts students from a broad range of majors, we have been careful to include examples and explanations that are relevant to them and to include sufficient scientific background to make the science accessible to them. The appendices help students who wish to learn more or need assistance with the science involved in human physiology, chemistry, and metabolism.

To better bridge the span of differing science backgrounds and to enhance student interest and achievement of course objectives, we organized the presentation of the material within chapters to flow seamlessly from concrete to abstract learning. In chapters focusing on nutrients, for example, concrete concepts, such as food sources of the nutrients and recommended intakes, are introduced early in the chapter to create a framework for more abstract concepts, such as functions, digestion, and absorption.

Accurate, Current Science That Engages Students

The twelfth edition continues the tradition of presenting scientific content that is reliable, accurate, and up-to-date. This edition incorporates coverage of recent nutrition research, as well as the recent updates to consumer guidelines and tools—Dietary Guidelines for Americans, MyPlate, *Healthy People,* and the new Nutrition Facts panel. It also retains the in-depth coverage students need to fully understand and appreciate the role of nutrition in overall health and to build the scientific knowledge base needed to pursue health-related careers or simply live healthier lives. To enhance these strengths and promote greater comprehension, new research findings and peer-reviewed references are incorporated and artwork is enhanced to further complement the discussions. The presentation of complex concepts was scrutinized to increase clarity through the use of clear, streamlined, precise, and student-friendly language. Timely and intriguing examples, illustrative analogies, clinical insights, culinary perspectives, historical notes, future perspectives, and thought-provoking photos make the text enjoyable and interesting to students and instructors alike.

CLINICAL PERSPECTIVE

Food Protein Allergies

People with hypersensitivity to certain foods can be tested to determine which food allergens cause their symptoms.

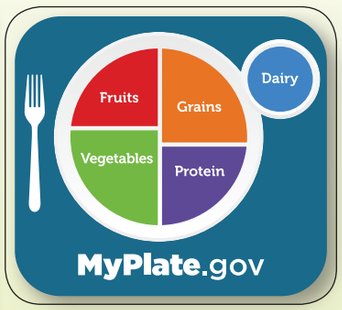
Science Photo Library/Getty Images

Allergies, including food allergies, involve responses of the immune system designed to eliminate foreign proteins (antigens). Food allergy responses occur when the body mistakenly reacts to a food as though it were a harmful invader. In some people, certain food components, typically proteins (called **allergens**), cause hypersensitivity reactions and trigger this response. These allergens stimulate white blood cells to produce antibodies (mostly, the **immunoglobulin** IgE) that bind to antigens and cause the symptoms associated with an allergic reaction.[21]

Fortunately, most allergic reactions are mild, such as a runny nose, sneezing, itching skin, hives, or digestive upset (indigestion, nausea, vomiting, diarrhea). For those who are severely allergic, exposure to the allergenic food may cause a generalized, life-threatening reaction involving all body systems (known as **anaphylaxis** or anaphylactic shock). Anaphylaxis causes decreased blood pressure without immediate medical help. In the U.S., allergic reactions result in 200,000 emergency room visits and 150 to 200 deaths per year.

The protein in any food can trigger an allergic reaction. However, 8 foods account for 90% of all food allergies: peanuts, tree nuts (e.g., walnuts and cashews), milk, eggs, fish, shellfish, soy, and wheat (Fig. 7-16). Other foods frequently identified as causing allergic reactions are sesame seeds, meat and meat products, fruits, and cheese.

The only way to prevent allergic reactions is to avoid foods known to trigger reactions. Carefully reading food labels and asking questions when eating out are essential, perhaps life-saving, steps for those with food allergies.[21] In addition, individuals preparing foods at home or in restaurants need to know their menu ingredients and take steps to ensure that foods that cause an allergic reaction in a person do not come in contact with the food to be served to that individual. Even trace amounts of an allergen can cause a reaction. To prevent



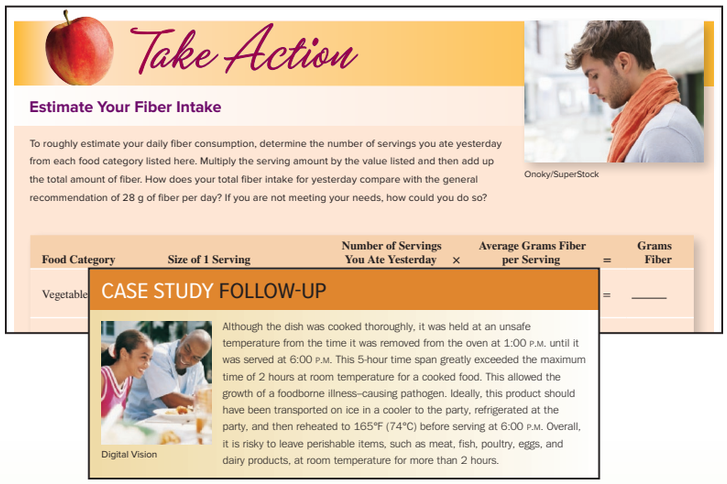
byr02421_fm_i-xxix.indd 9 2/10/21 12:33 AM

Connecting with a Personal Focus

Applying Nutrition on a Personal Level

A key objective in nearly all introductory courses is for students to apply their new knowledge of nutrition to their own lives. Practical applications clearly linked to nutritional science concepts are woven throughout each chapter to help students apply their knowledge to improving and maintaining their own health and that of others for whom they are responsible, such as future patients or offspring.

- **Take Action** features in each chapter allow students to examine their own diets and health issues.
- Updated **case studies** showcase realistic scenarios and thought-provoking questions.
- New discussion of the Nutrition Facts panel outlines the innovative changes to this important consumer tool.



Take Action

Estimate Your Fiber Intake

To roughly estimate your daily fiber consumption, determine the number of servings you ate yesterday from each food category listed here. Multiply the serving amount by the value listed and then add up the total amount of fiber. How does your total fiber intake for yesterday compare with the general recommendation of 28 g of fiber per day? If you are not meeting your needs, how could you do so?

Onoky/SuperStock

Food Category	Size of 1 Serving	Number of Servings You Ate Yesterday	×	Average Grams Fiber per Serving	=	Grams Fiber
Vegetable					=	____

CASE STUDY FOLLOW-UP

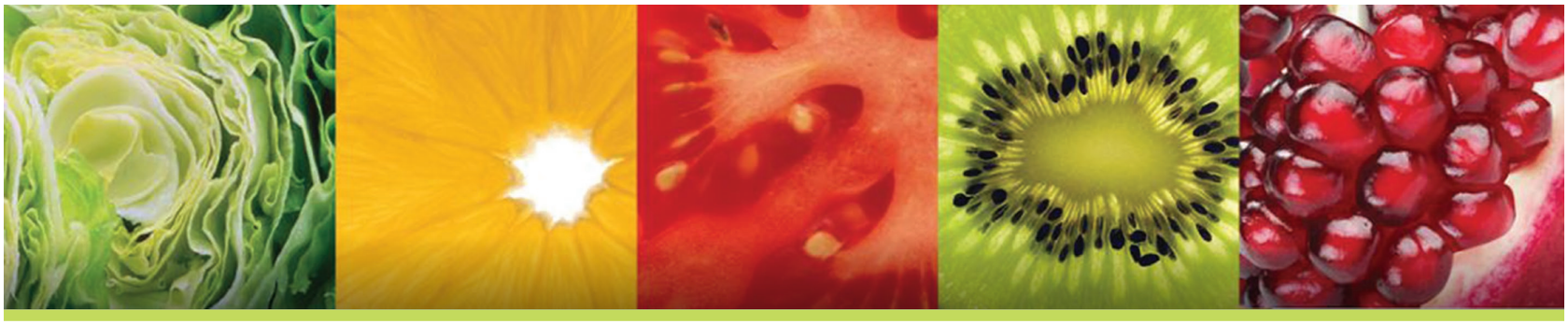
Although the dish was cooked thoroughly, it was held at an unsafe temperature from the time it was removed from the oven at 1:00 P.M. until it was served at 6:00 P.M. This 5-hour time span greatly exceeded the maximum time of 2 hours at room temperature for a cooked food. This allowed the growth of a foodborne illness–causing pathogen. Ideally, this product should have been transported on ice in a cooler to the party, refrigerated at the party, and then reheated to 165°F (74°C) before serving at 6:00 P.M. Overall, it is risky to leave perishable items, such as meat, fish, poultry, eggs, and dairy products, at room temperature for more than 2 hours.

Digital Vision

Applying Nutrition to Career and More

- ***Expert Perspective from the Field*** features examine cutting-edge topics and demonstrate how emerging, and sometimes controversial, research results affect nutrition knowledge and practice.
- ***Clinical Perspectives*** highlight the role of nutrition in the prevention and treatment of disease. These topics will be especially interesting to students planning careers in dietetics or health-related fields.
- ***Global Perspectives*** discuss concepts related to critical health and nutrition issues around the world. These timely features also aim to engage students with thought-provoking challenges.
- ***Historical Perspectives*** heighten awareness of critical discoveries and events that have affected our understanding of nutritional science.
- ***Perspective on the Future*** features address emerging trends affecting nutrition science and practice.
- ***Culinary Perspectives*** focus on interesting food trends and their impact on health.
- Each major heading in the chapters is numbered and cross-referenced to the end-of-chapter summary and study questions to make it easy to locate and prioritize important concepts.

byr02421_fm_i-xxix.indd 10 2/10/21 12:33 AM



HISTORICAL PERSPECTIVE

Photographing Atoms

Discovering the molecular layout of biologically important molecules is critical to understanding their function and treating disease. The biochemist and crystallographer Dorothy Crowfoot Hodgkin developed X-ray techniques that permitte her to determine the structure of over 10 molecules, including insulin, vitamin B-12 vitamin D, and penicillin. Her work with insulin improved the treatment of diabete Knowing the structure of vitamin B-12 advanced our knowledge of its role in blo health. Learn more about this Nobel Prize winner at www.nobelprize.org/prizes/chemistry/1964/hodgkin/biographical.

Digital Vision/Getty Images

Perspective on the Future

The common wisdom that eating 3500 kcal less than you need will result in the loss of 1 pound has come under great scrutiny. Weight loss research models based on thermodynamics, mathematics, physics, and chemistry indicate that many more than 3500 calories may be stored in a pound of body fat. Researchers have developed a body weight planner that allows users to make personalized calorie and physical activity plans to reach a goal weight.[24] Learn more at www.pbrc.edu/research-and-faculty/calculators/weight-loss-predictor.

NUTRITION

Expert Perspective from the Field

Tailoring a Healthy Eating Plan to Fit Your Lifestyle

According to Dr. Judith Rodriguez,* find your lifestyle is the key to controlling w diet. Dr. Rodriguez groups diets based consumers match their lifestyles with p you match what you like to eat or the c

CLINICAL PERSPECTIVE

Foodborne Illness Can Be De

Foodborne illness often means a few hours or even a few days of discomfort and then the illness resolves on its own. In some cases, though, foodborne illness causes more serious medical problems, which can have lifelong

inte
mor
the
• *List*
cau

GLOBAL PERSPECTIVE

How Big Is Your Food Print?

Growing evidence indicates that what we eat may affect not only our personal health but also that of the environment. The world population is projected to increase to over 9 billion by 2050. The Food and Agricultural Organization (FAO) projects that food and feed production will need to increase by 70% to adequately feed the world's population. Many scientists believe that meat rich diets and the agricultural practices that support the production of food for these diets negatively affect the environment. For instance, producing food for nonvegetarian diets (especially beef-based diets) uses more water, fossil fuel energy, and acres of farmland than producing food for vegetarian diets.[25] Meat rich diets also cause greater emissions of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, which are associated with global warming.[26] Scientists are concerned that continued population growth may, in turn, decrease agricultural productivity, reduce farmers' incomes, and increase global food insecurity.[27]

Not all scientists agree with these findings and concerns, however. Some believe that consuming a low-fat vegetarian diet with some dairy products and/or meat may actually increase land use efficiency, thereby protecting environmental resources and promoting food security.[28] They point out that high quality farmland is required to grow fruits, vegetables, and grains, whereas meat and dairy products can be produced on the more widely available, lower quality land. Even though diets containing meat use more land, they can feed more people because of the greater availability of lower quality farmland. It appears that diets have different "agricultural land footprints," depending on the amount of plant-based and animal-based food they contain. Supporters of mixed animal/vegetable–based diets point out that vegetarian diets often include tofu and other meat substitutes produced from soy, chickpeas, and lentils. Many meat substitutes are highly processed and require energy-intensive production methods. Thus, including small amounts of meat may offer both environmental and nutritional benefits.

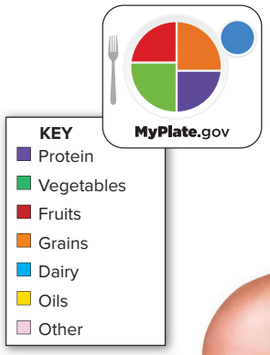
byr02421_fm_i-xxix.indd 11 2/10/21 12:33 AM

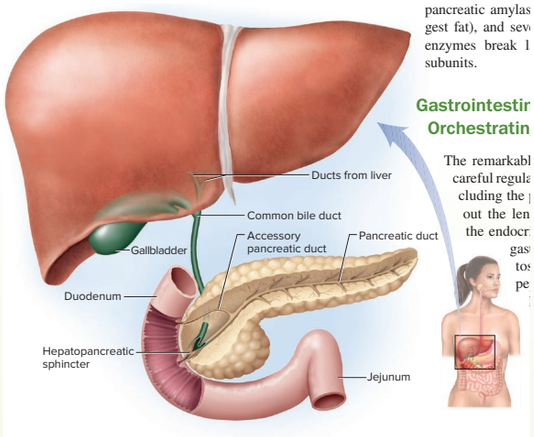
Making Visual Connections

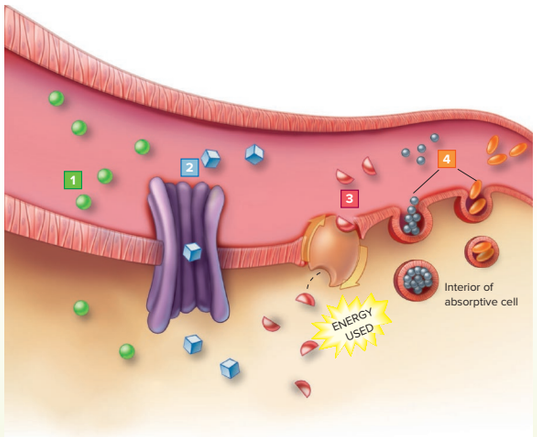
Dynamic, Accurate Artwork

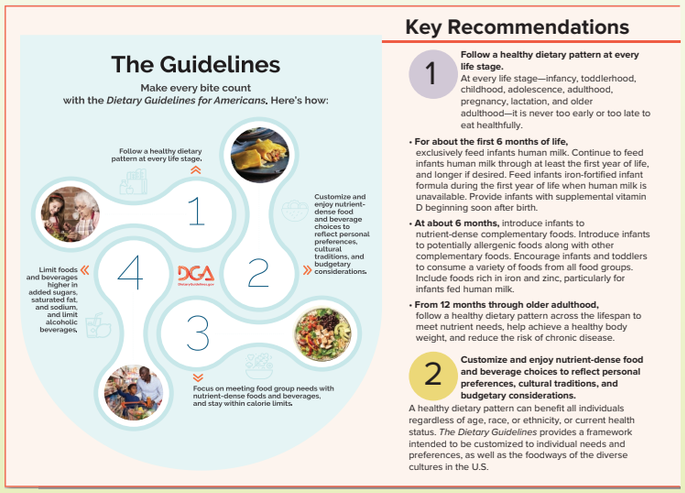
More than 1000 drawings, photographs, and tables in the text were critically analyzed to identify how each could be enhanced and refined to help students more easily master complex scientific concepts.

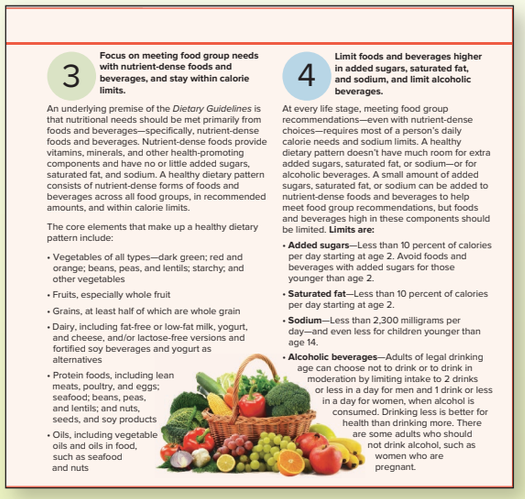
- Many images were updated or replaced to inspire student inquiry and comprehension and to promote interest and retention of information.
- Many illustrations were redesigned to use brighter colors and a more attractive, contemporary style. Others were fine-tuned to make them clearer and easier to follow. Navigational aids show where a function occurs and put it in perspective of the whole body.
- Coordinated color schemes and drawing styles keep presentations consistent and strengthen the educational value of the artwork. Color-coding and directional arrows in figures make it easier to follow events and reinforce interrelationships.



