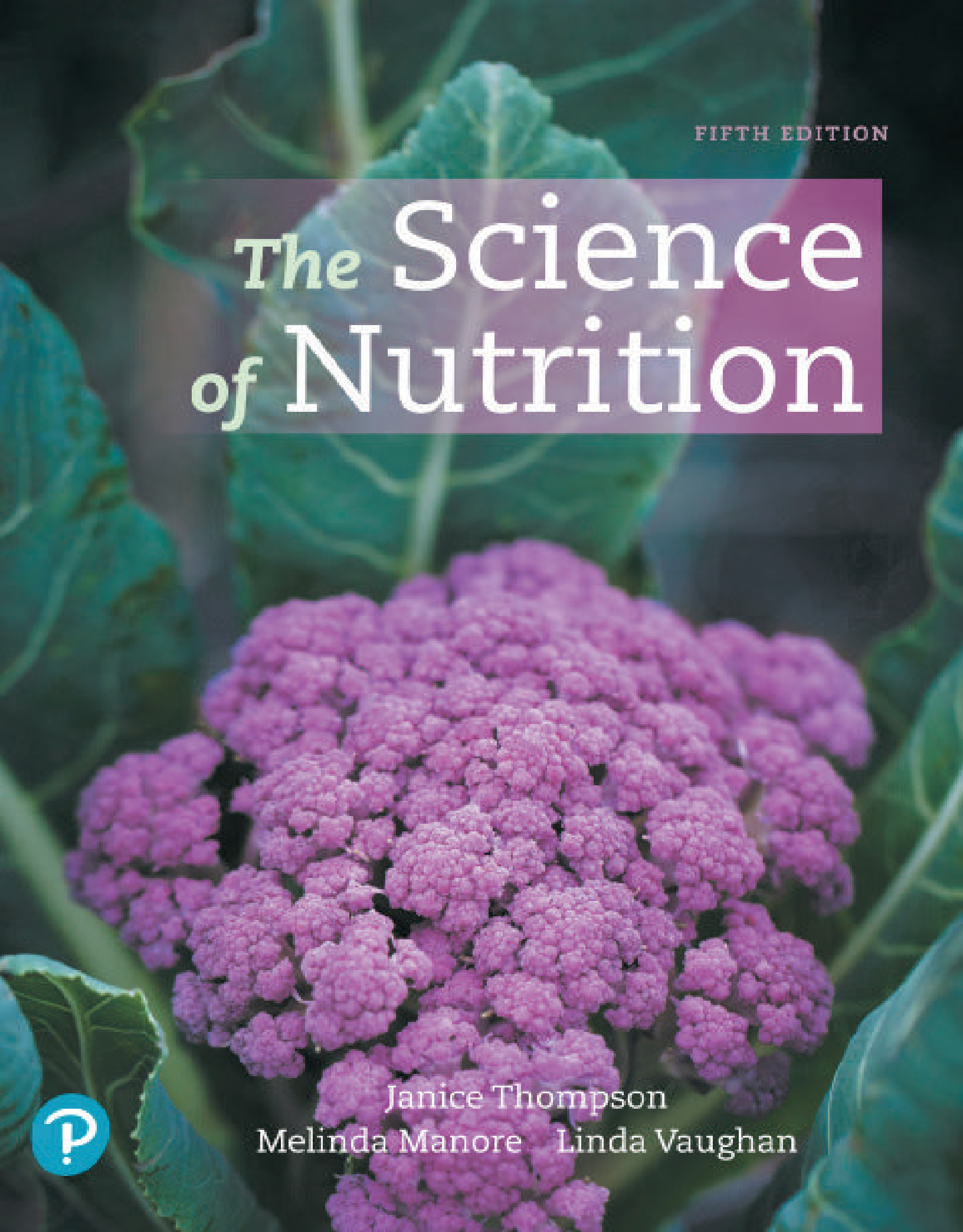
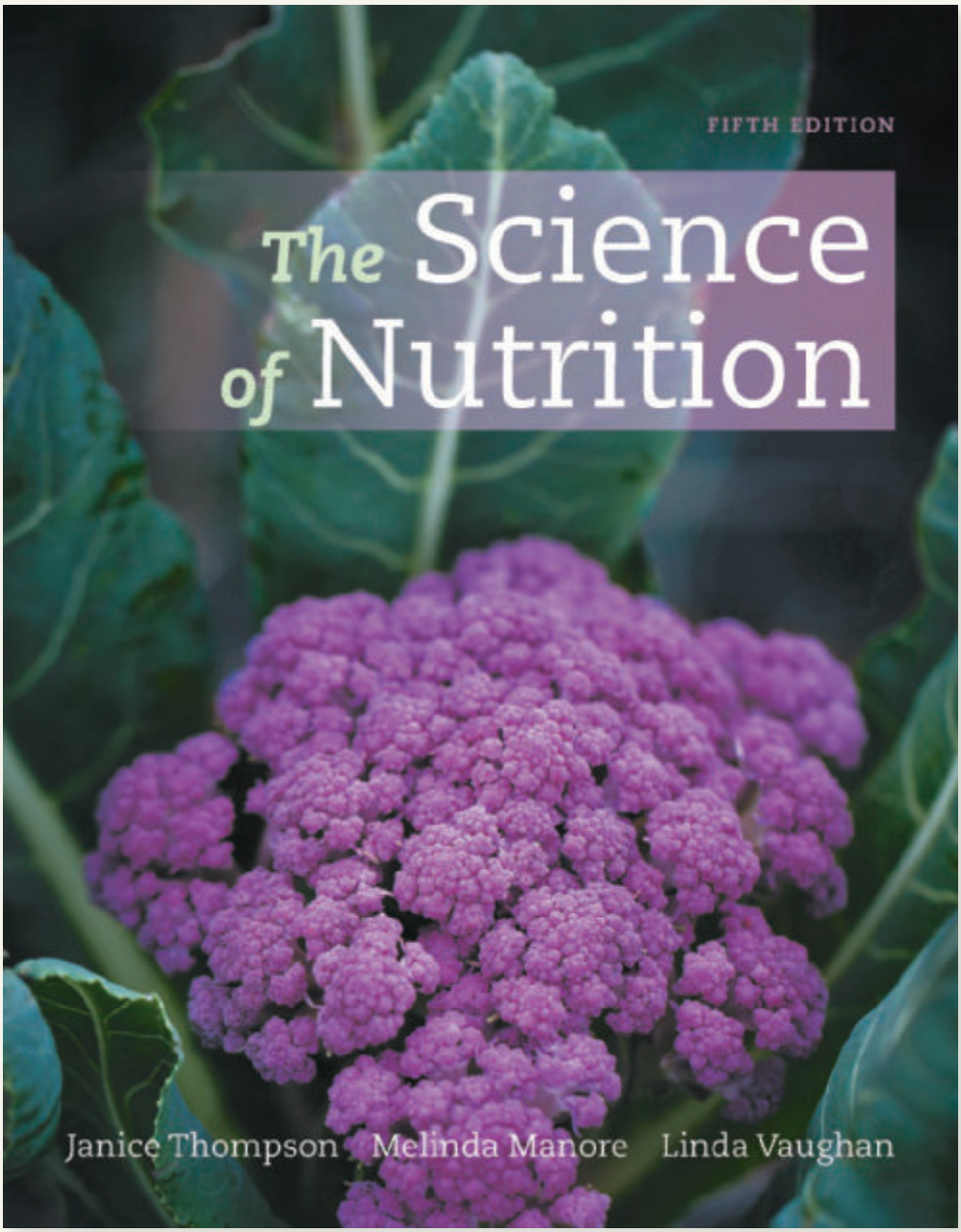