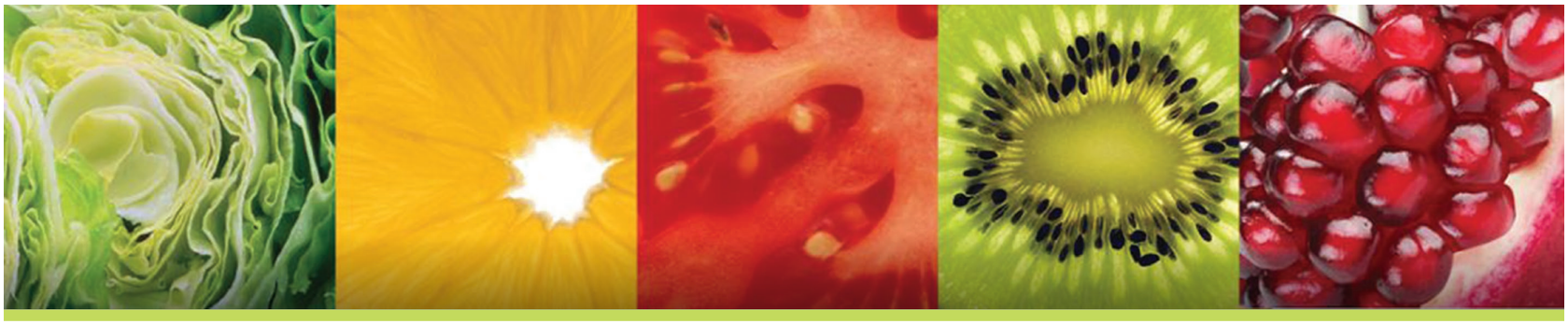


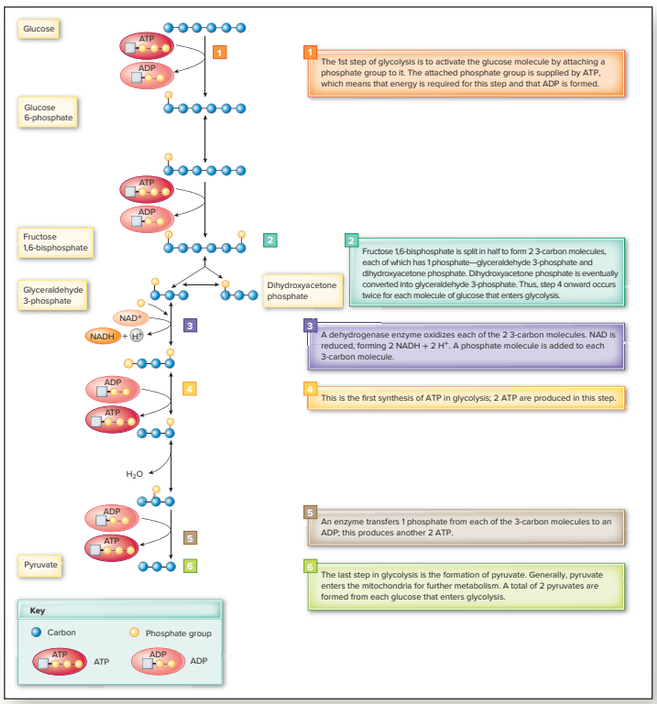






byr02421_fm_i-xxix.indd 12 2/10/21 12:33 AM

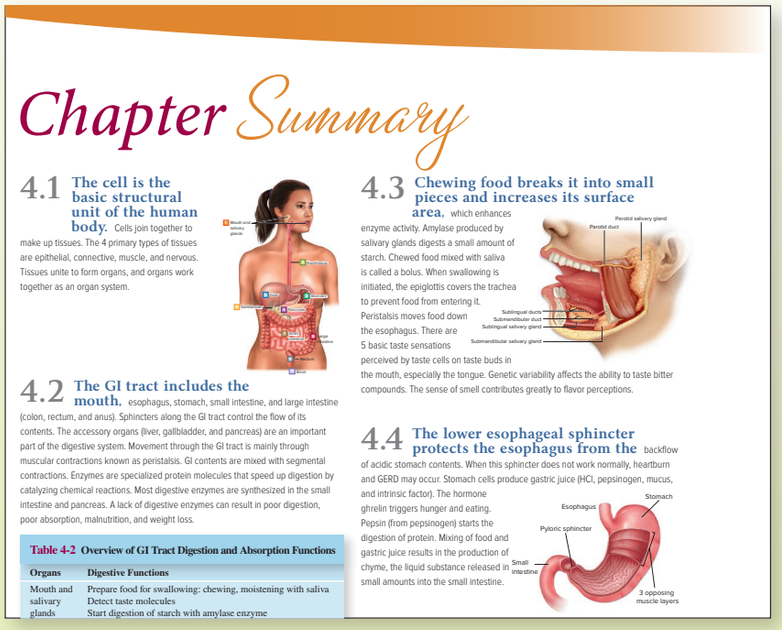




- In many figures, process descriptions appear in the body of the figure. This pairing of the action and an explanation walks students step-by-step through the process and increases the teaching effectiveness of these figures.
- Intriguing chapter opening photos pique students' curiosity by featuring seemingly unrelated topics that draw connections between the photo and nutrition.
- Finally, a careful comparison of artwork with its corresponding text was done to ensure that they are completely coordinated and consistent. The final result is a striking visual program that holds readers' attention and supports the goals of clarity, ease of comprehension, and critical thinking. The attractive layout and design of this edition are clean, bright, and inviting. This creative presentation of the material is geared toward engaging today's visually oriented students.

Illustrative Chapter Summary

The visual chapter summary continues to reinforce key concepts and promote student engagement and comprehension.



Chapter Summary

4.1 The cell is the basic structural unit of the human body. Cells join together to make up tissues. The 4 primary types of tissues are epithelial, connective, muscle, and nervous. Tissues unite to form organs, and organs work together as an organ system.

4.2 The GI tract includes the mouth, esophagus, stomach, small intestine, and large intestine (colon, rectum, and anus). Sphincters along the GI tract control the flow of its contents. The accessory organs (liver, gallbladder, and pancreas) are an important part of the digestive system. Movement through the GI tract is mainly through muscular contractions known as peristalsis. GI contents are mixed with segmental contractions. Enzymes are specialized protein molecules that speed up digestion by catalyzing chemical reactions. Most digestive enzymes are synthesized in the small intestine and pancreas. A lack of digestive enzymes can result in poor digestion, poor absorption, malnutrition, and weight loss.

Table 4-2 Overview of GI Tract Digestion and Absorption Functions

Organs	Digestive Functions
Mouth and salivary glands	Prepare food for swallowing: chewing, moistening with saliva Detect taste molecules Start digestion of starch with amylase enzyme

4.3 Chewing food breaks it into small pieces and increases its surface area, which enhances enzyme activity. Amylase produced by salivary glands digests a small amount of starch. Chewed food mixed with saliva is called a bolus. When swallowing is initiated, the epiglottis covers the trachea to prevent food from entering it. Peristalsis moves food down the esophagus. There are 5 basic taste sensations perceived by taste cells on taste buds in the mouth, especially the tongue. Genetic variability affects the ability to taste bitter compounds. The sense of smell contributes greatly to flavor perceptions.

4.4 The lower esophageal sphincter protects the esophagus from the backflow of acidic stomach contents. When this sphincter does not work normally, heartburn and GERD may occur. Stomach cells produce gastric juice (HCl, pepsinogen, mucus, and intrinsic factor). The hormone ghrelin triggers hunger and eating. Pepsin (from pepsinogen) starts the digestion of protein. Mixing of food and gastric juice results in the production of chyme, the liquid substance released in small amounts into the small intestine.

byr02421_fm_i-xxix.indd 13 2/10/21 12:33 AM

Connecting with the Latest Updates

Global Updates and Changes

- The entire third edition updated, refined, and streamlined to enhance student learning
- Complete Dietary Guidelines update to include 2020–2025 recommendations
- Nutrition Facts panels updated to latest FDA regulations
- Latest Daily Values incorporated in nutrient content charts
- New *Culinary Perspective* features throughout
- Fresh, new art for visual engagement
- People-first language used throughout the text to put the person before diagnosis, such as "a person with alcoholism" rather than "an alcoholic"

Chapter 1, *The Science of Nutrition*

- Updated statistics on leading causes of death
- *Culinary Perspective* featuring fermented foods
- Latest regulatory changes on *trans* fats introduced
- Streamlined and enhanced discussion of functional foods
- Expanded discussion of environmental factors affecting food choices
- Extensive revision of *Healthy People* goals and objectives
- Introduction of the concept of nutrition-focused physical exams
- New discussion on systematic reviews and meta-analyses
- New *Historical Perspective* on Joseph Goldberger
- New figure explaining human genome components

Chapter 2, *Tools of a Healthy Diet*

- Expansion of summary of nutrient claims on food labels table to include omega-3 fatty acid claims
- Enhanced menu labeling *Expert Perspective from the Field*
- *Take Action* updated to include the latest dietary intake recommendations
- Streamlined discussion of MyPlate and international dietary guidance graphic symbols

Chapter 3, *The Food Supply*

- Updated domestic and international food insecurity statistics highlighting the worldwide burden of malnutrition and hunger
- Updated food insecurity map
- Expanded discussion of food sustainability and agrobiodiversity
- New image depicting food sustainability from farm to table
- New *Culinary Perspective* on reducing food waste at the grocery store and home
- Extensive revision of discussion on amending agricultural plant and animal traits via selective breeding, mutagenesis, genetic (transgenetic) modification, genome editing, and safety and other concerns
- Expanded discussion of gene editing and illustration to increase comprehension
- Expanded discussion of food nanotechnology
- Latest BPA regulations added
- New non-nutritive sweetener, advantame, introduced
- Latest CDC foodborne illness statistics included
- Enhanced discussion of seafood toxins
- Fully updated discussion of water contamination in Flint, Michigan
- Enhanced *Expert Perspective from the Field* on sustainability in university food service

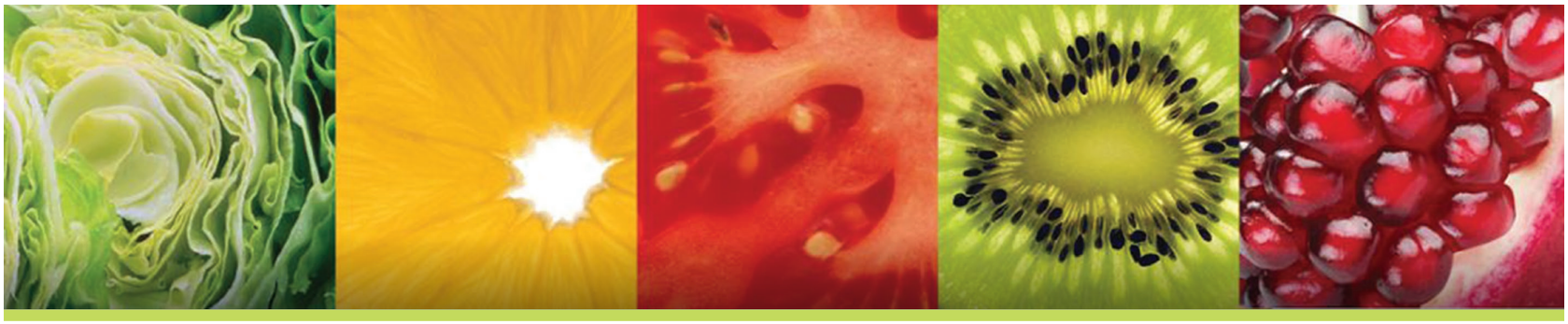
Chapter 4, *Human Digestion and Absorption*

- Enhanced discussion on structure and function of nasal lining
- Updated procedure for treating choking to new Red Cross recommendations
- Updated *Global Perspective* to include latest global data on child death from diarrhea
- Expanded discussion of probiotics and prebiotics
- Expanded discussion of erosive and non-erosive gastroesophageal reflux disease (GERD) and management
- Fully updated discussion of sugar's role in nonalcoholic fatty liver disease
- New discussion of effects of opioids on intestinal mobility and constipation
- Irritable bowel disease presentation refined to incorporate probiotics and FODMAP dietary protocol
- New *Take Action* on comparing breads on gluten content
- Celiac disease and non-celiac gluten sensitivity prevalence statistics update

Chapter 5, *Carbohydrates*

- Expanded content on function of pectin
- Typical sources of sweeteners (Table 5-1) expanded to include advantame
- Enhanced discussion of total sugar and added sugar declarations on Nutrition Facts panels
- Updated discussion on 100% fruit juice recommendations
- Addition of health concerns associated with high fructose corn syrup
- Streamlined discussion of non-nutritive (alternative) sweeteners
- Added discussion on advantame
- New *Culinary Perspective* on nutritive sweeteners
- Fully updated *Healthy People* carbohydrate intake goals
- Apps for managing diabetes mellitus introduced

byr02421_fm_i-xxix.indd 14 2/10/21 12:33 AM



Chapter 6, *Lipids*

- New FDA *trans* fats regulations incorporated
- Enhanced presentation of main sources of fatty acids (Table 6-1)
- Refined *Take Action* on dietary fat content
- New *Culinary Perspective* on phospholipids in food
- Revised discussion of phospholipids to reflect recent research findings on functions
- Table 6-2 enhanced and updated to reflect latest recommendations for fat intake
- New discussion on foods that affect blood cholesterol
- Streamlined *Expert Perspective from the Field* on a healthier approach to eating fats
- Refined fat content of foods chart (Figure 6-10)
- Refined fat absorption illustration to increase comprehension (Figure 6-16)

Chapter 7, *Proteins*

- Enhanced discussion on pulses and legumes
- New *Culinary Perspective* on entomophagy
- Enhanced discussion on high protein diets
- Latest statistics on protein-energy malnutrition incorporated
- New feature on meat sweats
- Revised transaminase enzyme pathway to improve understanding (Figure 7-3)

Chapter 8, *Alcohol*

- Enhanced feature on powdered alcohol
- Streamlined discussion of alcohol metabolism
- Revised *Healthy People* goals regarding alcohol use
- Updated alcohol consumption trends and statistics
- Refined discussion of potential benefits of alcohol intake
- Enhanced discussion of the effects of alcohol abuse on nutritional status
- Extensive revision of alcohol intake around the world
- Dangers of combining alcohol and caffeine added
- Updated cirrhosis section to reflect newest research

Chapter 9, *Energy Metabolism*

- Improved clarity of caption explaining ATP stores and energy (Figure 9-4)
- Extensive revision of aerobic carbohydrate metabolism figure and caption to increase student comprehension (Figure 9-5)
- Increased clarity of ATP production sections for carbohydrates and lipids
- Streamlined discussion of ketosis in diabetes
- Modified disposal of excess amino groups figure and caption to enhance student understanding (Figure 9-17)
- Extensive revision of international incidence of cancer figure (Figure 9-18)
- Revised discussion on ATP concentrations to promote learning
- New *Take Action* on intermittent fasting and metabolism
- Recommendations added from the Advisory Committee on Heritable Disorders in Newborns and Children regarding inborn errors of metabolism
- New discussion of trimethylaminuria in inborn errors of metabolism section

Chapter 10, *Energy Balance, Weight Control, and Eating Disorders*

- Most up-to-date map of obesity rates in the U.S.
- Enhanced discussion of estimated energy requirements
- Revised discussion on measuring body fat content
- Weight control objectives from *Healthy People* updated
- Extensive revision to popular diet approaches to weight control (Table 10-7)
- New *Take Action* on how to spot a fad diet
- Eating disorders section streamlined and updated
- Section on binge eating disorder refined

Chapter 11, *Nutrition, Exercise, and Sports*

- Extensive revision of benefits of exercise section
- Refined discussion of section addressing calorie restriction and protein needs of wrestlers
- Enhanced discussion of boosting glycogen stores
- Expanded discussion of fat needs of athletes
- Enhanced section on ketogenic diets and athletic performance
- Streamlined discussion of calcium intake and relative energy deficiency in sports (REDS)
- Refined discussion of fluid intake and replacement strategies
- New *Culinary Perspective* on sports nutrition in the home kitchen
- Extensive revision of gene doping and editing in sports section

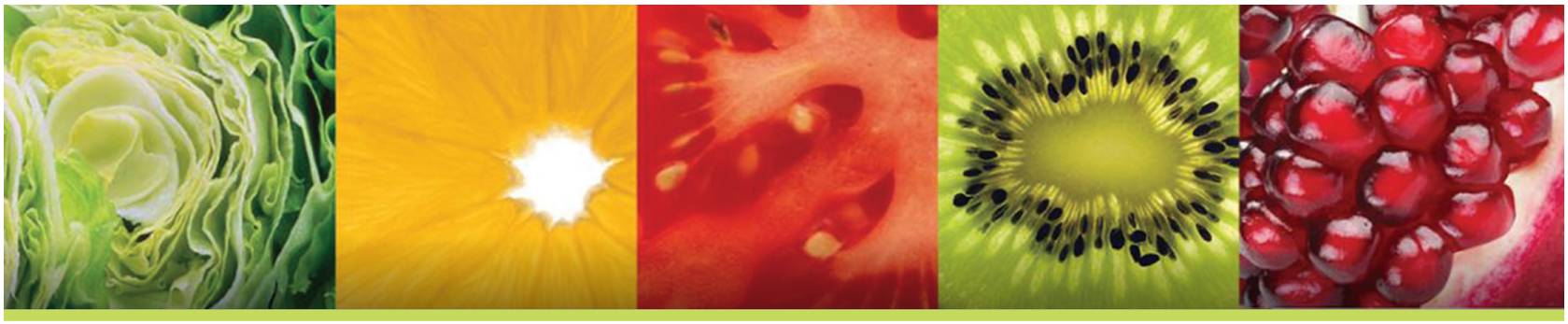
Chapter 12, *Micronutrients: Vitamins and Minerals*