FIFTH EDITION
The Science of Nutrition
Janice Thompson
Melinda Manore
Linda Vaughan

Move students beyond memorization with a functional approach to nutrition

Organized around the functional approach, ***The Science of Nutrition*** helps students master tough nutrition concepts while providing rich support to save instructors time. The **5th Edition** includes the most up-to-date scientific research, an increased emphasis on nutrition and disease content, and new pedagogical features to help direct student learning. **Mastering™ Nutrition** includes access to numerous resources, including the mobile-friendly Pearson eText, author-narrated videos, coaching activities that guide students through key nutrition concepts and calculations, autogradable MyDietAnalysis activities, and more!

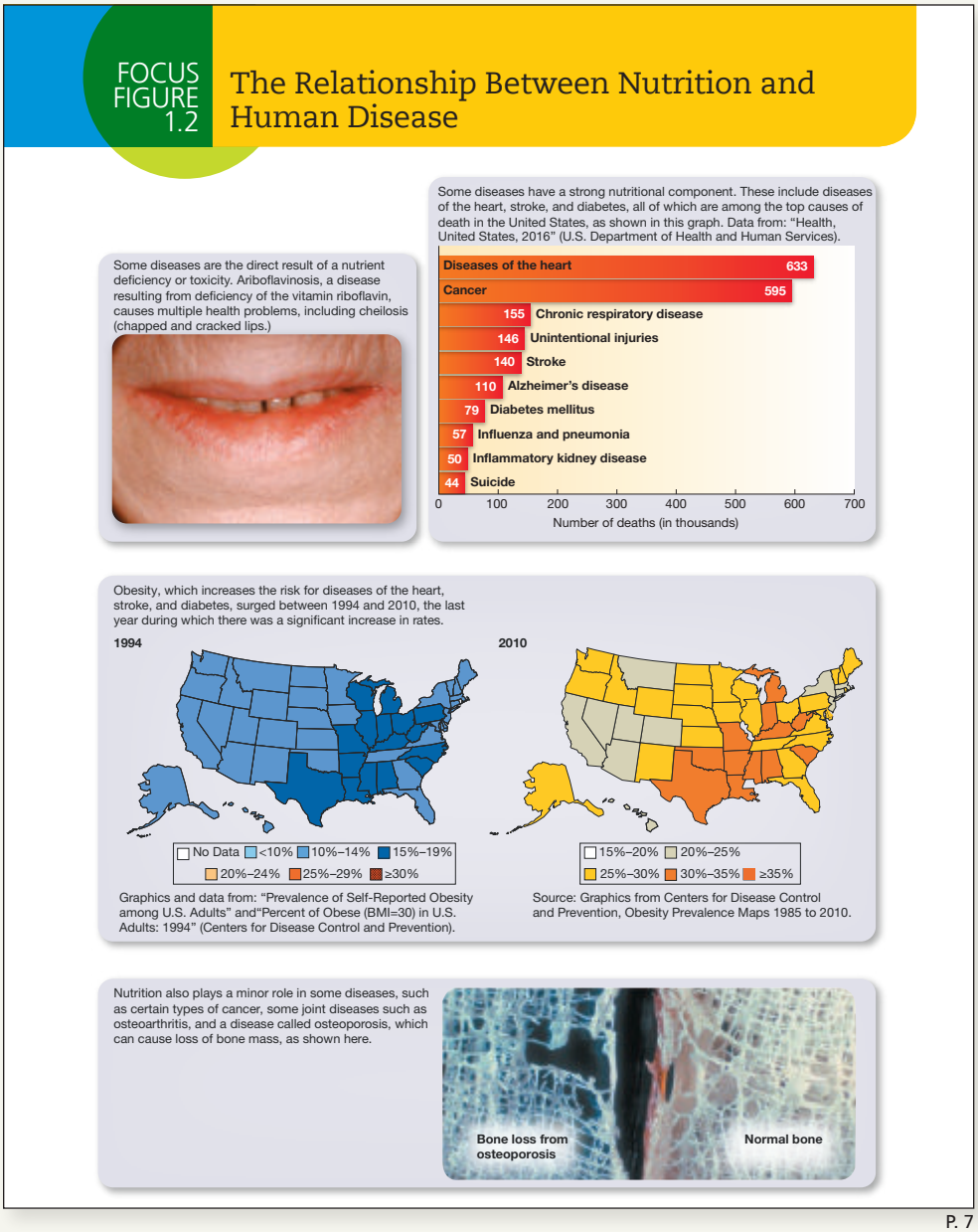


Pearson

Help students master difficult nutrition concepts . . .

UPDATED! Focus Figures
in each chapter are in-depth figures designed to teach key concepts in nutrition through bold, clear, and detailed visual presentations. **New Focus Figures for the 5th Edition** include The Relationship Between Nutrition and Human Disease (pg7) and The Six Groups of Nutrients Found in Foods (pg10). Each Focus Figure is accompanied by an assignable coaching activity in Mastering Nutrition, which guides students through the key nutrition concepts in the figure.

The text also includes **Meal Focus Figures**, which graphically depict the differences in sets of meals, such as a comparison of nutrient density or a comparison of two high-carbohydrate meals, to engage students with useful information.



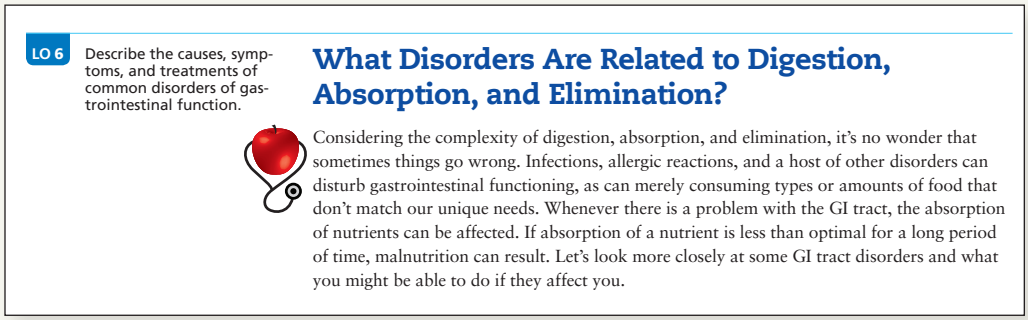
P. 7

and connect the science of nutrition to their health

P. 100

NEW! Icons in the margin direct students to Oregon State University's FoodHero.org, a site for healthy and fast recipes vetted by the Family and Community Health Department at the Ohio State University.

NEW! Disease Connection icons throughout the text signal where nutrition and disease is discussed, helping students put diseases in context.



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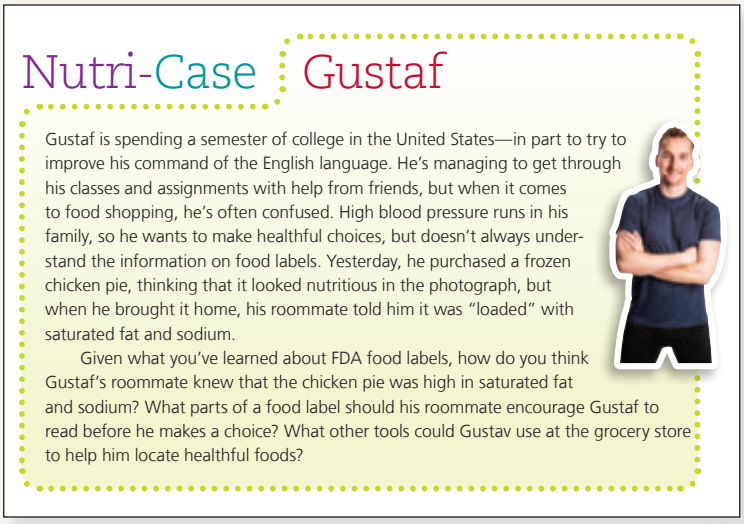
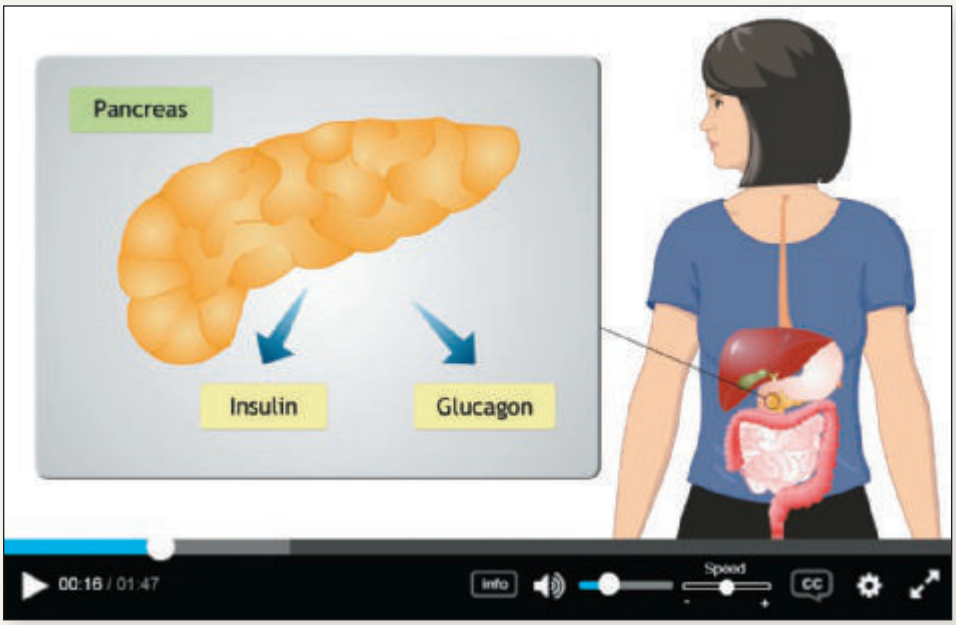


P. 51

UPDATED! Nutri-Cases are case studies that help students apply the information covered in class and prompt students to think about solutions to these issues in a real-world context to their own lives. The Nutri-Case profiles have been revised to feature more characters with various backgrounds and nutritional needs, focus on topics drawn from each chapter's content, and prompt students to think about these issues in a real-world context.