- Refined discussion of dietary supplements prevalence
- Expanded discussion of nutrition and cancer risk
- New *Culinary Perspective* on preserving vitamins in fruits and vegetables
- Expanded discussion of dairy, calcium, and cancer risk

Chapter 13, *Micronutrients in Energy and Amino Acid Metabolism*

- Updated prevalence of thiamin deficiency in older adults
- Expanded section on riboflavin and plant-based milk alternatives
- Streamlined discussion on thiamin absorption and transport
- New *Culinary Perspective* on cooking methods for enhancing niacin bioavailability

byr02421_fm_i-xxix.indd 15 2/10/21 12:33 AM



- Updated discussion on pharmacologic use of niacin
- Figure added depicting biotinidase deficiency manifested as hypotonia in infants
- Refined discussion of B-6 metabolism and functions
- New image depicting vitamin B-6 deficiency manifested as seborrheic dermatitis
- Update of neural tube defect prevalence and maternal folate status
- New *Take Action* on energy drinks and B-vitamins
- Art added to illustrate biological sources of sulfur
- Extensive revision of iodine deficiency disorders
- Updated iodine status worldwide map
- Extensive revision of the *Global Perspective* on nutrition

Chapter 14, *Fluid Balance and Blood Health*

- Expanded discussion of medical therapies used to slow bone loss
- Latest bottled water statistics
- Expansion of vitamin K functions section
- Streamlined discussion of iron
- New feature on disease-causing bacteria and the need for iron
- Enhanced illustration of heme and nonheme absorption
- Enhanced discussion of zinc
- New *Historical Perspective* on unleavened bread and zinc deficiency
- Streamlined discussion on zinc transport
- Menkes disease, a genetic condition impairing copper transport and utilization, pathology image added
- Refined *Take Action* on local water supply fluoridation

Chapter 15, *Bone Health and Body Defense Systems*

- Enhanced *Take Action* on calcium intake
- Image of uses of phosphorus beyond nutrient functions
- Figure added to depict the structure of chlorophyll and contributions to magnesium intake
- Amsler grid for macular degeneration added
- Role of lutein in brain development and cognitive function added to carotenoid section
- New figure depicting bioconcentration and vitamin A content
- *Historical Perspective* on rickets added
- Fitzpatrick sun-reactive scale added to discussion of skin type and vitamin D deficiency risk
- Enhanced and updated section on current vitamin D concerns and additional functions
- New *Culinary Perspective* on plant-based milk alternatives
- Expanded discussion of vitamin C and cancer

Chapter 16, *Nutritional Aspects of Pregnancy and Breastfeeding*

- Expanded discussion of folate and vitamin B-12 needs during pregnancy
- Refined section on maternal factors increasing the risk of neural tube defects
- Streamlined discussion of maternal prepregnancy weight
- Refined section on recommendations for maternal weight gain during pregnancy
- Added section on postpartum weight loss
- Expanded discussion of maternal age to include older, first-time mothers
- Expanded discussion of breastfeeding links to reduced diabetes risk

Chapter 17, *Nutrition during the Growing Years*

- Streamlined section on tracking child growth
- Extensive refinement of *Global Perspective* on autism
- Expanded discussion on energy needs during growth
- Expanded discussion on water needs during fever, diarrhea, and vomiting
- Expanded discussion of iron deficiency anemia during the growing years
- Updated American Academy of Pediatrics's vitamin D supplementation for exclusively breastfed infants recommendations
- Extensive revision of nutritional qualities of breast milk section
- New *Culinary Perspective* on homemade baby food added
- Contribution of snacks to children's diets added

Chapter 18, *Nutrition during the Adult Years*

- Updated statistics and figure (Figure 18-1) summarizing life expectancy
- Vitamin D links with Alzheimer disease and other types of dementia added
- Strength training recommendations for older adults expanded and updated
- Expanded exercise guidelines for adults
- Added discussion on effects of dysphagia (trouble swallowing) on dietary status
- Revised *Clinical Perspective* to address drug-nutrient interactions
- Expanded discussion on Alzheimer disease
- New illustration depicting body composition changes with sarcopenia

byr02421_fm_i-xxix.indd 16 2/10/21 12:33 AM

Acknowledgments

We offer a hearty and profound thank you to the many individuals who have supported and guided us along the way.

To our loved ones: Without your patience, understanding, assistance, and encouragement, this work would not have been possible.

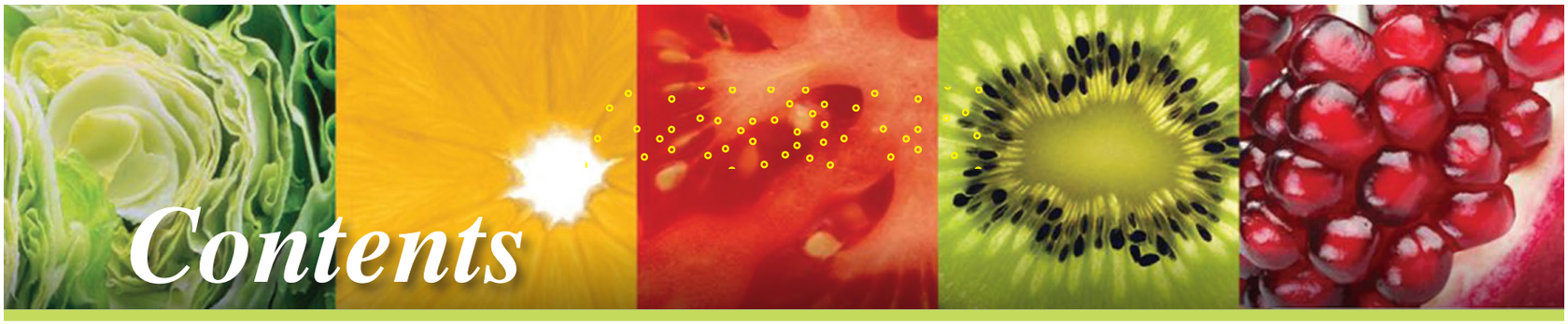
To our wonderful students—past, present, and future: The lessons you have taught us over the years have enlightened us and sustained our desire to provide newer, better opportunities to help you successfully launch your careers and promote healthful lifelong living. Thank you, in particular, to the students who have used SmartBook®, as your feedback was instrumental in the revisions for this edition.

To our amazing team at McGraw Hill: Portfolio Manager Lauren Vondra and Product Developer Erin DeHeck—we thank you most of all for your confidence in us! We deeply appreciate your endless encouragement and patience as you expertly shepherded us along the way. A special thanks to Director Michelle Vogler, Marketing Manager Tami Hodge, and Content Project Managers Jessica Portz and Rachael Hillebrand for all their hard work. An additional thank you to Designer David Hash, Copy Editor Debra DeBord for her meticulous attention to detail, Content Licensing Specialist Shawntel Schmitt, and the many talented illustrators and photographers for their expert assistance.

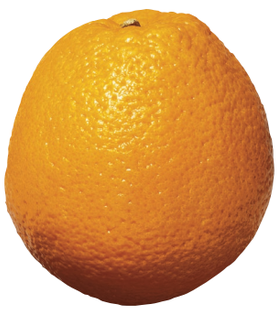
To your health!

Carol Byrd-Bredbenner
Jacqueline Berning
Danita Kelley
Jaclyn Maurer Abbot

byr02421_fm_i-xxix.indd 17 2/10/21 12:33 AM

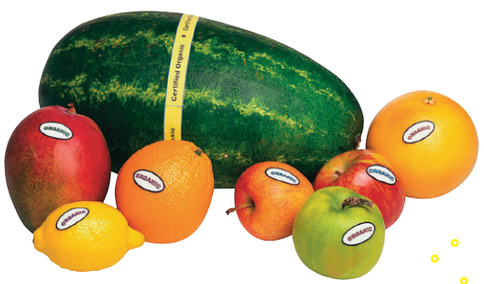


Contents



©Stockbyte/Getty images RF

byr02421_fm_i-xxix.indd 18 2/10/21 12:33 AM



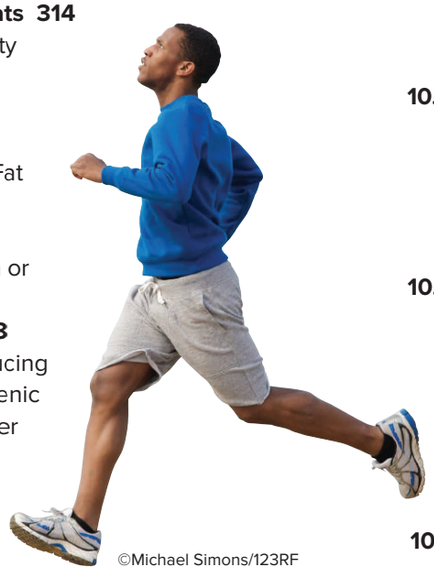
©C Squared Studios/Getty Images RF

©D. Hurst / Alamy

©Brand X Pictures/Getty Images RF

7 PROTEINS 241

8 ALCOHOL 277



©Michael Simons/123RF

©Jules Frazier/Getty Images RF

©Ingram Publishing / Alamy RF

13 MICRONUTRIENTS IN ENERGY AND AMINO ACID METABOLISM 455

©C Squared Studios/Getty Images

14 FLUID BALANCE AND BLOOD HEALTH 505

15 BONE HEALTH AND BODY DEFENSE SYSTEMS 553

©C Squared Studios/Getty Images

©D. Hurst / Alamy RF

(Lettuce): ©Pixtal/AGE Fofostock; (Orange Slice): ©Goodshoot / Alamy; (Tomato slice): ©Stockbyte/PunchStock; (Kiwi slice): ©lynx/ iconotec.com/Glow Images; (pomegranate): ©Valentyn Volkov/Getty Images

A nutritious, delicious, and varied diet is key to good health and longevity. To learn more, carefully study this text and visit **nutrition.gov.** Letterberry/Shutterstock

1 The Science of Nutrition

Learning Objectives

After studying this chapter, you will be able to

1. Define the terms *nutrition, carbohydrates, proteins, lipids* (fats and oils), *vitamins, minerals, water,* and *calories.*
2. Use the physiological fuel values of energy-yielding nutrients to determine the total energy content (calories) in a food or diet.
3. Describe the major characteristics of the North American diet and the food behaviors that often need improvement.
4. Describe the factors that affect our food choices.
5. Discuss the components and limitations of nutritional assessment.
6. List the attributes of lifestyles that are consistent with *Healthy People* goals and those that contribute to the leading causes of death in North America.
7. Describe the role of genetics in the development of nutrition-related diseases.
8. Explain how the scientific method is used in developing hypotheses and theories in the field of nutrition.
9. Identify reliable sources of nutrition information.

Chapter Outline

IN OUR LIFETIMES, WE WILL eat about 60 tons of food served at 70,000 meals and countless snacks. Research over the last 50 years has shown that the foods we eat have a profound impact on our health and longevity. A healthy diet—especially one rich in fruits and vegetables—coupled with frequent exercise can prevent and treat many age-related diseases.[1] In contrast, eating a poor diet and getting too little exercise are **risk factors** for many common life-threatening, chronic diseases, such as cardiovascular (heart) disease, diabetes, and certain forms of cancer.[2,3] Another diet-related problem, drinking too much alcohol, can impair nutritional status and is associated with liver disease, some forms of cancer, accidents, and suicides. As you can see in Figure 1-1, diet plays a role in the development of most of the leading causes of death in the U.S. The combination of poor diet and too little physical activity contributes to well over half of these deaths.[3,4]

We live longer than our ancestors did, so preventing age-related diseases is more important now than ever before. Today, many people want to know more about how nutritious dietary choices can bring the goal of a long, healthy life within reach.[5] They may wonder what the best dietary choices are, how nutrients contribute to health, or if multivitamin and mineral supplements are needed. How can people know if they are eating too much saturated fat, *trans* fat, or cholesterol? Why are carbohydrates important? Is it possible to get too much protein?

byr9559x_ch01_002-039.indd 3 10/02/21 1:00 AM

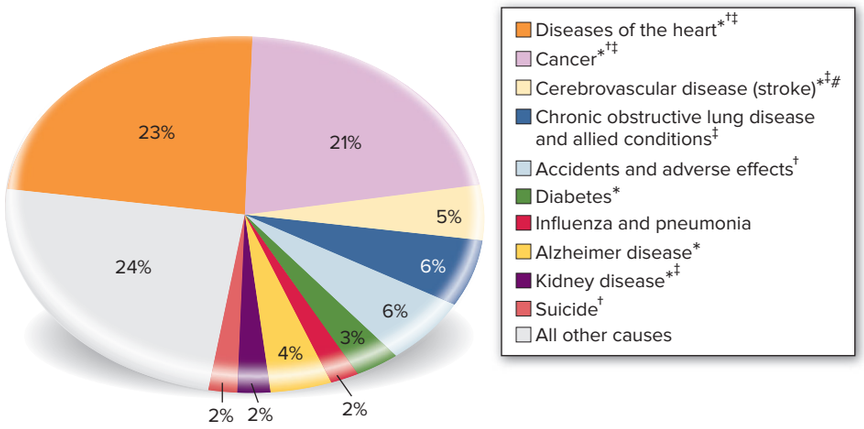


Figure 1-1 Leading causes of death in the U.S. The major health problems in North America are largely caused by a poor diet, excessive energy intake, and not enough physical activity. (Percentages do not total 100% due to rounding.)

Source: From Centers for Disease Control and Prevention, National vital Statistics Report, Canadian Statistics are quite similar.

*Causes of death in which diet plays a part
†Causes of death in which excessive alcohol consumption plays a part
‡Causes of death in which tobacco use plays a part
#Diseases of the heart and cerebrovascular disease are included in the more global term *cardiovascular disease.*

Bold terms in the book are defined in the Glossary. Bold terms also are defined in the text and/or nearby when first presented.

Is the food supply safe to eat? Would a vegetarian diet lead to better health? This book, beginning with this chapter, will help you build the nutrition knowledge base needed to answer these questions (and many more!) and apply this knowledge to safeguard your health, as well as the health of others.

As you begin your study of nutrition, keep in mind that this field draws heavily on chemistry, biology, and other sciences. For the greatest understanding of nutrition principles, you may want to review human physiology (Appendix A), basic chemistry concepts (Appendix B), and the metric system (Appendix H).

1.1 Nutrition Overview

The Council on Food and Nutrition of the American Medical Association defines **nutrition** as the "science of food; the nutrients and the substances therein; their action, interaction, and balance in relation to health and disease; and the process by which the organism (e.g., human body) ingests, digests, absorbs, transports, utilizes, and excretes food substances." Food provides the nutrients needed to fuel, build, and maintain all body cells.

Nutrients

You probably are already familiar with the terms *carbohydrates, lipids* (fats and oils), *proteins, vitamins,* and *minerals* (Table 1-1). These, plus water, make up the 6 classes of nutrients in food. **Nutrients** are substances essential for health that the body cannot make or that it makes in quantities too small to support health.

To be considered an essential nutrient, a substance must have these characteristics:

- Have a specific biological function
- Cause a decline in normal human biological function, such as the normal functions of the blood cells or nervous system, if removed from the diet
- Restore normal human biological function that was impaired by its absence if returned to the diet before permanent damage occurs

Table 1-1 Nutrients in the Human Diet*

Energy-Yielding Nutrients					
Carbohydrate	**Lipids (Fats and Oils)**		**Protein (Amino Acids)**		
Glucose (or a carbohydrate that yields glucose)	Linoleic acid (omega-6) Alpha-linolenic acid (omega-3)	Histidine Isoleucine Leucine	Lysine Methionine Phenylalanine	Threonine Tryptophan Valine	
Non-Energy-Yielding Nutrients					
Vitamins		**Minerals**			
Water-Soluble	**Fat-Soluble**	**Major**	**Trace**	**Questionable**	**Water**
Thiamin	A	Calcium	Chromium	Arsenic	Water
Riboflavin	D	Chloride	Copper	Boron	
Niacin	E	Magnesium	Fluoride	Nickel	
Pantothenic acid	K	Phosphorus	Iodide	Silicon	
Biotin		Potassium	Iron	Vanadium	
B-6		Sodium	Manganese		
B-12		Sulfur	Molybdenum		
Folate			Selenium		
C			Zinc		

*This table includes nutrients that the current *Dietary Reference Intakes* and related publications list for humans. There is some disagreement about whether the questionable minerals and certain other minerals not listed in the table are required for human health. Fiber could be added to the list of required substances, but it is not a nutrient (see Chapter 5). The vitamin-like compound choline plays vital roles in the body but is not listed under the vitamin category at this time. Alcohol is a source of energy, but it is not a nutrient.

Nutrients can be assigned to 3 functional categories (Table 1-2):

1. Those that primarily provide energy (typically expressed in kilocalories [kcal])
2. Those that are important for growth and development (and later maintenance)
3. Those that regulate body processes and keep body functions running smoothly

Some overlap exists among these categories. The energy-yielding nutrients and water make up a major portion of most foods.[6]

Because carbohydrates, proteins, lipids, and water are needed in large amounts, they are called **macronutrients**. In contrast, vitamins and minerals are needed in such small amounts in the diet that they are called **micronutrients**. Let's now look more closely at the classes of nutrients.

Table 1-2 Functional Categories of Nutrients

Provide Energy	Promote Growth and Development	Regulate Body Processes
Most carbohydrates	Proteins	Proteins
Proteins	Lipids	Some lipids
Most lipids (fats and oils)	Some vitamins	Some vitamins
	Some minerals	Some minerals
	Water	Water

Alcoholic beverages are rich in energy (calories), but alcohol is not a nutrient.

foodiepics/Shutterstock

Many foods are rich sources of the nutrients we recognize today as essential for health.

©JGI/Blend Images LLC

Carbohydrates

Carbohydrates are composed mainly of the **elements** carbon, hydrogen, and oxygen. Fruits, vegetables, grains, beans, and sugars are the primary dietary sources of carbohydrate. The main types of carbohydrates are simple and complex. Small carbohydrate structures are called sugars or simple carbohydrates—table sugar (sucrose) and blood sugar (glucose) are examples. Some sugars, such as glucose, can chemically bond together to form large carbohydrates, called polysaccharides or complex carbohydrates (Fig. 1-2). Examples of complex carbohydrates include the starch in grains and the glycogen stored in our muscles. Fiber, another type of complex carbohydrate, forms the structure of plants.

Glucose, which comes from simple carbohydrates and starch, is a major source of energy in most cells. It and most other carbohydrates provide an average of 4 calories per gram (kcal/g).[7] (Fiber provides little energy because it cannot be broken down by digestive processes.) When too little carbohydrate is eaten to supply sufficient glucose, the body is forced to make glucose from proteins. (Chapter 5 focuses on carbohydrates.)

Lipids

Like carbohydrates, lipids (e.g., fats, oils, cholesterol) are **compounds** composed mostly of the elements carbon, hydrogen, and oxygen (Fig. 1-3). Note that the term *fats* refer to lipids that are solid at room temperature, whereas oils are those that are liquid at room temperature.

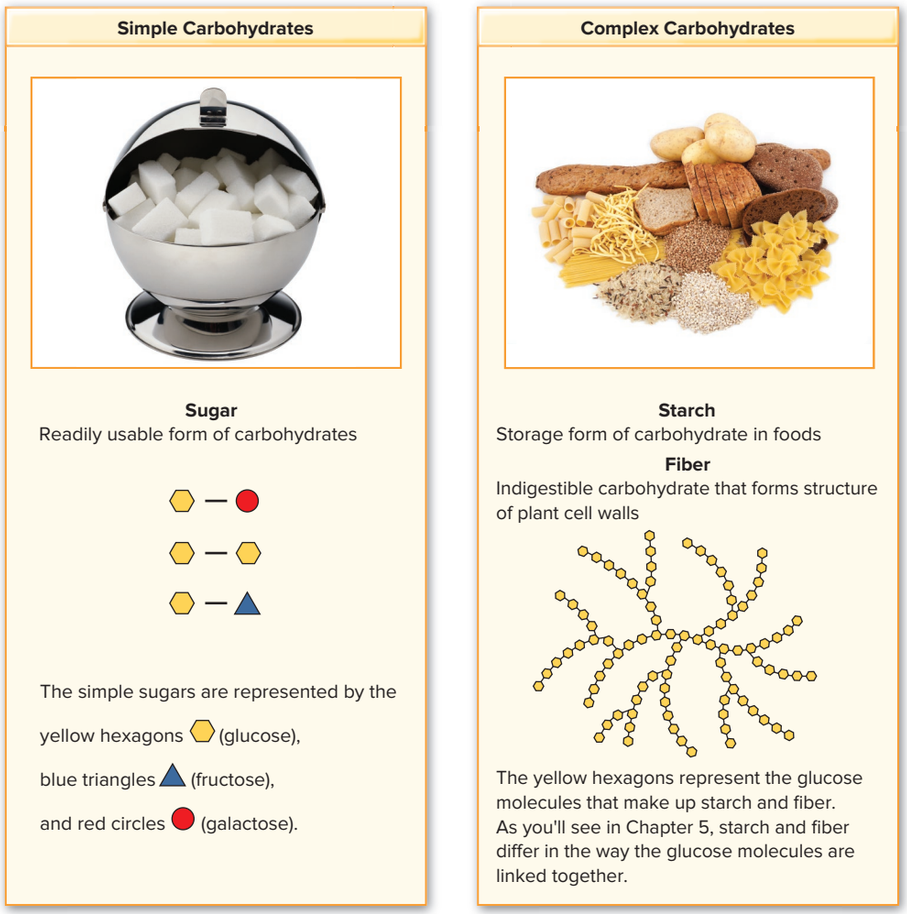


Figure 1-2 Two views of carbohydrates—dietary and chemical.

Photodisc/PunchStock; Shutterstock/Evgenia Sh.

macronutrient Nutrient needed in gram quantities in the diet.

micronutrient Nutrient needed in milligram or microgram quantities in a diet.

element Substance that cannot be separated into simpler substances by chemical processes. Common elements in nutrition include carbon, oxygen, hydrogen, nitrogen, calcium, phosphorus, and iron.

Lipids yield more energy per gram than carbohydrates—on average, 9 calories per gram. (See Chapter 9 for details about the high energy yield of lipids.) Lipids are insoluble in water but can dissolve in certain organic solvents (e.g., ether and benzene).

The lipid type called a **triglyceride** is the major form of fat in foods and a key energy source for the body. Triglycerides also are the major form of energy stored in the body. They are composed of 3 fatty acids attached to a glycerol **molecule**. Fatty acids are long chains of carbon flanked by hydrogen with an acid group attached to the end opposite glycerol.

Most lipids can be separated into 2 basic types—saturated and unsaturated—based on the chemical structure of their dominant fatty acids. This difference helps determine whether a lipid is solid or liquid at room temperature, as well as its effect on health. Although almost all foods contain a variety of saturated and unsaturated fatty acids, plant oils tend to contain mostly unsaturated fatty acids, which make them liquid at room temperature. Many animal fats are rich in saturated fatty acids, which make them solid at room temperature. Unsaturated fats tend to be healthier than saturated fats—saturated fat raises blood cholesterol, which can clog arteries and eventually lead to cardiovascular disease.

Two specific unsaturated fatty acids—linoleic acid and alpha-linolenic acid—are essential nutrients. They must be supplied by our diets. These essential fatty acids have many roles, including being structural components of cell membranes and helping regulate blood pressure and nerve transmissions. A few tablespoons of vegetable oil daily and eating fish at least twice weekly supply sufficient amounts of essential fatty acids.[7]

Some foods also contain *trans* fatty acids—unsaturated fats that have been processed to change their structure from the more typical *cis* form to the *trans* form (see Chapter 6). Partially hydrogenated oils are the primary source of *trans* fats. In the U.S., partially hydrogenated oils have been banned for use in foods because they pose health risks. These oils will be phased out of the food supply in the next few years.[8] Partially hydrogenated foods are used to prepare many deep-fried foods (e.g., donuts, french fries), baked snack foods (e.g., cookies, crackers), and solid fats (e.g., stick margarine, shortening). (Chapter 6 focuses on lipids.)

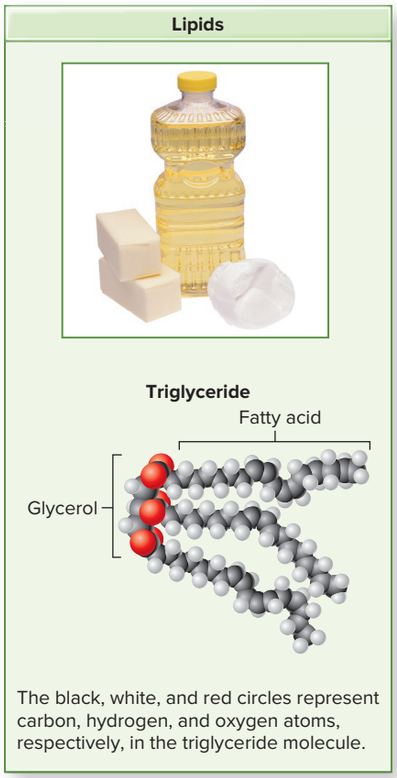


Figure 1-3 Dietary and chemical views of lipids.

Getty Images

Proteins

Proteins, like carbohydrates and fats, are composed of the elements carbon, oxygen, and hydrogen (Fig. 1-4). Proteins also contain another element—nitrogen. Proteins are the main structural material in the body. For example, they are a major part of bone and muscle; they also are important components in blood, cell membranes, **enzymes**, and immune factors.[7] Proteins can provide energy for the body—on average, 4 calories per gram; however, the body typically uses little protein to meet its daily energy needs.

Proteins form when amino acids bond together. Twenty common amino acids are found in food; 9 of these are essential nutrients for adults, and 1 additional amino acid is essential for infants. (Chapter 7 focuses on proteins.)

Vitamins

Vitamins have a wide variety of chemical structures and can contain the elements such as carbon, hydrogen, nitrogen, oxygen, phosphorus, sulfur, and others. The main function of vitamins is to enable many **chemical reactions** to occur in the body. Some of these reactions help release the energy trapped in carbohydrates, lipids, and proteins. Vitamins themselves provide no usable energy for the body.

The 13 vitamins are divided into 2 groups. Fat-soluble vitamins (A, D, E, and K) dissolve in fat. Vitamin C and the B-vitamins (thiamin, riboflavin, niacin, vitamin B-6, pantothenic acid, biotin, folate, and vitamin B-12) are water-soluble vitamins. The vitamin groups often act quite differently. For example, cooking is more likely to destroy water-soluble vitamins than fat-soluble vitamins. Water-soluble vitamins are excreted from the body much more readily than fat-soluble vitamins. As a result, fat-soluble vitamins, especially vitamin A, are much more likely to accumulate in excessive amounts in the body, which then can cause toxicity. (Vitamins are the focus of Part 4.)

atom Smallest unit of an element that still has all the properties of the element. An atom contains protons, neutrons, and electrons.

molecule Atoms linked (bonded) together; the smallest part of a compound that still has all the properties of a compound.

compound Atoms of 2 or more elements bonded together in specific proportions.

enzyme Compound that speeds the rate of a chemical process but is not altered by the process. Almost all enzymes are proteins (some are made of nucleic acids).

chemical reaction Interaction between 2 or more chemicals that changes both chemicals.

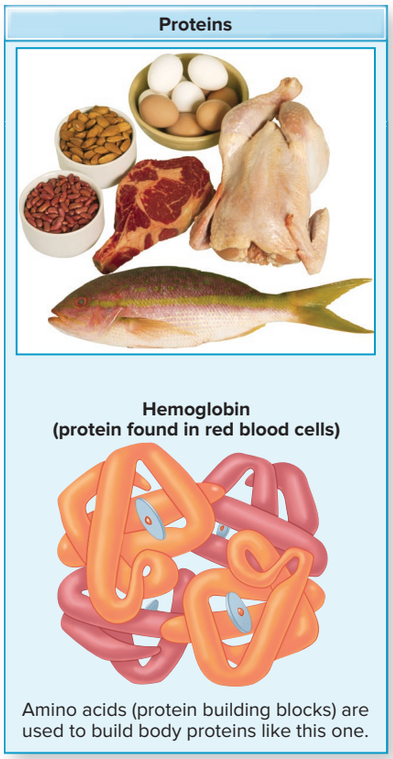


Figure 1-4 Dietary and chemical views of proteins.

Comstock Images/Getty Images

Minerals

The nutrients discussed so far are all complex organic compounds, whereas minerals are structurally very simple, inorganic substances. The chemical structure of an **organic compound** contains carbon atoms bonded to hydrogen atoms, whereas an **inorganic substance** generally does not. In this case, the term *organic* is not related to the farming practices that produce organic foods (these are described in Chapter 3).

Minerals typically function in the body as groups of one or more of the same atoms (e.g., sodium or potassium) or as parts of mineral combinations, such as the calcium- and phosphorus-containing compound called hydroxyapatite, found in bones. Because they are elements, minerals are not destroyed during cooking. (However, they can leak into cooking water and get discarded when food is drained.) Minerals yield no energy for the body but are required for normal body function. For instance, minerals play key roles in the nervous system, the skeletal system, and water balance.

Minerals are divided into 2 groups: major minerals and trace minerals. Major minerals are needed daily in gram amounts. Sodium, potassium, chloride, calcium, and phosphorus are examples of major minerals. Trace minerals are those that we need in amounts of less than 100 milligrams (mg) daily. Examples of trace minerals are iron, zinc, copper, and selenium. (Minerals are the focus of Part 4.)

Water

Water is the 6th class of nutrients. Like minerals, water also is inorganic. Although sometimes overlooked as a nutrient, water is the nutrient needed in the largest quantity. Water (H_2O) has numerous vital functions in the body. It acts as a solvent and lubricant and is a medium for transporting nutrients to cells. It also helps regulate body temperature. Beverages, as well as many foods, supply water. The body even makes some water as a by-product of **metabolism**. (Water is examined in detail in Part 4.)

Tomatoes contain the phytochemical lycopene; thus, they can be called a functional food.

David R. Frazier Photolibrary, Inc./Alamy Stock Photo

Phytochemicals and Zoochemicals

Phytochemicals (plant components in fruits, vegetables, legumes, and whole grains) and **zoochemicals** (components in animals) are physiologically active compounds. They are not considered essential nutrients in the diet. Still, many of these substances provide significant health benefits.[9] For instance, numerous studies show reduced cancer risk among people who regularly consume fruits and vegetables. Researchers surmise that some phytochemicals in fruits and vegetables block the development of cancer (see Part 4).[10] Some phytochemicals and zoochemicals also have been linked to a reduced risk of cardiovascular disease.[11]

It will likely take many years for scientists to unravel the important effects of the many different phytochemicals and zoochemicals in foods. Multivitamin and mineral supplements currently contain few or none of these beneficial chemicals.

organic compound Substance that contains carbon atoms bonded to hydrogen atoms in the chemical structure.

inorganic substance Substance lacking carbon atoms bonded to hydrogen atoms in the chemical structure.

metabolism Chemical processes in the body that provide energy in useful forms and sustain vital activities.

phytochemical Physiologically active compound in plants that may provide health benefits.

zoochemical Physiologically active compounds in foods of animal origin that may provide health benefits.

Table 1-3 Examples of Phytochemicals and Zoochemicals under Study

Phytochemicals	Food Sources
Allyl sulfides/organosulfides	Garlic, onions, leeks
Saponins	Garlic, onions, licorice, legumes
Carotenoids (e.g., lycopene)	Orange, red, and yellow fruits and vegetables; egg yolks
Monoterpenes	Oranges, lemons, grapefruit
Capsaicin	Chili peppers
Lignans	Flaxseed, berries, whole grains
Indoles	Cruciferous vegetables (broccoli, cabbage, kale)
Isothiocyanates	Cruciferous vegetables, especially broccoli
Phytosterols	Soybeans, other legumes, cucumbers, other fruits and vegetables
Flavonoids	Citrus fruit, onions, apples, grapes, red wine, tea, chocolate, tomatoes
Isoflavones	Soybeans, fava beans, other legumes
Catechins	Tea
Ellagic acid	Strawberries, raspberries, grapes, apples, bananas, nuts
Anthocyanosides	Red, blue, and purple produce (eggplant, blueberries)
Fructooligosaccharides	Onions, bananas, oranges
Stilbenoids (e.g., resveratrol)	Blueberries, grapes, peanuts, red wine
Zoochemicals	
Sphingolipids	Meat, dairy products
Conjugated linoleic acid	Meat, cheese

Thus, nutrition and health experts suggest that a diet rich in fruits, vegetables, legumes, and whole-grain breads and cereals is the most reliable way to obtain the potential benefits of phytochemicals.[12] In addition, foods of animal origin, such as fatty fish, can provide the beneficial zoochemical omega-3 fatty acids (see Chapter 6), and fermented dairy products provide probiotics (see Chapter 4). Table 1-3 lists some phytochemicals and zoochemicals under study, with their common food sources.

Functional Foods

Foods rich in phytochemicals (chemicals from plants) and zoochemicals (chemicals from foods of animal origin) are sometimes referred to as functional foods. A **functional food** provides health benefits beyond those supplied by the traditional nutrients it contains—the food or food ingredient offers additional components that may decrease disease risk and/or promote optimal health due to the physiologically active compounds they contain. Table 1-4 describes the categories of functional foods.[8]

The phytochemicals and zoochemicals that are present naturally in unmodified whole foods like fruits and vegetables are thought to provide many health benefits (see Table 1-3). Foods modified by adding nutrients, phytochemicals, zoochemicals, or herbs (see Chapter 18) also may provide health benefits. For instance, orange juice fortified with calcium may help prevent osteoporosis. Medical foods are designed to help enhance the management of health conditions. An example is phenylalanine-restricted formula fed to infants born with the inborn error of metabolism condition called phenylketonuria (PKU) (see Chapter 9). This formula helps them develop normally. An important trend in the food industry is the addition of nutrients, phytochemicals, and other components in hopes of boosting the healthfulness of the food supply.