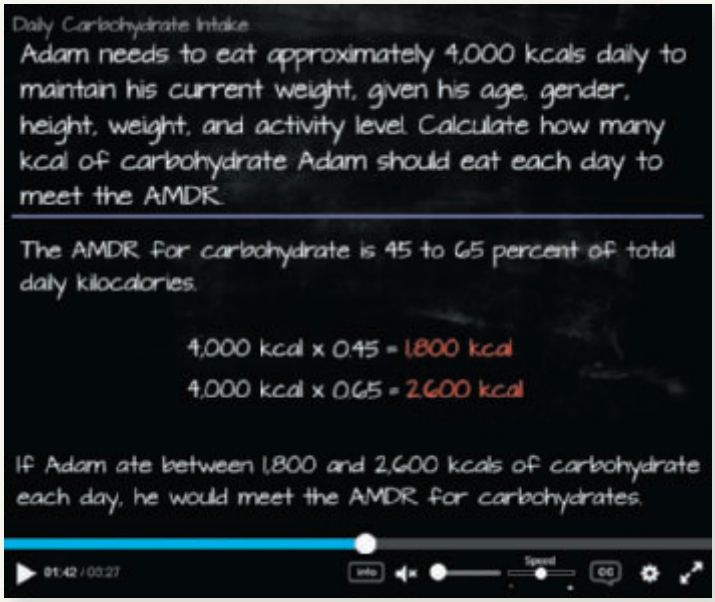
Engage students with dynamic content . . .



Nutrition Animation Activities
explain big picture concepts that help students learn the hardest topics in nutrition. These animations include questions with wrong-answer feedback that address students' common misconceptions and have been refreshed and made compatible for Mastering and mobile devices.

Current *ABC News* videos
cover up-to-date hot topics in the nutrition field, bringing nutrition to life and sparking discussion. These are accompanied by multiple-choice questions with wrong-answer feedback.

in Mastering™ Nutrition

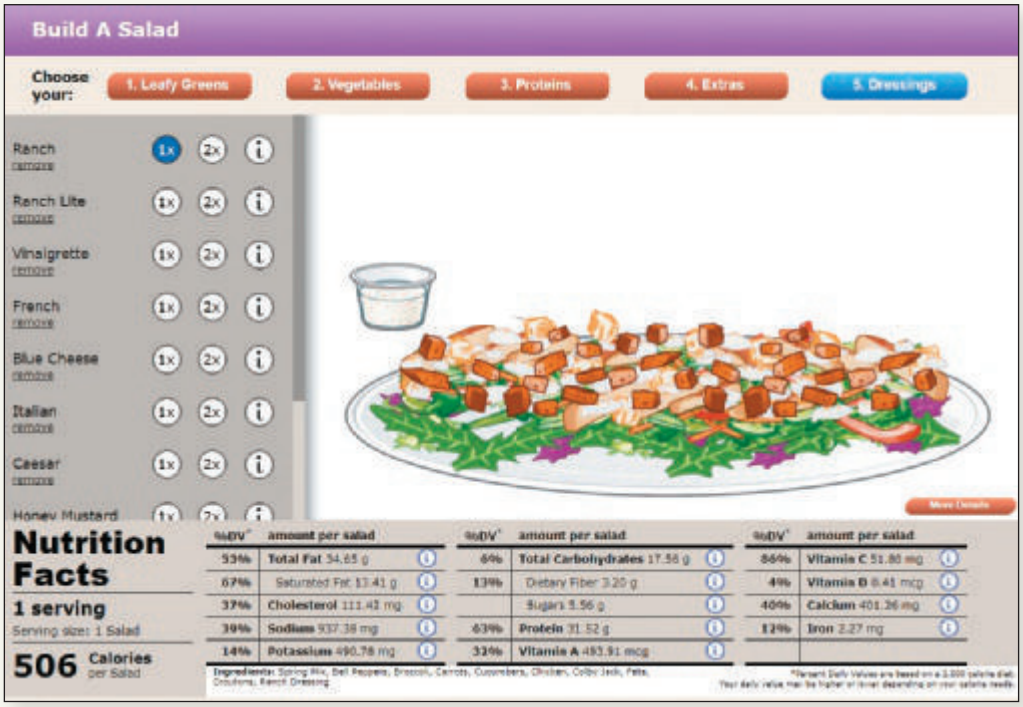


Math Video Activities

provide hands-on practice of important nutrition-related calculations to help students understand and apply the material. Students watch a video showing the calculation and then are asked questions to check for understanding. Questions include wrong-answer feedback.

UPDATED! NutriTool Activities

are dynamic coaching activities that allow students to apply nutrition concepts to improve their health. Activities, such as Carbohydrates on a Food Label and FDA Packaging Requirements, have been updated and/or created to reflect recently-updated nutrition standards.



Help students make healthy eating choices

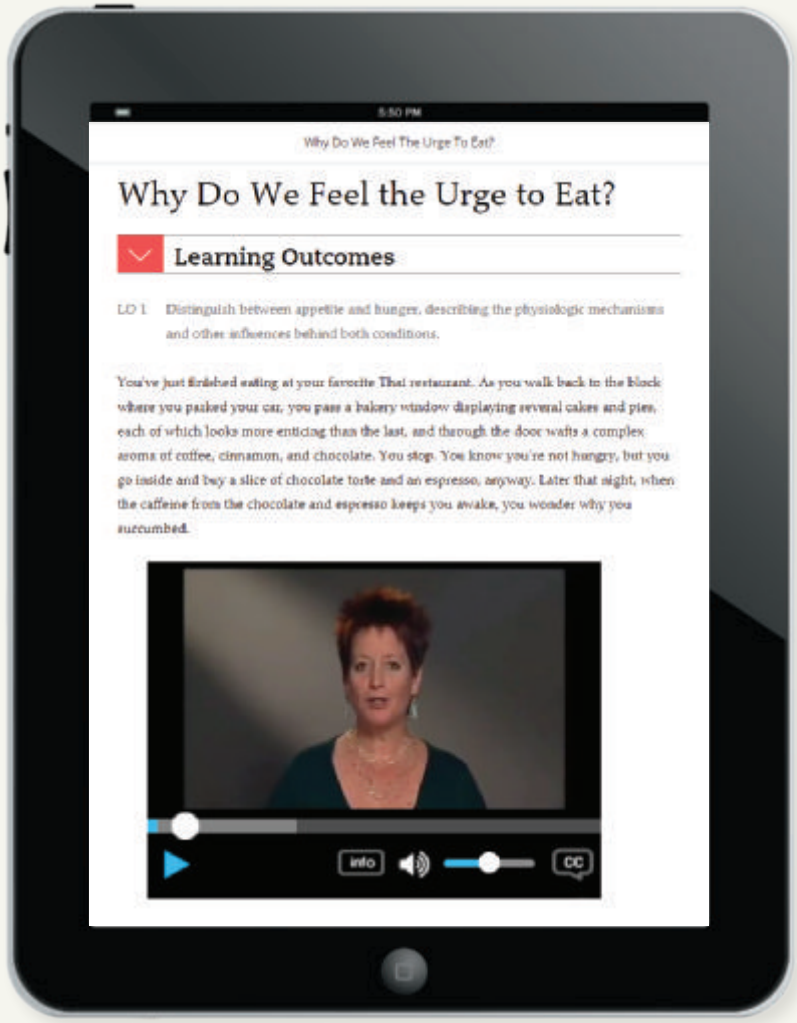
MyDietAnalysis is included with Mastering Nutrition at no additional charge, and offers an up-to-date, accurate, reliable, and easy-to-use program for your students' diet analysis needs. Featured is a database of nearly 50,000 foods and multiple reports. Students can track their diet and activity intake accurately—anytime and anywhere—from any device!