Shutterstock/Ivonne Wierink

Table 1-4 Functional Food Categories[9]

Conventional Foods: Unmodified Whole Foods

Fruits	Spices	Dairy products
Vegetables	Nuts	Fish
Herbs		

Modified Foods: Fortified, Enriched, or Enhanced Foods

- Calcium-fortified orange juice
- Omega-3-enriched bread
- Breakfast bars enhanced with ginkgo biloba
- Cheese made with plant sterols

Medical Foods: Food, Formula, or Supplement Used under Medical Supervision to Manage a Health Condition

- Phenylalanine-free formulas for phenylketonuria (PKU)
- Limbrel® for osteoarthritis
- Axona® for Alzheimer disease
- VSL#3® for ulcerative colitis
- GlycemX™ 360 for diabetes management

Special Dietary Use Foods: Foods That Help Meet a Special Dietary Need

- Infant formula for infants
- Lactose-free foods for lactose intolerance
- Sugar-free foods for weight loss
- Gluten-free foods for celiac disease

Measuring Spoons: Stockbrokerxtra Images/Photolibrary; Orange Juice: ©Stockbyte/Getty Images; Baby Bottle: Photodisc; Lacctaid Carton: ©McGraw-Hill Education/Jill Braaten, photographer

Knowledge Check

1. What are the 6 classes of nutrients?
2. What characteristics do the macronutrients share?
3. How are vitamins categorized?
4. How are minerals different from carbohydrates, lipids, protein, and vitamins?
5. What are phytochemicals and zoochemicals?

Culinary Perspective

Fermented Foods

LapaiIrKrapai/Shutterstock

This man from Kyrgyzstan is drinking fermented horse milk, which is called kumis.

©Ronald Wixman

Fermented foods have been enjoyed around the world for centuries. Initially, people fermented soybeans, vegetables, milk, fruits, and even fish to preserve them. Fermentation was especially important when refrigeration or canning was not available. Fermented foods rely on bacteria, yeast, or fungi to convert natural sugars and starches to lactic and other acids, which in turn preserve the food. Research supports that there is a potential to use fermentation to help reduce short-chain fermentable carbohydrates (FODMAPs—see the Clinical Perspective in Chapter 4) during food preparation (e.g., proofing bread), potentially expanding food options for people with digestive disorders[13] (see Chapter 4). Today, interest focuses on fermented foods' flavor and probiotic and nutrient contents.

A very common fermented food is German sauerkraut (literally, "sour or pickled cabbage"). Sauerkraut is made by packing chopped cabbage and spices into a crock with rock salt. Over a few weeks, *Lactobacillus* bacteria on the cabbage multiply and cause fermentation, converting the raw cabbage to flavorful sauerkraut. Yogurt, another common fermented food, is made by adding a bacterial culture to warm milk. As the bacteria multiply, the pH drops, causing the formation of the smooth, soft, tangy curd that we know as yogurt. Some pickles and the traditional Korean cabbage dish called kimchi also are fermented. Other fermented foods include tempeh, a cakelike product made from slightly fermented soybeans, and miso, a rich paste made from soybeans, seasonings, and sometimes grains such as rice and barley. Both tempeh and miso are fermented with fungi. (Tofu, another soybean product, is not fermented.) Kombucha, a popular fermented tangy and slightly fizzy beverage, is made from green or black tea. Eating fermented foods may offer benefits to an individual's intestinal microbiota. Which fermented foods have you tried? How would you describe their flavors?

1.2 Energy Sources and Uses

Humans obtain the energy needed to perform body functions and do work from carbohydrates, fats, and proteins. Alcohol also is a source of energy, supplying about 7 calories per gram. As mentioned previously, it is not considered a nutrient, however, because alcohol has no required function. After digesting and absorbing energy-producing nutrients, the body transforms the energy trapped in carbohydrate, protein, fat, and alcohol into other forms of energy in order to

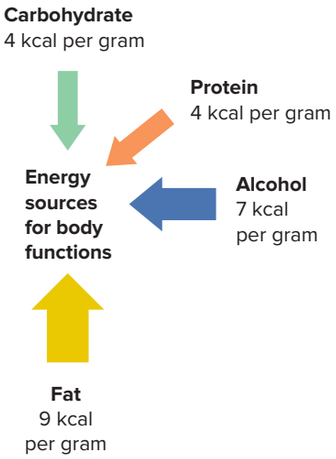
- Build new compounds
- Move muscles
- Transmit nerve impulses
- Balance **ions** within cells

(See Chapter 4 for more on digestion and absorption. Chapter 9 describes how energy is released from chemical bonds and then used by body cells to support the processes just described.)

ion Atom with an unequal number of electrons and protons. Negative ions (anions) have more electrons than protons; positive ions (cations) have more protons than electrons.

byr9559x_ch01_002-039.indd 11 10/02/21 1:01 AM

Physiological fuel values.



The word *calorie* typically is used to mean kilocalorie; thus, this book uses the term *calorie* and its abbreviation, *kcal*.

Many scientific journals express energy content of food as kilojoules (kJ), rather than kilocalories. A mass of 1 gram moving at a velocity of 1 meter/second possesses the energy of 1 joule (J); 1000 J = 1 kJ. Heat and work are 2 forms of energy; thus, measurements expressed in terms of kilocalories (a heat measure) are interchangeable with measurements expressed in terms of kilojoules (a work measure): 1 kcal = 4.18 kJ.

kilocalorie (kcal) Heat energy needed to raise the temperature of 1000 grams (1 L) of water 1 degree Celsius; also written as *Calorie*.

Calorie is often the term used to express the amount of energy in foods. Technically, a **calorie** is the amount of heat energy it takes to raise the temperature of 1 gram of water 1 degree Celsius (1°C). Because a calorie is such a tiny measure of heat, food energy is more accurately expressed in terms of the kilocalorie (kcal), which equals 1000 calories. (If the *c* in *calories* is capitalized, this also signifies kilocalories.) A **kilocalorie (kcal)** is the amount of heat energy it takes to raise the temperature of 1000 g (1 liter) of water 1°C. In everyday usage, the word *calorie* (without a capital *c*) also is used to mean kilocalorie. Thus, the term *calorie* and its abbreviation, *kcal,* are used throughout this book. Any values given in calories on food labels are actually in kilocalories (Fig. 1-5).

The calories in food can be measured using a bomb calorimeter (see Chapter 10). Or they can be estimated by multiplying the amount of carbohydrates, proteins, fats, and alcohol in a food by their physiological fuel values. The physiological fuel values are 4, 9, 4, and 7 for carbohydrate, fat, protein, and alcohol, respectively. These values are adjusted to account for the extent to which foods can be digested and for substances (e.g., waxes and fibers) that humans cannot digest. Thus, they should be considered estimates.

Physiological fuel values can be used to determine the calories in food. Consider these foods:

HONEY WHEAT BREAD

Nutrition Facts

19 servings per container
Serving size **1 slice (36g)**

Amount Per Serving
Calories **80**

	% Daily Value*
Total Fat 1g	**2**%
Saturated Fat 0g	**0**%
Trans Fat 0g	
Cholesterol 0mg	**0**%
Sodium 200mg	**8**%
Total Carbohydrate 15g	**5**%
Dietary Fiber 2g	**8**%
Total Sugars 1g	
Includes 0g added sugars	**0**%
Protein 3g	
Vitamin D 0mcg	0%
Calcium 0mg	0%
Iron 1mg	4%
Potassium 0mg	0%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Figure 1-5 Use the nutrient values on the Nutrition Facts label to calculate the energy content of a food. Based on carbohydrate, fat, and protein content, a serving of this food (honey wheat bread) contains 81 kcal ([15 × 4] + [1 × 9] + [3 × 4] = 81). The label lists 80 because Nutrition Facts labels round values.

1 Large Hamburger

Carbohydrate	39 grams × 4 = 156 kcal
Fat	32 grams × 9 = 288 kcal
Protein	30 grams × 4 = 120 kcal
Alcohol	0 grams × 7 = 0 kcal
Total	**564 kcal**

8-ounce Pina Colada

Carbohydrate	57 grams × 4 = 228 kcal
Fat	5 grams × 9 = 45 kcal
Protein	1 gram × 4 = 4 kcal
Alcohol	23 grams × 7 = 161 kcal
Total	**438 kcal**

hamburger: ©Burke/Triolo/Brand X Pictures RF;
pina colada: C Squared Studios/Getty Images

These values also can be used to determine the portion of total energy intake that carbohydrate, fat, protein, and alcohol provide to your diet. Assume that one day you consume 283 g of carbohydrates, 60 g of fat, 75 g of protein, and 9 g of alcohol. This consumption yields a total of 2035 kcal ([283 × 4] + [60 × 9] + [75 × 4] + [9 × 7] = 2035). The percentage of your total energy intake derived from each nutrient can then be determined:

$$\% \text{ of energy intake as carbohydrate} = (283 \times 4) / 2035 = 0.56 \times 100 = 56\%$$

$$\% \text{ of energy intake as fat} = (60 \times 9) / 2035 = 0.27 \times 100 = 27\%$$

$$\% \text{ of energy intake as protein} = (75 \times 4) / 2035 = 0.15 \times 100 = 15\%$$

$$\% \text{ of energy intake as alcohol} = (9 \times 7) / 2035 = 0.03 \times 100 = 3\%$$

Knowledge Check

1. What does the term *calorie* mean?
2. How do calories, kilocalories, and kilojoules differ?
3. How many calories are in a food that has 8 g carbohydrate, 2 g alcohol, 4 g fat, and 2 g protein?

1.3 The North American Diet

In the U.S. and Canada, large surveys are conducted to determine what people are eating. The U.S. government uses the National Health and Nutrition Examination Survey (NHANES) administered by the U.S. Department of Health and Human Services. In Canada, this information is gathered by Health Canada in conjunction with Agriculture and Agrifood Canada. Results from these surveys and others show that North American adults consume, on average, 16% of their energy intake as proteins, 50% as carbohydrates, and 33% as fats. These percentages are estimates, and they vary slightly from year to year and to some extent from person to person. Although these percentages fall within a healthy range[14] (see Chapter 2), many people are eating more than they need to maintain a healthy weight.[15]

Animal sources, such as meat, seafood, dairy products, and eggs, supply about two-thirds of the protein intake for most North Americans; plant sources provide only about a third. In many other parts of the world, it is just the opposite: plant proteins—from rice, beans, corn, and other vegetables—dominate protein intake. About half the carbohydrates in North American diets are simple carbohydrates (sugars); the other half are starches (e.g., pastas, breads, and potatoes). Most North Americans need to reduce their sugar intake and increase their intake of starch and fiber. Because approximately 60% of dietary fat comes from animal sources and only 40% from plant sources, many North Americans are consuming far more saturated fat and cholesterol than is recommended.

These surveys also indicate that most of us could improve our diets by focusing on rich food sources of vitamin A, vitamin E, iron, potassium, and calcium and reducing sodium intake. Nutrient intake varies in some demographic groups, which means these individuals need to pay special attention to certain nutrients. For example, older adults often get too little vitamin D, and many women of childbearing years have inadequate iron intake.

Many North Americans could improve their nutrient intake by moderating intake of sugared soft drinks and fatty foods and eating more fruits, vegetables, whole-grain breads, and reduced-fat dairy products. Vitamin and mineral supplements also can help meet nutrient needs but, as you'll see in Part 4, they cannot fully make up for a poor diet in all respects.[16]

Increasing vegetable intake, such as a daily salad, is one strategy to boost intake of important nutrients.

D. Hurst/Alamy Stock Photo

hunger Primarily physiological (internal) drive for food.

appetite Primarily psychological (external) influences that encourage us to find and eat food, often in the absence of obvious hunger.

What Influences Our Food Choices?

Although we have to eat to obtain the nutrients we need to survive, many factors other than health and nutrition affect our food choices. Daily food intake is a complicated mix of the need to satisfy **hunger** (physical need for food) and social and psychological needs (Fig. 1-6).[17] In areas of the world where food is plentiful and fairly easy to access (e.g., the U.S., Canada, Europe, Australia, and Japan), food selection is largely guided by **appetite**—the psychological desire to eat certain foods and reject others. Appetite and food choice depend on many factors:

- *Food flavor, texture, and appearance preferences*—for many people, these are the most important factors affecting food choices. Creating more flavorful foods that are both healthy and profitable is a major focus of the food industry. Food preferences are affected by many factors, including genetics, culture, and lifestyle.
- *Culture* (knowledge, beliefs, religion, and traditions shared by a group or social network of people) teaches individuals which foods are considered proper or appropriate to eat and which are not. For example, many people in North America believe it is proper to eat beef; however, people in some cultures never consider eating beef. Some cultures savor foods such as blood, mice, and insects; even though these foods are packed with nutrients and safe to eat, few North Americans feel they are proper to eat. Early experiences with people, places, and situations influence lifelong food choices. New immigrants often retain the diet patterns of their country of origin until they become acculturated (i.e., they have adopted the cultural traits or social patterns of the new country).

Figure 1-6 Food choices are affected by many factors. Which have the greatest impact on your food choices?

mimagephotography/Shutterstock

Take Action

Why You Eat What You Do

Choose a day of the week that is typical of your eating pattern. List all the foods and drinks you consume for 24 hours. Using the factors that influence food choices discussed in Section 1.3, indicate why you consumed each item. Note that there can be more than 1 reason for choosing a particular food or drink.

Now ask yourself, What was the most frequent reason for eating or drinking? To what extent are health or nutrition concerns the reason for your food choices? Should you make these reasons higher priorities?

©Eric Audras/Photoalto/PictureQuest RF

- *Lifestyle* includes the way we spend our resources and assign priorities. People with very busy lives often have limited time and energy to buy and prepare foods, so they opt for convenience or fast food. For some, it may be more important to spend extra time working rather than making it a priority to exercise and eat healthfully.
- *Routines and habits* related to food and eating affect *what* as well as *when* we eat. Most of us eat primarily from a core group of foods—only about 100 basic items account for 75% of a person's total food intake.
- *Food cost and availability* are important but play only moderate roles in food choices for many of us because food is relatively inexpensive and widely available in North America.[1] In fact, we spend less than 10% of our income on food—about half on food at home and half on food away from home.[18] However, as described in the Global Perspective, this is not the case in many other areas of the world. The type of food available also is affected by the environment.
- *Environment* includes your surroundings and experiences. In North America, the environment is filled with opportunities to obtain affordable, delicious, high-calorie food—vending machines, bake sales, food courts in shopping areas, and candy displays in bookstores—and encourages (via marketing) the consumption of these foods. Experiences with friends, family, and others also can influence food choices, as can mood and psychological needs. Geographic location can affect the food environment, too. Think about the regional cuisine in the area where you live. For example, in the southwestern U.S., barbecue is popular. In New England, seafood is readily available.
- *Food marketing* is any type of action a company takes to create a desire in consumers to buy its food; *advertising* is a type of food marketing. Food influencers, or thought leaders, are another type of food marketing. These individuals often are paid by companies to promote their products or services by recommending them on social media. Before following the advice of someone on social media, be sure to find out if that person is being paid to promote the product, and think about how this type of marketing affects your choices. The food industry in the U.S. spends billions of dollars annually on marketing. Some of this marketing is helpful, such as when it promotes the importance of calcium and fiber intake. However, the food industry more frequently advertises fast food, candy, cookies, cakes, and pastries because such products generate the greatest profits.
- *Health and nutrition concerns, knowledge, beliefs, and values* also can affect food choices. Those most concerned about health and who have the greatest nutrition knowledge tend to be well-educated, middle-income professionals. The same people are generally health oriented, have active lifestyles, and work hard to keep their bodies at a healthy weight. Values guide the food choices of many people. For instance, people who are concerned about the environment may opt to eat mostly locally produced food or organic foods. Those who value low-fat, high-fiber diets or animal rights may choose a vegan diet.

The major health problems in North America are largely caused by a poor diet, excessive energy intake, and not enough physical activity.

LiliGraphie/Shutterstock

romastudio © 123RF.com

An assessment of this child's nutritional health status indicates stunted growth and edema due to limited protein intake caused by an inability to purchase enough protein-rich foods. Learn more about protein deficiency in Chapter 7.

©Jean-Marc Giboux/Getty Images

sign Physical attribute that can be observed by others, such as bruises.

symptom Change in health status noted by the person with the problem, such as a stomach pain.

Knowledge Check

1. What type of food provides most of the protein in the diets of North Americans?
2. Which types of carbohydrates do most North Americans need to increase in their diets?
3. Which vitamins and minerals do many North Americans need to increase in their diets?
4. What factors affect food choices?

1.4 Nutritional Health Status

In a well-nourished person, the total daily intake of protein, fat, and carbohydrate weighs about 450 g (about 1 pound). In contrast, the typical daily mineral intake weighs about 20 g (about 4 teaspoons) and the daily vitamin intake weighs less than 300 mg (1/15th of a teaspoon). These nutrients can come from a variety of sources—fruits, vegetables, meats, dairy products, or other foods. Our body cells are not concerned with which food has supplied a nutrient—what is important, however, is that each nutrient be available in the amounts needed for the body to function normally.

The body's nutritional health is determined by the sum of its status with respect to each nutrient. There are 3 general categories of nutritional status: desirable nutrition, undernutrition, and overnutrition. The common term *malnutrition* can refer to either overnutrition or undernutrition, neither of which is conducive to good health.

Optimal, or **desirable nutritional status** for a particular nutrient is the state in which the body tissues have enough of the nutrient to support normal functions, as well as to build and maintain surplus stores that can be used in times of increased need. A desirable nutritional status can be achieved by obtaining essential nutrients from a variety of foods.

Undernutrition occurs when nutrient intake does not meet nutrient needs, causing surplus stores to be used. Once nutrient stores are depleted and tissue concentrations of an essential nutrient fall sufficiently low, the body's metabolic processes eventually slow down or even stop. The early stage of a nutrient deficiency is termed **subclinical** because there are no overt signs or symptoms that can be detected or diagnosed. If a deficiency becomes severe, clinical signs and symptoms eventually develop and become outwardly apparent. A **sign** is a feature that can be observed, such as flaky skin. A **symptom** is a change in body function that is not necessarily apparent to a health-care provider, such as feeling tired or achy. Table 1-4 describes the signs and symptoms associated with iron status.

Consumption of more nutrients than the body needs can lead to **overnutrition**. In the short run—for instance, a week or so—overnutrition may cause only a few symptoms, such as intestinal distress from excessive fiber intake. If an excess intake continues, the levels of some nutrients in the body may increase to toxic amounts. For example, too much vitamin A can have negative effects, particularly in children, pregnant women, and older adults. The most common type of overnutrition in industrialized nations—excess intake of energy-yielding nutrients—often leads to obesity. Obesity, in turn, can lead to other serious chronic diseases, such as type 2 diabetes and certain forms of cancer.

Table 1-4 Nutritional Status, Using Iron as an Example

Condition	Signs and Symptoms Related to Iron
Undernutrition: nutrient intake does not meet needs	Decline in iron-related compounds in the blood, which reduces the ability of the red blood cells to carry oxygen to body tissues and, in turn, causes fatigue on exertion, poor body temperature regulation, and eventually pale complexion
Desirable nutrition: nutrient intake supports body function and permits storage of nutrients to be used in times of increased need	Adequate liver stores of iron, adequate blood levels of iron-related compounds, and normal functioning of red blood cells
Overnutrition: nutrient intake exceeds needs	Excess liver stores of iron, which damage liver cells

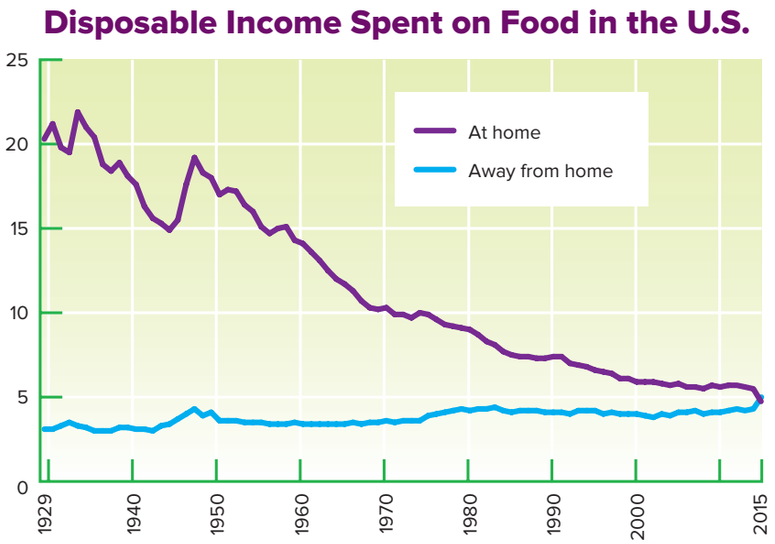
GLOBAL PERSPECTIVE

The Price of Food

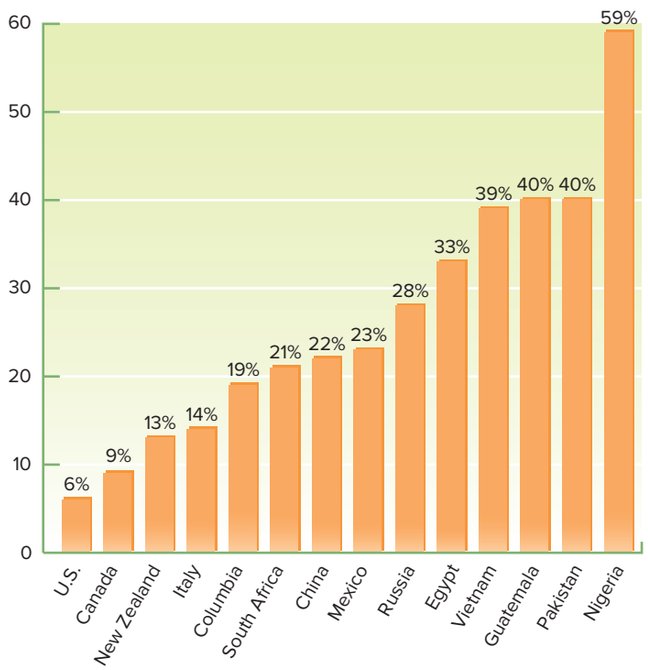
The cost of food as a percentage of income varies widely around the world. In the U.S., for instance, food consumed at home by the average household is less than 6% of total income, whereas families in Nigeria spend almost two-thirds of their income on food eaten at home. Accounting partly for this difference is that a substantial amount is spent in the U.S. for food eaten away from home. As shown in the line chart, over the past century, the proportions of money spent in the U.S. on food eaten at home and away from home have gotten closer with each passing year.

Another reason for this differential among countries is that food production, packaging, and distribution have become more efficient in some parts of the world but less so in others. Greater efficiency means we can buy more for less. In developed nations, nearly all households have a refrigerator, which greatly reduces food spoilage and therefore food expenditures. Food packaging innovations also help keep food fresh longer. Pest management in homes, food processing plants, and farming further minimize food losses. In addition, U.S. government policies and legislation, primarily the Farm Bill, affect how food is produced and how the prices of some foods are set.

It is important to realize that the percentage of income spent on food in the countries shown in the bar graph is for the "average" household. The proportion of a family's budget spent on food tends to be higher for those with lower incomes. Regardless of why these proportional differences occur in the U.S. or in other nations, as the percentage of family income spent on food rises, the typical family has less to devote to other components that contribute to overall health and quality of life, such as health care, shelter, clothing, and education. In addition, these families may be unable to purchase sufficient amounts of nutritious food because they need to pay rent or other essential expenses. The cost of food can affect both food choices and health.



Source: Calculated by the Economic Research Service, USDA, from various data sets from the U.S. Census Bureau and the Bureau of Labor Statistics.



Source: USDA, ERS, Percent of household final consumption expenditures spent on food, alcoholic beverages, and tobacco that were consumed at home, by selected countries, 2016; www.ers.usda.gov/data-products/food-expenditures.aspx.

Critical Thinking

Ying loves to eat hamburgers, fries, and lots of pizza with double amounts of cheese. He rarely eats any vegetables and fruits but, instead, snacks on cookies and ice cream. He insists that he has no problems with his health, is rarely ill, and doesn't see how his diet could cause him any health risks. How would you explain to Ying that, despite his current good health, his diet could predispose him to future health problems?

Table 1-5 Nutrition and Weight Status Objectives from *Healthy People 2030*

Reduce proportion of adults with obesity
Reduce household food insecurity and hunger
Increase fruit, vegetable, and whole grain consumption by people aged 2 years and over
Reduce consumption of saturated fat, sugar, and added sugar by people aged 2 years and over
Increase calcium, potassium, and vitamin D consumption by people aged 2 years and over
Reduce iron deficiency in children aged 1 to 2 years and females aged 12 to 49 years
Increase proportion of students participating in the School Breakfast Program
Increase proportion of worksites that offer employee nutrition programs

Note: Related objectives include those addressing osteoporosis, cancer, diabetes, foodborne illness, heart disease, nutrition during pregnancy, physical activity, and alcohol use.

To review all of the *Healthy People* objectives, visit www.healthypeople.gov.

National Health Objectives

Health promotion and disease prevention have been public health strategies in the U.S. and Canada since the late 1970s. One part of this strategy is *Healthy People*, a report issued by the U.S. Department of Health and Human Services, Public Health Service.[19] This is a national effort to set science-based, 10-year national goals and objectives for improving the health and well-being of all Americans. The overarching goals of *Healthy People* are

- Attain healthy, thriving lives and well-being, free of preventable disease, disability, injury and premature death
- Eliminate health disparities, achieve health equity, and attain health literacy to improve the health and well-being of all
- Create social, physical, and economic environments that promote attaining full potential for health and well-being for all
- Promote healthy development, healthy behaviors, and well-being across all life stages
- Engage leadership, key constituents, and the public across multiple sectors to take action and design policies that improve the health and well-being of all[20]

Many *Healthy People* objectives are related to nutrition. For example, the objectives aim to reduce food insecurity and hunger, reduce intake of sodium, and increase consumption of fruits and vegetables. Table 1-5 lists the nutrition and weight status objectives proposed for *Healthy People 2030*. Learn more at health.gov/healthypeople.

Assessing Nutritional Status

A nutritional assessment can help determine how nutritionally fit you are (Table 1-6). Generally, assessments are performed by a physician, often with the aid of a registered dietitian nutritionist.[5]

Assessments include an analysis of numerous background factors known to affect health. For example, many diseases have a genetic component, so family history plays an important role in determining nutritional and health status. Another background factor is a person's own medical history, especially any health conditions, diseases, or treatments that could hinder the absorption or use of a nutrient.

In addition to background factors, parameters that complete the picture of nutritional status are anthropometric, biochemical, clinical, dietary, and environmental assessments. **Anthropometric assessment** involves measuring various aspects of the body, including height, weight (and weight changes), body circumferences (e.g., waist, hips, arm), and skinfold thickness (an indicator of body fatness and body composition). Anthropometric measurements are easy to obtain and are generally reliable.

Table 1-6 Conducting an Evaluation of Nutritional Health

Factors	Examples
Background	**Medical history** (e.g., current and past diseases and surgeries, body weight history, current medications) **Family medical history**
Nutritional	**Anthropometric assessment** (e.g., height, weight, skinfold thickness, arm muscle circumference, body composition) **Biochemical (laboratory) assessment** (e.g., compounds in blood and urine) **Clinical assessment** (e.g., physical examination of skin, eyes, and tongue; ability to walk) **Dietary assessment** (e.g., usual food intake, food allergies, supplements used) **Environmental assessment** (e.g., education and economic background, marital status, housing condition)

A practical example using the ABCDEs for evaluating nutritional state can be illustrated in a person who chronically abuses alcohol. On evaluation, the physician notes the following:

Anthropometric: Low weight-for-height, recent 10 lb weight loss, muscle wasting in the upper body

Biochemical: Low amounts of the vitamins thiamin and folate in the blood

Clinical: Psychological confusion, skin sores, and uncoordinated movement

Dietary: Consumed mostly alcohol-fortified wine and hamburgers for the last week

Environmental: Currently residing in a homeless shelter, $35.00 in his wallet, unemployed

Assessment: This person needs professional medical attention, including nutrient repletion.

Biochemical assessments include the measurement of the concentrations of nutrients and nutrient by-products in the blood, urine, and feces and of specific blood enzyme activities. For example, the status of the vitamin thiamin is measured, in part, by determining the activity of an enzyme called transketolase used to metabolize glucose (see Part 4). To test for this, cells (e.g., red blood cells) are broken open and thiamin is added to see how it affects the rate of the transketolase enzyme activity.

During a **clinical assessment**, health-care providers search for any physical evidence of diet-related diseases (e.g., high blood pressure, skin conditions). The health-care provider tends to focus the clinical assessment on potential problem areas identified from a dietary assessment. Clinical assessments related to nutritional issues are referred to as **nutrition-focused physical exams**. These head-to-toe examinations of a person's physical appearance and functions search for evidence of nutrient deficiencies and toxicities. **Dietary assessment** examines how often a person eats certain types of foods (called a food frequency); the types of foods eaten over a long period of time, perhaps as far back as childhood (called a food history); and typical intake, such as foods eaten in the last 24 hours or several days (e.g., a 24-hour recall or a 3-day recall). Finally, an **environmental assessment** (based on background data) provides information on the person's education and economic background. This information is important because people who have inadequate education, income, and housing and/or live alone often have a greater risk of poor health. Those with limited education may have a reduced ability to follow instructions given by health-care providers and/or an income that hinders their ability to purchase, store, and prepare nutritious food. Taken together, these 5 parameters form the ABCDEs of nutritional assessment: anthropometric, biochemical, clinical, dietary, and environmental (Fig. 1-7).

Figure 1-7 The ABCDEs of nutritional assessment: anthropometric, biochemical, clinical, dietary, and environmental status.

Photodisc/Getty Images; © Adam Gault/age fotostock; Comstock Images/Jupiterimages; Janis Christie/Getty Images; Ryan McVay/Getty Images RF

Limitations of Nutritional Assessment

Nutritional assessments can be helpful in improving one's health. However, it is important to recognize the limitations of these assessments. First, many signs and symptoms of nutritional deficiencies—diarrhea, skin conditions, and fatigue—are not very specific. They may

Soft drinks account for about 10% of the energy intake of teenagers in North America and, in turn, contribute to generally poor calcium intakes seen in this age group. Consuming insufficient calcium increases their risk of osteoporosis in future years.

Santirat Praeknokkaew/Shutterstock

be caused by poor nutrition or by other factors unrelated to nutrition. Second, it can take a long time for the signs and symptoms of nutritional deficiencies to develop and, because they can be vague, it is often difficult to establish a link between an individual's current diet and his or her nutritional status.

Third, a long time may elapse between the initial development of poor nutritional health and the first clinical evidence of a problem. For instance, a diet high in saturated fat often increases blood cholesterol, but it does not produce any clinical evidence for years. Nonetheless, the cholesterol is building up in blood vessels and may lead to a heart attack. Another example of a serious nutrition-related health condition with signs and symptoms that often don't appear until later in life is low bone density (osteoporosis) resulting from insufficient calcium intake, which may have begun in the teen years. Currently, a great deal of nutrition research is trying to identify better methods for detecting nutrition-related problems early—before they damage the body.

Importance of Being Concerned about Nutritional Status

Regardless of the limitations of nutritional assessment, people who focus on maintaining desirable nutritional health are apt to enjoy a long, vigorous life and are less likely to develop health problems, such as those in Figure 1-8. For example, women who followed a healthy lifestyle experienced an 80% reduction in risk of heart attacks, compared with women without such healthy practices.[21] Here is what these healthy women did:

- Consumed a healthy diet that was varied, rich in fiber, and low in animal fat and *trans* fat and that included some fish
- Avoided becoming overweight
- Regularly drank a small amount of alcohol
- Exercised for at least 30 minutes daily
- Did not smoke

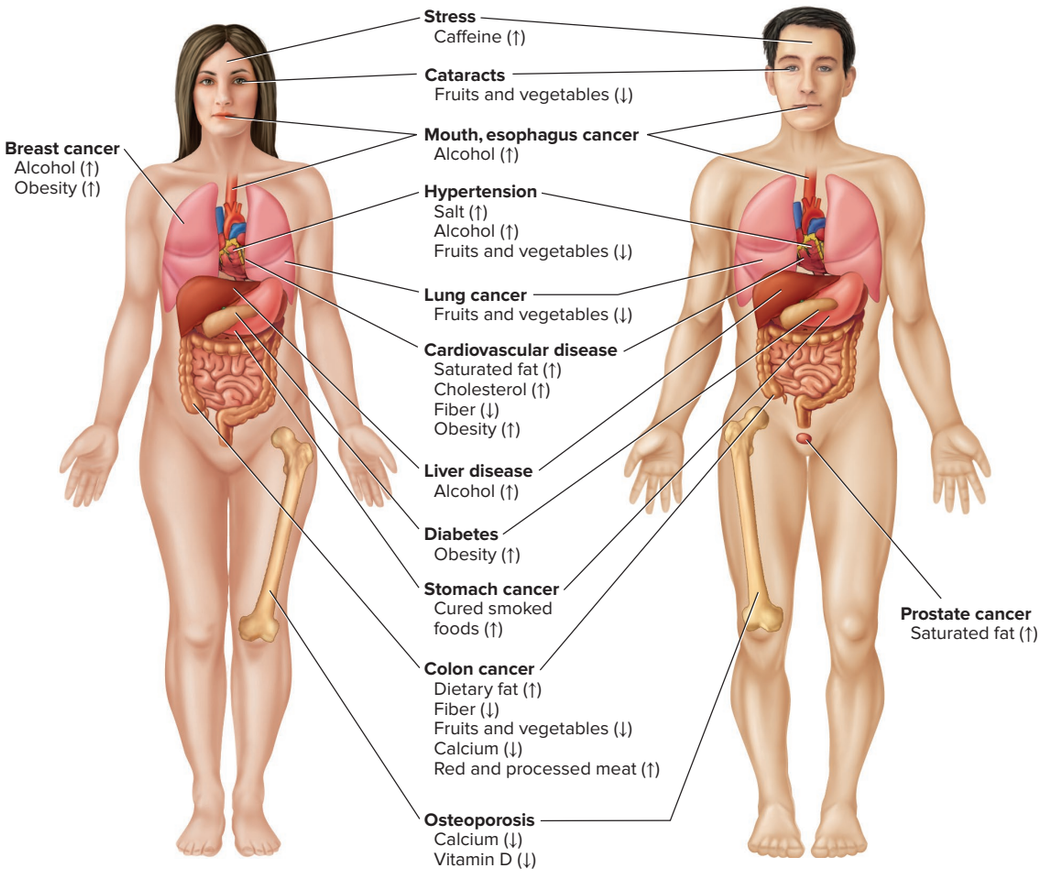


Figure 1-8 Examples of health problems associated with poor dietary habits. An upward arrow (↑) indicates that a high intake and a downward arrow (↓) indicates that a low intake contributes to the health problem. In addition to the habits in the figure, no illicit drug use, adequate sleep (7–8 hours), adequate water intake, regular physical activity, minimal emotional stress, a positive outlook on life, and close friendships provide a more complete approach to good health. Also important is regular consultation with health-care professionals—early diagnosis is especially useful for controlling the damaging effects of many diseases.