MyDietAnalysis Personalized Dietary Analysis Activities are autogradable activities that guide students in a thorough investigation of their dietary intake and are focused on the most commonly assigned topics in diet analysis projects.

Give students anytime, anywhere access with Pearson eText

Pearson eText is a simple-to-use, mobile-optimized, personalized reading experience available within Mastering. It allows students to easily highlight, take notes, and review key vocabulary all in one place—even when offline. Seamlessly integrated videos and other rich media engage students and give them access to the help they need, when they need it. Pearson eText is available within Mastering when packaged with a new book; students can also purchase Mastering with Pearson eText online.

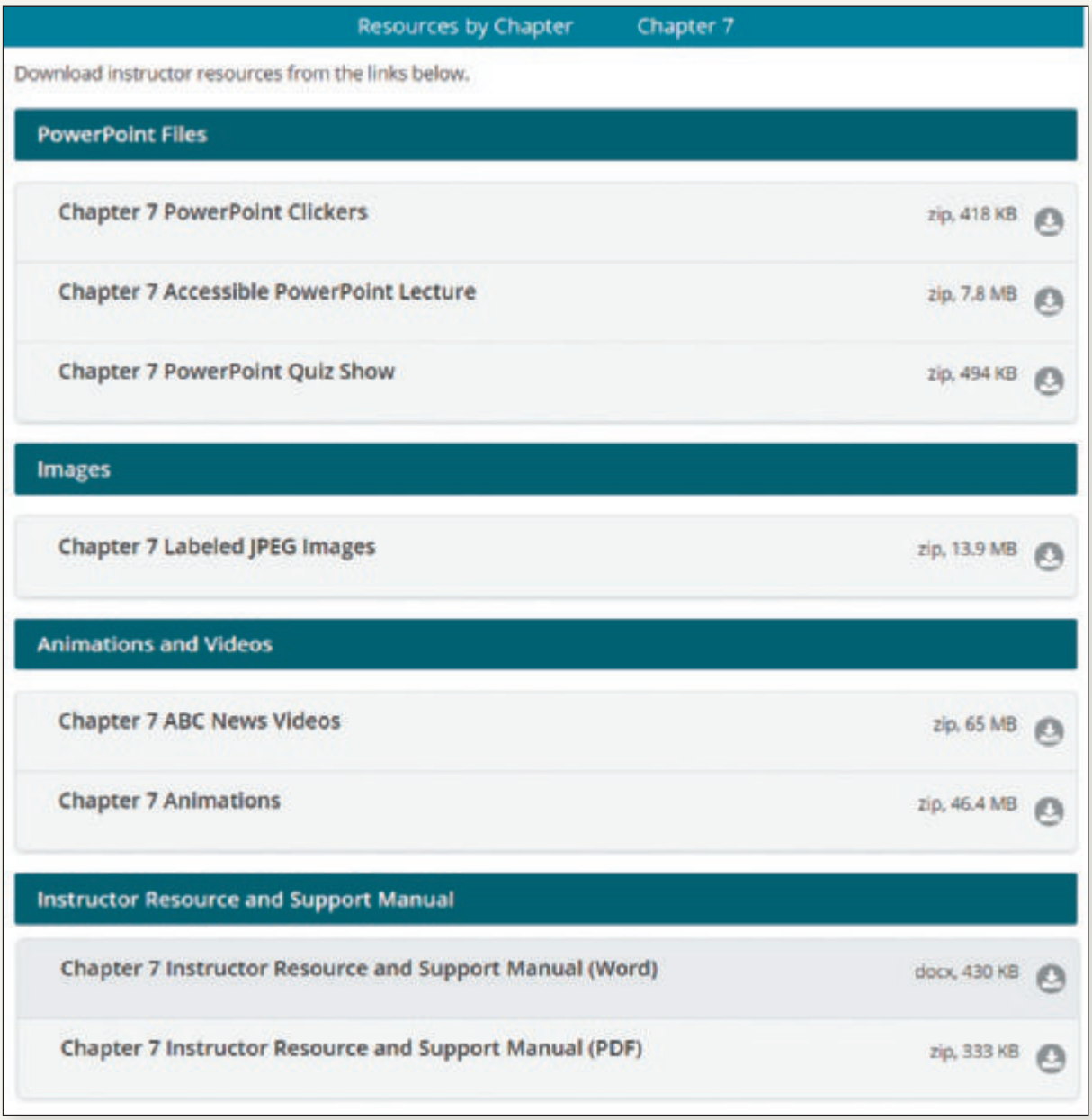
For instructors not using Mastering, Pearson eText can also be adopted on its own as the main course material.



NEW! Nutrition Concept Videos, featuring author Janice Thompson explaining difficult concepts, are now embedded in the eText, giving students access to reliable, engaging content right when they need it.

Instructor support you can rely on

The Science of Nutrition includes a full suite of instructor support materials in the Instructor Resources area in Mastering Nutrition. Resources include PowerPoint lecture outlines; animations, videos, and images to show in class; a test bank; and an instructor manual with in-class activities, diet analysis activities, web resources, and more.