CASE STUDY

Lane Oatey / Blue Jean Images/Getty Images

While Allen was driving to campus last week, he heard a radio advertisement for a nutrient supplement containing a plant substance that was discovered recently. It supposedly gives people more energy and helps them cope with the stress of daily life. This advertisement caught Allen's attention because he has been feeling run-down lately. He is taking a full course load and has been working 30 hours a week at a local restaurant. Allen doesn't have a lot of extra money to spare. Still, he likes to try new things, and this recent breakthrough sounded almost too good to be true. After searching for more information on the Internet, he discovered that the recommended dose would cost $60 per month. Because Allen is looking for some help with his low energy level, he decides to order a 30-day supply. Does this extra expense make sense to you?

Getting Nutrition-Related Advice: The Nutrition Care Process

For those who feel they need to improve their diets and health, a safe approach is to consult a physician or registered dietitian (R.D.). A person with the credentials "R.D." after his or her name (or "R.D.N.," registered dietitian nutritionist) has completed a rigorous baccalaureate degree program approved by the Academy of Nutrition and Dietetics, has performed hundreds of hours of supervised professional practice, and has passed a registration examination. Starting in 2024, registered dietitian nutritionists will be required to also have a master's degree. Registered dietitian nutritionists are trained to provide scientifically valid nutrition advice. To find a registered dietitian nutritionist, visit the website of the Academy of Nutrition and Dietetics (www.eatright.org) or Dietitians of Canada (www.dietitians.ca) or call the dietary department of a local hospital.

When you meet with a registered dietitian nutritionist, you should expect that he or she will follow the **Nutrition Care Process**:[22]

- Conduct a nutritional assessment: asks questions about your food and nutrition history and anthropometric, biochemical, clinical, dietary, and environmental assessment data. The registered dietitian nutritionist also may conduct a nutrition-focused physical exam.
- Diagnose nutrition-related problem: uses your nutrition history and assessment data to determine your specific nutrition-related problem
- Create an intervention: formulates a diet plan tailored to your needs, as opposed to simply tearing a form from a tablet that could apply to almost anyone, that addresses the root cause of your nutrition problem with the goal of relieving the signs and symptoms of your diagnosis
- Monitor and evaluate progress: schedules follow-up visits to track your progress, answer questions, help keep you motivated, and perhaps reassess, rediagnose, and modify your intervention. Family members may be involved in the diet plan, when appropriate. The dietitian consults directly with your physician and readily refers you back to your physician for those health problems a nutrition professional is not trained to treat.

Be skeptical of health practitioners who prescribe very large doses of vitamin, mineral, or protein supplements for everyone.

Registered dietitians (also called registered dietitian nutritionists) are a reliable source of nutrition advice.

liquidlibrary/PictureQuest

Knowledge Check

1. What is the difference between a sign and a symptom?
2. How does undernutrition differ from overnutrition?
3. What are the ABCDEs of nutritional assessment?
4. What are 3 limitations of nutritional assessment?
5. What should you expect when you meet with a registered dietitian nutritionist?

Nutrition Care Process Systematic approach used by registered dietitian nutritionists to ensure that patients receive high-quality, individualized nutrition care; process involves nutrition assessment, diagnosis, intervention, monitoring, and evaluation.

CLINICAL PERSPECTIVE

Genetics and Nutrition

Your **genome**, in addition to lifestyle and diet, affects almost every medical condition. During digestion, the nutrients supplied by food are broken down, absorbed into the bloodstream, and transported to cells. There, genetic material, called **deoxyribonucleic acid (DNA)**, inside the nucleus of the cells directs how the body uses the nutrients consumed. As you can see in Figure 1-9, foods and humans contain the same nutrients, but the proportions differ—**genes** in body cells dictate the type and amount of nutrients in food that will be transformed and reassembled into body structures and compounds.

Genes direct the growth, development, and maintenance of cells and, ultimately, of the entire organism. Genes contain the codes that control the expression of individual traits, such as height, eye color, and susceptibility to many diseases. An individual's genetic risk for a given disease is an important factor, although often not the only factor, in determining whether he or she develops that disease.

Each year, new links between specific genes and diseases are reported. It is likely that soon it will be relatively easy to screen a person's DNA for genes that increase the risk of disease. Currently, there are about 1000 tests that can determine whether a person has genetic **mutations** that increase the risk of certain illnesses. For example, a woman can be tested for certain gene mutations that elevate her chances of developing breast cancer.

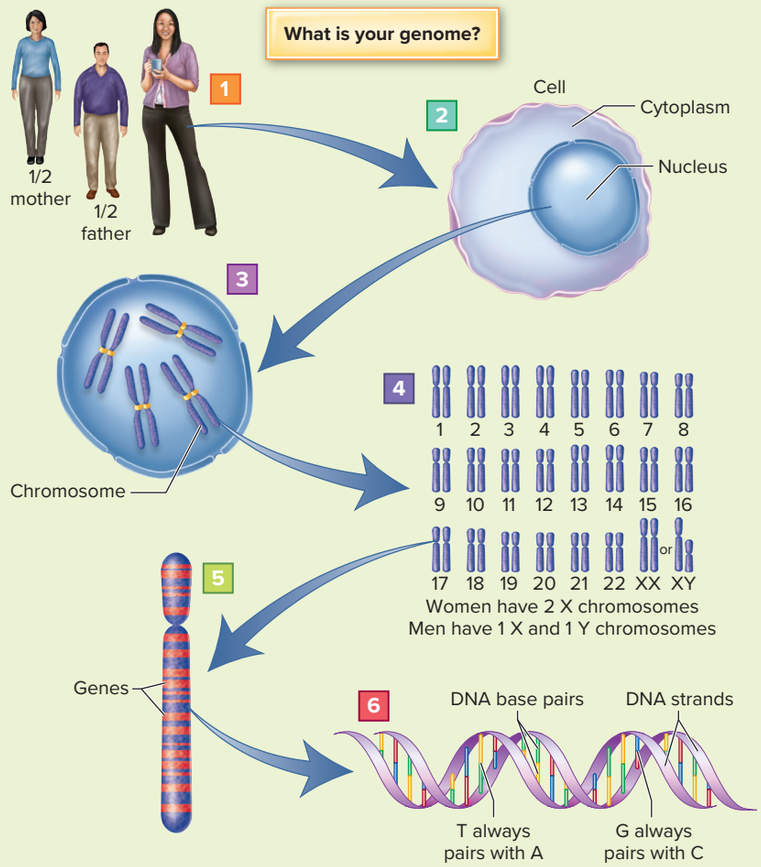
Nutritional Diseases with a Genetic Link

Most chronic nutrition-related diseases (e.g., diabetes, cancer, osteoporosis, cardiovascular disease, hypertension, and obesity) are influenced by interactions among genetic, nutritional, and other lifestyle factors. Studies of families, including those with twins and

deoxyribonucleic acid (DNA) Site of hereditary information in cells. DNA directs the synthesis of cell proteins.

genes Hereditary material on chromosomes that makes up DNA. Genes provide the blueprint for the production of cell proteins.

mutation Change in the chemistry of a gene that is perpetuated in subsequent divisions of the cell in which it occurred; a change in the sequence of the DNA.



1 A genome is an organism's complete set of DNA, including all of its genes. DNA contains all the information needed to build and maintain an organism throughout life. DNA is passed down from parents. The human genome has more than 3 billion DNA base pairs.

2 Humans have billions of cells. We have a copy of our entire genome in every cell that has a nucleus. In humans, all cells, except red blood cells, contain a nucleus. The nucleus is a cell's "command center"—it controls cell growth and reproduction.

3 Chromosomes are structures within the nucleus that contain hundreds to thousands of genes. Humans have a total of about 20,000 to 25,000 genes.

4 Each parent provides 23 chromosomes, which pair up in their offspring.

5 Each chromosome has genes that consist of DNA, which provides the code, or "recipe," for making proteins.

6 Each DNA molecule is a long double helix—it looks like a spiral staircase with millions of steps. The two long strands are made of phosphate and sugar (deoxyribose) molecules. The strands are connected by pairs of molecules called base pairs. All base pairs are made of a combination of base molecules: adenine (A) and thymine (T) or guanine (G) and cytosine (C).

byr9559x_ch01_002-039.indd 22 10/02/21 1:01 AM

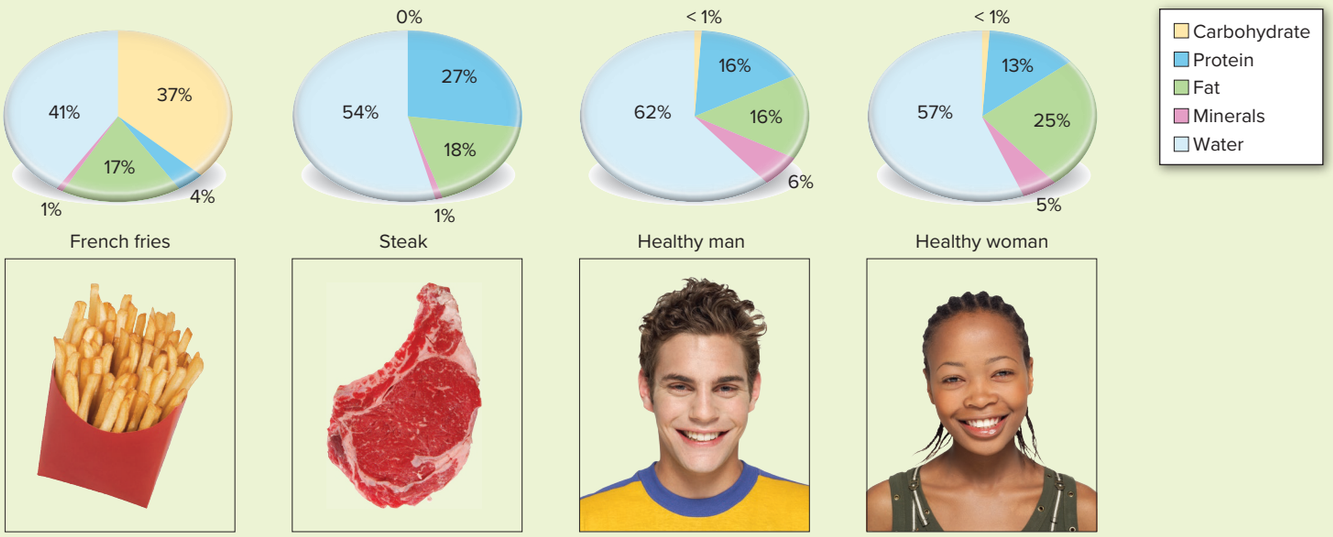
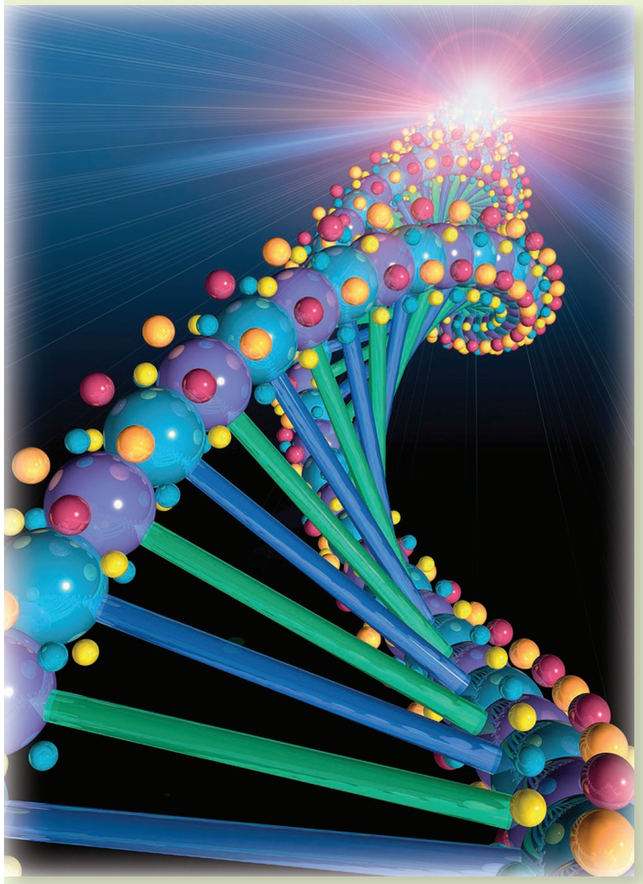


Figure 1-9 Proportions of nutrients in the human body, compared with those in typical foods—animal or vegetable. Note that the amount of vitamins found in the body is extremely small and, so, is not shown.

Comstock Images/Jupiterimages; ©FoodCollection/StockFood; MSPhotographic/Shutterstock; Stockbyte/Getty Images; Stockbyte/Getty Images



Genes are present on DNA—a double helix. The cell nucleus contains most of the DNA in the body.

©Brand X Pictures/age fotostock RF

adoptees, provide strong support for the effect of genetics in these disorders. In fact, family history is considered one of the most important risk factors in the development of many nutrition-related diseases.[23,24]

For example, both of the common types of diabetes, certain cancers (e.g., colon, prostate, and breast cancer), and osteoporosis have genetic links. In addition, about 1 in every 500 people in North America has a defective gene that greatly delays cholesterol removal from the bloodstream—this defective gene increases the risk of cardiovascular disease. Another example is hypertension (high blood pressure). Numerous North Americans are very sensitive to salt intake. When these individuals consume too much salt, their blood pressure climbs above the desirable range. The fact that more of these people with sensitivity are Black suggests that at least some cases of hypertension have a genetic component. Obesity also has genetic links. A variety of genes (likely 1000 or more) are involved in the regulation of body weight.

Although some individuals may be genetically predisposed to chronic disease, whether they actually develop the disease depends on lifestyle choices and environmental factors that influence the disease. It's important to realize that

Epigenetics is the study of how environmental factors affect the way genetic potential is expressed.

predisposition to chronic disease is not the same type of genetic characteristic as being born with blue eyes or larger ears. With chronic disease, heredity is not necessarily destiny—individuals can exert some control over the expression of their genetic potential. For instance, those with a predisposition to premature heart disease can take steps to delay its onset by eating a nutritious diet, getting regular exercise, keeping weight under control, and getting medical treatment to lower blood cholesterol levels and control blood pressure. Likewise, those who did not inherit the potential for heart disease put themselves at risk of this disease by gaining excess body fat, smoking, abusing alcohol, and not getting medical treatment to keep blood cholesterol, blood pressure, and type 2 diabetes under control.

Your Genetic Profile

By recognizing your potential for developing a particular disease, you can avoid behaviors that contribute to it. For example, women with a family history of breast cancer should avoid gaining excess body fat, minimize alcohol

byr9559x_ch01_002-039.indd 23 10/02/21 1:01 AM

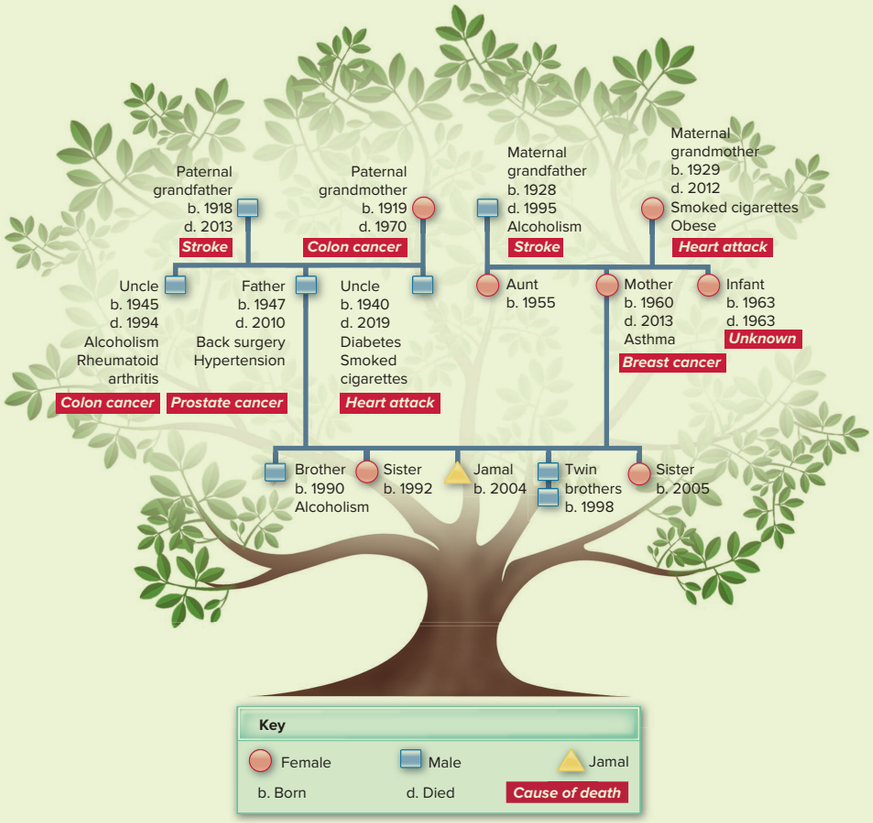


Figure 1-10 Example of a family tree for Jamal. If a person is deceased, the cause of death is shown. In addition to causes of death, medical conditions family members experienced are noted.

use, and get mammograms regularly. In general, the more relatives with a genetically transmitted disease and the more closely they are related to you, the greater your risk. One way to assess your risk is to create a family tree of illnesses and deaths (a genogram) by compiling a few key facts on your primary biological relatives: siblings, parents, aunts, uncles, and grandparents (Fig. 1-10).

High-risk conditions include having more than 1 first-degree relative (i.e., biological parents, siblings, and offspring) with a specific disease, especially if the disease occurred before age 50 to 60 years.[24] In the family in Figure 1-10, prostate cancer killed Jamal's father. Knowing this, his physician likely would recommend that he be tested for prostate cancer more frequently or starting at an earlier age than men without a family history of the disease. Because Jamal's mother died of breast cancer, his sisters' doctor may recommend they consider having their 1st regular mammograms at a younger age than typical, as well as adopting other preventive practices. Heart attack and stroke also are common in the family, so all the children should adopt a lifestyle that minimizes the risk of developing these conditions, such as moderating their intake of animal fat and sodium. Colon cancer is evident in the family, which makes it important for them to have careful screening throughout life.

virus One of the smallest known types of infectious agents, many of which cause disease in humans. They do not metabolize, grow, or move by themselves. They reproduce by the aid of a living cellular host. A virus is essentially a piece of genetic material surrounded by a coat of protein.

Gene Therapy

Scientists are developing therapies to correct DNA that causes some genetic disorders. Currently, gene therapy research focuses on diseases that have no other cures. Gene therapy may involve replacing a mutated gene with a healthy copy of the gene, inactivating a mutated gene that does not function normally, or introducing a new gene to help the body fight disease. When replacing a mutated gene, scientists typically isolate normal DNA, package it into a molecular delivery vehicle (usually a disabled **virus**), and inject it into the cells affected by the disease—such as liver cells. Inside the cell, the normal genetic material begins functioning and restores the cells to normal.

Hundreds of research studies are under way and success with gene therapy is growing, yet many obstacles remain to be overcome before gene therapy can become a safe, effective treatment. Government regulatory agencies in the U.S. (especially the National Institutes of Health and Food and Drug Administration) and Europe are actively overseeing human gene therapy research. Approved gene therapies are increasing; for instance, several are available for certain blood diseases and cancers. This ongoing research could lead to gene-based treatments for other types of cancer, heart disease, cystic fibrosis, and other diseases.

byr9559x_ch01_002-039.indd 24 10/02/21 1:01 AM

These websites can help you gather more information about genetic conditions and testing.

www.geneticalliance.org
www.kumc.edu/gec/support
www.genome.gov
ghr.nlm.nih.gov/primer/therapy/genetherapy
www.dnalc.org
www.ncgr.org

Critical Thinking

At family gatherings, Wesley notices that his parents, uncles, aunts, and older siblings tend to be overweight. His father has had a heart attack, as has his aunt. Two of his uncles died before the age of 60 from diabetes. His grandfather died of prostate cancer. Wesley wonders if he is destined to have obesity and develop heart disease, cancer, or diabetes. What advice would you give Wesley?

Genetic Testing

Genetic tests analyze a person's genes to determine the likelihood of developing certain diseases. These tests are especially valuable for families afflicted by certain illnesses. In addition, they can help people who are healthy now predict the illnesses they will probably develop. Advance knowledge that a disease is likely to develop may provide opportunities to replace genes that encourage diseases, such as cancer and Alzheimer disease, with those that do not. Advance knowledge also could help couples wanting to have children make more informed choices (e.g., consider alternatives, such as adoption) and help health-care providers develop health and nutrition care plans that delay the onset of the disease. Additionally, this knowledge could help health-care providers diagnose diseases earlier and more accurately and prescribe individualized medical and nutrition therapies, instead of giving the same treatment to all patients with the same disease. It is likely that many medications may be more appropriate in people with certain genetic traits.

Some experts recommend that anyone considering genetic testing first have a genetic counselor analyze his or her family history, evaluate the risk of developing or passing along an inherited disease, and help determine whether testing is worth the time and effort. If you want to know if you are at risk of a specific genetic disease, it is a good idea to ask your physician about the possibility and likely usefulness of testing you. Some consumers opt to purchase at-home genetic test kits directly without involving a doctor or an insurance company. Typically, the test kit is mailed to the consumer, who collects the DNA sample (often by swabbing inside the cheek) and returns it to the lab. Results are provided by mail, fax, phone consultation, or web posting.

Genetic testing can help consumers take a more proactive role in protecting their health. However, given the limit on resources allocated to medical care in North America, it is not possible to identify all the people at genetic risk of the major chronic diseases and other health problems. In addition, in many cases, genetic susceptibility does not guarantee development of the disease. And, in almost all cases, there is no way to cure a specific gene alteration—only the resulting health problems can be treated. Researchers also are concerned that people who are found to have genetic alterations that increase disease risk may face job and medical insurance discrimination. Testing positive also could lead to unnecessary treatment. As well, a seemingly hopeless diagnosis could result in depression when a cure is out of reach.[25] Users of at-home genetic tests may face additional risks, such as receiving misleading results if unproven or invalid tests are used, making unsafe health decisions if they do not receive guidance from a health-care professional, or finding that the testing company has not kept their genetic information confidential.

Genetic analysis for disease susceptibility is becoming more common as the genes that increase the risk of developing various diseases are isolated and decoded.

Rob Melnychuk/Getty Images

The wisdom of genetic testing is an open question. Perhaps preventive measures and careful scrutiny of the specific genetically linked diseases using one's family tree would suffice. Be aware that, throughout this book, discussions will point out how to avoid "controllable" risk factors that contribute to the development of genetically linked nutrition-related diseases present in your family tree.

Knowledge Check

1. What is the role of genes?
2. What are 3 chronic nutrition-related diseases with a genetic link?
3. What is a genogram?

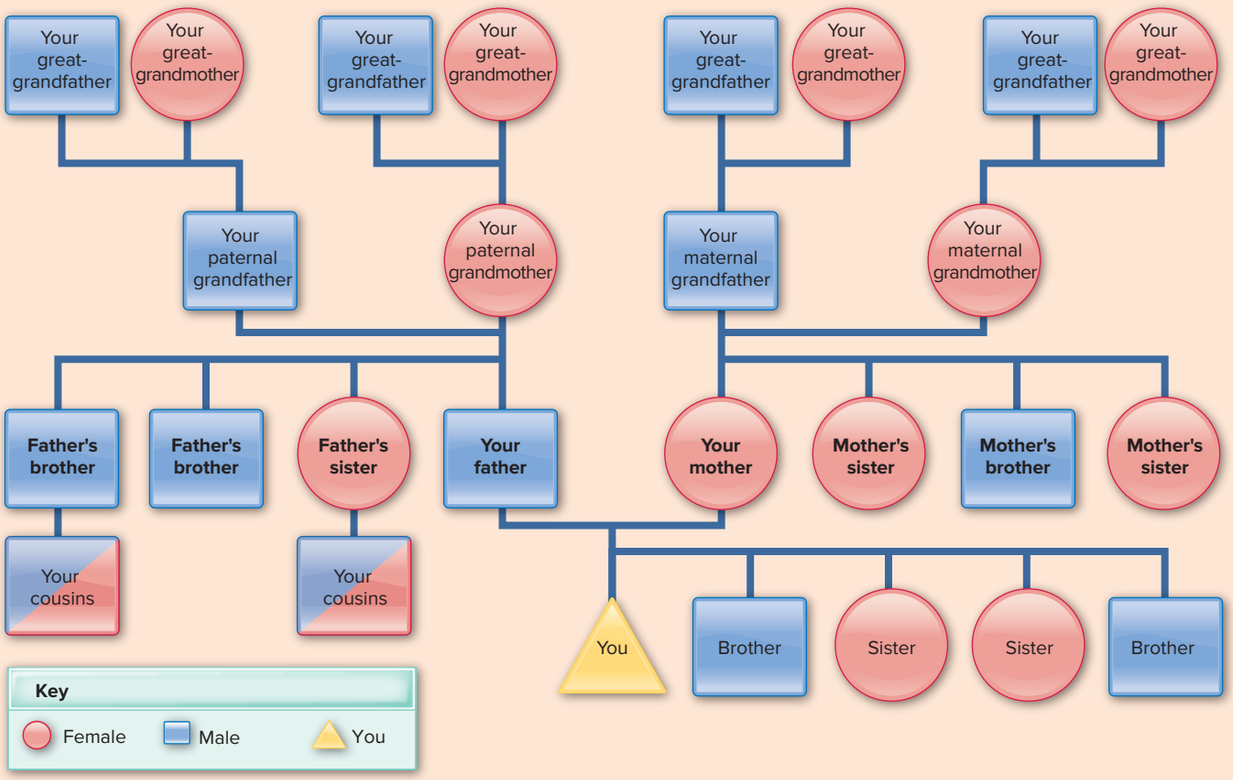
byr9559x_ch01_002-039.indd 25 10/02/21 1:02 AM

Take Action

Create Your Family Tree for Health-Related Concerns

Adapt this diagram to your own family tree. Under each heading, list year born, year died (if applicable), major diseases that developed during the person's lifetime, and cause of death (if applicable). Figure 1-10 provides an example.

Note that you are likely to be at risk of developing any diseases listed. Creating a plan for preventing such diseases when possible, especially those that developed in your family members before age 50 to 60 years, is advised. An online version of the family tree is available at www.hhs.gov/familyhistory. Speak with your health-care provider about any concerns arising from this activity.



Perspective on the Future

Nutritional genomics (nutrigenomics) examines how the foods you eat affect your genes and how your unique genetic profile affects the way your body uses nutrients, phytochemicals, and zoochemicals. In the future, nutrigenetic testing may help you get the most out of your diet and prevent chronic diet-related diseases.

1.5 Using Scientific Research to Determine Nutrient Needs

How do we know what we know about nutrition? How has this knowledge been gained? In a word, research. Like other sciences, the research that sets the foundation for nutrition has developed through the use of the scientific method—a testing procedure designed to uncover facts and detect and eliminate error. The first step is the observation of a natural phenomenon. Scientists then suggest possible explanations, called hypotheses, about the causes of the phenomenon. Distinguishing a true cause-and-effect relationship from mere coincidence

can be difficult. For instance, early in the 20th century, many people who suffered from the disease pellagra lived in orphanages, prisons, and mental hospitals, which suggested this disease was caused by germs that spread among people living close together. In time, however, it became clear that this connection was simply coincidental—the real cause of pellagra is a poor diet that contains too little of the B-vitamin niacin.

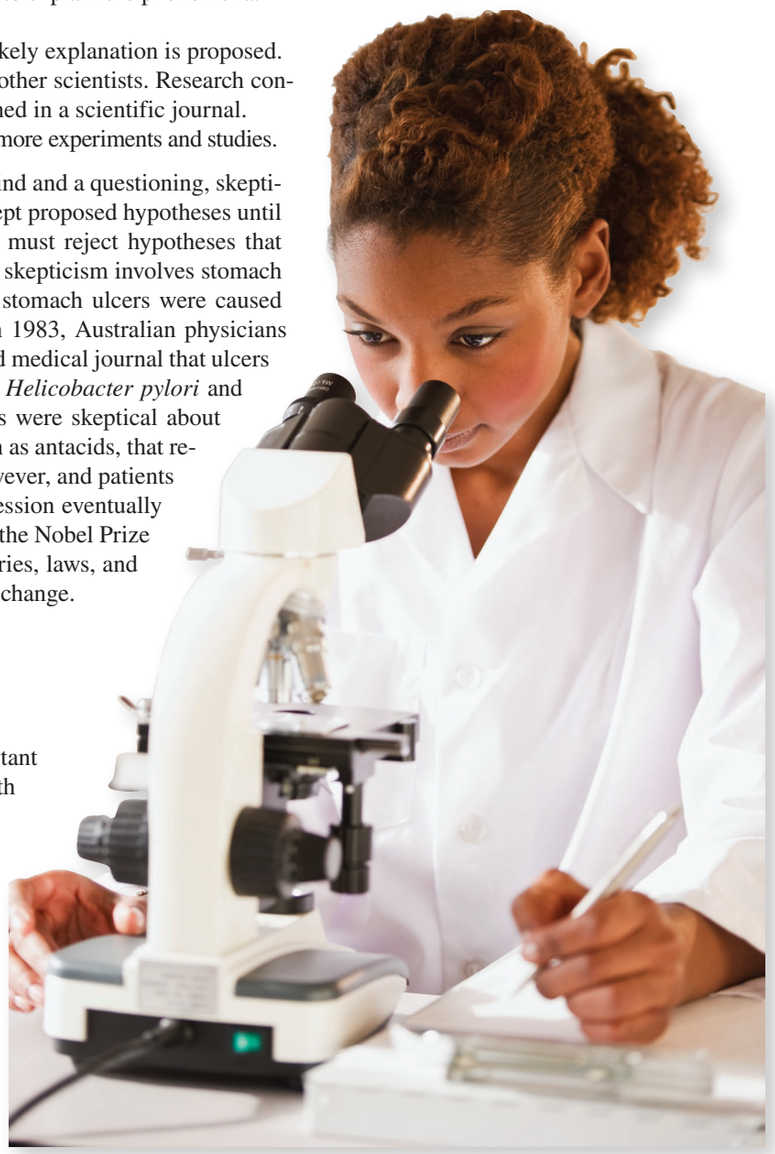
To test hypotheses and eliminate coincidental or erroneous explanations, scientists perform controlled experiments to gather data that either support or refute a hypothesis (Fig. 1-11). Very often, the results of an experiment lead to a new set of questions to be answered. If the results of many well-designed experiments provide valid evidence that supports a hypothesis, the hypothesis becomes generally accepted by scientists as a well-documented explanation for the phenomenon. As valid, extensive evidence about a related set of phenomena accumulates, a scientific theory or scientific law may be proposed. A scientific theory or law is a scientifically acceptable explanation of phenomena and how the phenomena are related to each other.

Sound scientific research requires the following:

1. Phenomena are observed.
2. Questions are asked and hypotheses are generated to explain the phenomena.
3. Research is conducted with **scientific integrity**.
4. Incorrect explanations are rejected and the most likely explanation is proposed.
5. Research results are scrutinized and evaluated by other scientists. Research conducted in an unbiased, scientific manner is published in a scientific journal.
6. The results are confirmed by other scientists and by more experiments and studies.

The scientific method requires an open, curious mind and a questioning, skeptical attitude. Scientists (as well as students) must not accept proposed hypotheses until they are supported by considerable evidence, and they must reject hypotheses that fail to pass critical analysis. An example of this need for skepticism involves stomach ulcers. For many years, it was generally accepted that stomach ulcers were caused mostly by a stressful lifestyle and a poor diet. Then, in 1983, Australian physicians Barry Marshall and Robin Warren reported in a respected medical journal that ulcers usually are caused by a common microorganism called *Helicobacter pylori* and can be cured with antibiotics. Initially, other physicians were skeptical about this finding and continued to prescribe medications, such as antacids, that reduce stomach acid. As more studies were published, however, and patients were cured of ulcers using antibiotics, the medical profession eventually accepted the findings. (Marshall and Warren were given the Nobel Prize for Medicine in 2005 for this discovery.) Scientific theories, laws, and discoveries always should be subjected to challenge and change.

scientific integrity Integrity demonstrated by adhering to professional values and practices when conducting, interpreting, reporting, and using scientific research. These values and practices help ensure that research activities are objective, clear, reproducible, and useful. These values and practices also help prevent bias, fabrication or falsification of data, plagiarism, inappropriate interference by others who might want to influence the way the research is conducted or reported, censorship of scientific findings, and inadequate research activity security.



Careful research contributes to scientifically valid nutrition knowledge.

JGI/Daniel Grill/Blend Images/Getty Images

Making Observations and Generating Hypotheses

Historical observations have provided clues to important relationships in nutrition science. In the 15th and 16th centuries, for example, many European sailors on long voyages developed the often fatal disease scurvy. A British naval surgeon, James Lind, observed that the diet eaten while at sea differed from usual diets. Specifically, few fruits and vegetables were available onboard ships. He hypothesized that a missing dietary component caused scurvy. He set up an experiment in which he supplied sailors with a ration of salt water, vinegar, cider, citrus juice, or other liquid. The results of this experiment indicated that citrus (lemons, limes) prevents and cures scurvy. After this, British sailors were given a ration of lime juice, earning them