THE SCIENCE OF NUTRITION

FIFTH EDITION

Janice L. Thompson, PhD, FACSM
UNIVERSITY OF BIRMINGHAM

Melinda M. Manore, PhD, RD, CSSD, FACSM
OREGON STATE UNIVERSITY

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Dedication

This book is dedicated to my amazing family, friends, and colleagues—you provide constant support, encouragement, and unconditional love. It is also dedicated to my students and the communities with which I work—you continue to inspire me, challenge me, and teach me. —**JLT**

This book is dedicated to my wonderful colleagues, friends, and family—your guidance, support, and understanding have allowed this book to happen. —**MMM**

This book is dedicated to my strong circle of family, friends, and colleagues. Year after year, your support and encouragement sustain me. —**LAV**

About the Authors

Janice L. Thompson, PhD, FACSM University of Birmingham • United Kingdom

Janice Thompson earned a doctorate in exercise physiology and nutrition at Arizona State University. She is currently Professor of Public Health Nutrition and Exercise at the University of Birmingham in the School of Sport and Exercise Sciences. Her research focuses on designing and assessing the impact of nutrition and physical activity interventions to reduce the risks for obesity, cardiovascular disease, and type 2 diabetes in high-risk populations. She also teaches nutrition and research methods courses and mentors graduate research students.

Janice is a Fellow of the American College of Sports Medicine (ACSM), a Fellow of the European College of Sports Science, and a member of the American Society for Nutrition (ASN), the British Association of Sport and Exercise Science (BASES), and the Nutrition Society. Janice won an undergraduate teaching award while at the University of North Carolina, Charlotte; a Community Engagement Award while at the University of Bristol; a Doctoral Student Supervisor Award at the University of Birmingham; and the ACSM Citation Award for her contributions to research, education, and service to the Exercise Sciences. In addition to *The Science of Nutrition*, Janice coauthored the Pearson textbooks *Nutrition: An Applied Approach* and *Nutrition for Life* with Melinda Manore.

Janice loves hiking, yoga, traveling, and cooking and eating delicious food. She likes almost every vegetable except fennel and believes chocolate should be listed as a food group.

Melinda M. Manore, PhD, RD, CSSD, FACSM Oregon State University

Melinda Manore earned a doctorate in human nutrition with minors in exercise physiology and health at Oregon State University (OSU). She is the past chair of the Department of Nutrition and Food Management and is currently an emeritus professor of nutrition at OSU. Prior to her move there, she was a professor at Arizona State University. Melinda's area of expertise is nutrition and exercise, particularly the role of diet and exercise in health and prevention of chronic disease, exercise performance, and weight control. She has a special focus on the energy and nutritional needs of active women and girls across the life cycle.

Melinda is an active member of the Academy of Nutrition and Dietetics (AND) and the American College of Sports Medicine (ACSM). She is the past chair of the AND Research Dietetic Practice Group; served on the AND Obesity Steering Committee; and is an active member of the Sports, Cardiovascular, and Wellness Nutrition Practice Group. She is a fellow of ACSM and has served as vice president and on the Board of Trustees.

Melinda is also a member of the American Society of Nutrition (ASN), the Obesity Society, and Professionals in Nutrition and Exercise Science (PINES). She is the past chair of the U.S. Department of Agriculture (USDA) Nutrition and Health Committee for Program Guidance and Planning, and the USDA, ACSM, and AND Expert Panel Meeting, *Energy Balance at the Crossroads: Translating Science into Action*. She serves, or has served, on the editorial board of numerous research journals and has won awards for excellence in research and teaching. Melinda also coauthored the Pearson textbooks *Nutrition: An Applied Approach* and *Nutrition for Life* with Janice Thompson.

Melinda is an avid walker, hiker, and former runner who loves to garden, cook, and eat great food. She is also an amateur birder.

Linda A. Vaughan, PhD, RDN, FAND Arizona State University

Linda Vaughan is professor emerita and past director of the School of Nutrition and Health Promotion at Arizona State University (ASU). Linda earned her doctorate in agricultural biochemistry and nutrition at the University of Arizona.

Linda served as an active member of the Academy of Nutrition and Dietetics (AND), the American Society of Nutrition (ASN), and the Arizona Dietetic Association. She served as chair of the Research and Dietetic Educators of Practitioners practice groups of the AND. Linda has received numerous awards, including the Medallion Award from the Academy of Nutrition and Dietetics, the Arizona Dietetic Association Outstanding Educator Award, and multiple awards from Arizona State University for leadership, innovation, mentoring, and community involvement. She was also honored through the establishment of an endowed scholarship in her name to support nutrition and dietetic students at ASU. In addition to being a coauthor of *The Science of Nutrition*, Linda was also a key contributor to the Pearson textbooks *Nutrition: An Applied Approach* and *Nutrition for Life* by Janice Thompson and Melinda Manore.

In her new, post-retirement free time, Linda enjoys "grandma time," swimming, cycling, and crafting bread. She also volunteers at the United Food Bank and other local non-profit community agencies.

Welcome to *The Science of Nutrition*, Fifth Edition!

As nutrition researchers and educators, we know that the science of nutrition is constantly evolving. Our goal as authors is to provide students and instructors with the most recent and scientifically accurate nutrition information available.

Learning to Avoid Nutrition Confusion

What should I eat? In this age of information saturation, many different answers to that question are available 24 hours a day, from multiple sources: via the Internet, social media, television, and radio; in books, newspapers, and magazines; and on billboards, posters, and the sides of vending machines—even food packages offer nutrition advice. From research studies with contradictory findings to marketing claims for competing products, potential sources of confusion abound.

You're probably not fooled by the ads for diets and supplements in your e-mail inbox, but what kinds of nutrition messages *can* you trust? Which claims are backed up by scientific evidence, and of those, which are relevant to you? How can you evaluate the various sources of nutrition information and find out whether the advice they provide is accurate and reliable? How can you navigate the Internet to find reliable nutrition facts and avoid nutrition myths? How can you develop a way of eating that's right for you—one that supports your physical activity, allows you to maintain a healthful weight, and helps you reduce your risk for chronic diseases? And if you're pursuing a career in nutrition or another healthcare field, how can you continue to obtain the most current and valid information about food and physical activity as you work with individual clients?

Why We Wrote This Book

The Science of Nutrition began with the conviction that both students and instructors would benefit from an accurate, clear, and engaging textbook that links nutrients with their functional benefits. As instructors, we recognized that students have a natural interest in their bodies, their health, their weight, and their success in sports and other activities. We developed this text to demonstrate how nutrition relates to these interests. ***The Science of Nutrition*** empowers you to reach your personal health and fitness goals while teaching you about the scientific evidence linking nutrition with disease. This information will be vital to your success as you build a career in nutrition or another health-related discipline.

You'll also learn how to debunk nutrition myths and how to distinguish nutrition fact from fiction. Throughout the chapters, material is presented in lively narrative that is scientifically sound and that continually links the evidence with these goals. Information on current events, and recent and ongoing research, keeps the inquisitive spark alive, illustrating how nutrition is very much a "living" science and a source of spirited ongoing debate.

The content of this text is designed for nutrition and other science and healthcare majors, but is also applicable and accessible to students in the liberal arts. We present the *science* of nutrition in a conversational style with engaging features that enable you to master the information and apply it in the real world. To support visual learning, the writing is supplemented by illustrations and photos that are attractive, effective, and level-appropriate.

As teachers, we are familiar with the myriad challenges of presenting nutrition information in the classroom. We have therefore developed an exceptional ancillary package with a variety of tools to assist instructors in successfully meeting these challenges. We hope to contribute to the excitement of teaching and learning about nutrition—a subject that affects every one of us, a subject so important and relevant that correct and timely information can make the difference between health and disease.

Hallmark Text Features

A multitude of popular features have been updated throughout this new edition, challenging you to think about how the recommendations of different nutritional experts (and others who may be less than expert, such as some media sources) apply to your unique health issues, activity level, energy requirements, food preferences, and lifestyle. **What Do You Think?** questions, formerly known as **Test Yourself**, open each chapter, providing instructors and students an opportunity to challenge common nutrition-related myths and misperceptions. The questions are repeated, with answers, in the end-of-chapter Study Plan. **Nutrition Myth or Fact?** essays, which now appear near the end of each chapter preceeding the Study Plan section, explore the science supporting or challenging common beliefs about foods, whereas the shorter **Highlight** essays explore research across a range of important, specific nutritional issues. **Nutrition Label Activities** help you understand and apply food label information, so that you can make better nutritional choices. **You Do the Math** features give you a hands-on chance to practice important calculations that reveal key nutrition information. **Nutrition Milestones** essays explore the breakthrough research behind some of the most important discoveries in nutrition science.

Food-source figures identify foods that are good sources of fiber or key micronutrients. These have been redesigned to indicate each food's group by color; thus, for example, students can see at a glance that fruits and vegetables—indicated with bands of red and green—are the key sources of vitamin C. **Focus Figures** illuminate some of the toughest topics for students to learn and understand, including the scientific method, glucose regulation, atherosclerosis, and fluid balance. **Meal Focus Figures** graphically depict the differences in two sets of meals, such as meals high and low in nutrient density, fiber, or protein, to demonstrate to students the power of each day's food choices to influence diet quality.

Four visually vibrant **In Depth** "mini chapters" cover the key areas of alcohol, vitamins and minerals, dietary supplements, and disorders related to body image, eating, and exercise. These offer instructors flexibility in incorporating the topics into their course. The Vitamins and Minerals In Depth specifically provides an overview of micronutrient basics prior to the first functional micronutrients chapter.

In providing these features, in addition to the new features listed shortly, we hope that by the time you finish this book you'll feel more confident in making decisions about your diet and physical activity.

Nutri-Case | You Play the Expert!

In addition to the aforementioned features, our **Nutri-Case** scenarios—which have been redesigned and comprehensively revised for the Fifth Edition—provide you with the opportunity to evaluate the nutrition-related beliefs and behaviors of a variety of individuals grappling with common nutrition-related challenges. You might find that they remind you of people you know, and you may discover you have something in common with one or more of them. Our hope is that by applying the information you learn in this course to their situations, you will deepen your ability to apply the science of nutrition to your own life.

As you read these case scenarios, keep in mind that they are for instructional purposes, and not intended to suggest that students using this text are qualified to offer nutritional advice to others. In the real world, only properly trained and licensed health professionals are qualified to provide nutritional counseling.

Mastering Nutrition

The Fifth Edition of *The Science of Nutrition* includes **Mastering Nutrition**, the teaching and learning platform that empowers you to reach *every* student. By combining trusted author content with digital tools developed to engage students and emulate the office-hour

experience, Mastering personalizes learning and improves results for each student. Key Mastering Nutrition features include the following:

- **Pearson eText** is a simple-to-use, mobile-optimized, personalized reading experience available within Mastering. It allows students to easily highlight, take notes, and review key vocabulary all in one place—even when offline. Seamlessly integrated videos and other rich media engage students and give them access to the help they need, when they need it. Pearson eText is available within Mastering when packaged with a new book; students can also purchase Mastering with Pearson eText online.
  - **For instructors not using Mastering, Pearson eText can also be adopted on its own as the main course material.**
- **Focus Figure** and **Meal Focus Figure Coaching Activities** that guide students through key nutrition concepts with interactive mini-lessons.
- **Nutrition Animations** have been updated and made compatible for Mastering and mobile devices. Corresponding activities with wrong-answer feedback have also been updated.
- ***ABC News* Videos** with quizzing bring nutrition to life and spark discussion with up-to-date hot topics that occur in the nutrition field. Multiple-choice questions provide wrong-answer feedback to redirect students to the correct answer.
- **18 NutriTools Coaching Activities** allow students to apply nutrition concepts to improve their health through interactive mini-lessons that provide hints and feedback. The Build a Meal, Build a Pizza, Build a Salad, and Build a Sandwich tools have been carefully rethought to improve the user experience, are now HTML5 compatible, and have been updated to reflect the changes in the 2015–2020 USDA Dietary Guidelines.
- **Single sign-on for MyDietAnalysis**, a software system that allows students to complete a diet assignment. Students keep track of their food intake and exercise and enter the information to create a variety of reports (e.g., the balance between fats, carbohydrates, and proteins in their diet; how many calories they're eating; whether they're meeting the Recommended Dietary Allowances [RDAs] for vitamins and minerals; etc.). **MyDietAnalysis activities** have been added within Mastering that incorporate the use of MyDietAnalysis and provide instructors the tools to auto-grade commonly assigned portions of their diet analysis projects. A mobile version gives students 24/7 access via their smart phones to easily track food, drink, and activity on the go.
- With **Learning Catalytics™**, you'll hear from every student when it matters most. You pose a variety of questions that help students recall ideas, apply concepts, and develop critical-thinking skills. Your students respond using their own smartphones, tablets, or laptops. You can monitor responses with real-time analytics and find out what your students do –and don't–understand. Then, you can adjust your teaching accordingly and even facilitate peer-to-peer learning, helping students stay motivated and engaged. **Clicker questions** from the Instructional Resource Materials are now part of Learning Catalytics with this edition. All questions are specifically tagged to *The Science of Nutrition* and majors nutrition.
- **MP3s** related to chapter content, with multiple-choice questions that provide wrong-answer feedback.
- **Access to** Get Ready for Nutrition, providing students with extra math and chemistry study assistance.
- **A Study Area** that is broken down into learning areas and includes videos, animations, MP3s, and other resources.

New to the Fifth Edition

The following features are new to the Fifth Edition:

- **Learning outcomes linked to Study Plan.** Each chapter begins with numbered learning outcomes, which are then repeated at the beginning of the corresponding section of the

chapter. At the end of each chapter, the relevant learning outcome is again referenced in the Study Plan, both in the chapter summary and alongside four types of review questions: multiple choice, true or false, short answer, and math review. This coordination of learning outcomes to review material offers students a clear learning path through the chapter. Corresponding activities in Mastering reinforce the connections. The end-of-chapter Study Plan also now repeats the *What Do You Think?* questions from the chapter opener while providing the answers.

- **Food Hero recipe links.** The Fifth Edition identifies nutritious, easy, and low-cost recipes that students can find on the Food Hero website, an initiative of Oregon's Supplemental Nutrition Assistance Program Education (SNAP-Ed). Food Hero is a social marketing campaign developed by the Oregon State University Extension Service and funded jointly by OSU Extension Service, the Oregon Department of Human Services, and the United States Department of Agriculture Food and Nutrition Service.

- **Disorders headings.** New section headings identify main chapter sections devoted to content exploring the interrelationships of nutrition and human disease, including gastrointestinal disorders, diabetes, cardiovascular disease, osteoporosis, obesity, and many others.

The visual walkthrough at the front of the book provides additional information on the features of the Fifth Edition. Specific changes to each chapter include the following:

Chapter 1

1. Altered Figure 1.1 to reflect the many ways that consuming a nutritious diet contributes to wellness.
2. Added new Focus Figure 1.2 on the relationship between nutrition and human disease, combining former Figures 1.2–1.4.
3. Added information on the determinants of health as identified within *Healthy People 2020*.
4. Added new Focus Figure 1.3, which combines the six groups of nutrients found in foods into one figure.
5. Introduced and defined the term "metabolism" in the margin before it is discussed in more detail in Chapter 7.
6. Added a section introducing beneficial non-nutrient compounds found in food, including functional foods and phytochemicals.
7. Restructured the section on assessing nutrition status to include an overview of the four steps of the Nutrition Care process and organized into the five domains of nutrition assessment as identified by the Academy of Nutrition and Dietetics.
8. Added emphasis that nutrition is an evidence-based science.
9. Updated and further clarified various types of research studies and the information they provide.
10. Added a new Figure 1.6 on Types of Research Studies.
11. Defined the terms "bias" and "systematic review," adding these to the margin definitions.
12. Introduced the concept of hierarchy of evidence used to rank scientific studies on the quality of evidence they provide.

Chapter 2

1. Rewrote chapter introduction to better represent the topics presented in the chapter.
2. Reorganized the section on "What Is a Healthful Diet?" to improve flow, and enhanced information on nutrient-dense diets.
3. Added new unnumbered figure on the Guiding Stars nutritional guidance system.
4. Updated information on the new Nutrition Facts panel, including the new design and deadlines for food manufacturers to comply with the changes.
5. Added new Figure 2.4 illustrating the Facts Up Front front-of-pack nutrition labelling system.

6. Deleted FDA Health Claims Report Card, as it is now outdated.
7. Added information on the terms *organic*, *natural*, and *kosher*.
8. Updated the information and reorganized the section on the Dietary Guidelines for Americans, and included more detail on the process of developing the guidelines and selecting committee members.
9. Added a section on the three underlying principles of a healthful eating pattern, including a new Figure 2.5.
10. Restructured the narrative of the information on MyPlate and MiPlato, including the placement of Figures 2.7 (MyPlate) and 2.8 (MiPlato).
11. New Appendix on evolution of contemporary food guides referred to in Chapter 2 and included in the back of the text.
12. Added an updated and restructured section on "What Other Tools Can Help You Design a Healthful Diet," focusing on the Mediterranean-style eating pattern (Figure 2.11), the exchange system, the Healthy Eating Plate, and the Power Plate (Figure 2.12).
13. Removed information on the ChooseMyPlate Supertracker, as this tool is no longer available; replaced with information on MyPlate Checklist Calculator.
14. Updated nutritional information from McDonald's and Burger King restaurants in Table 2.3.
15. In the You Do the Math feature called How Much Exercise Is Needed to Combat Increasing Food Portion Sizes?, clarified that the calculations are rough estimates due to the highly variable response of humans to food intake and exercise.
16. In the You Do the Math feature called Determining the Healthiest Food Choices When Eating Out, revised the narrative to focus more on saturated fat intake, and clarified that the chicken sandwich was made with fried chicken.
17. In the Nutrition Myth or Fact feature, added headings to improve flow, and added in new information describing potential factors that prevent people from adopting the Dietary Guidelines for Americans and recommendations for increasing consumer awareness and transparency of the process of DGA development.

Chapter 3

1. Identified and included a new figure of the four primary tissue layers of the GI tract.
2. Added a Nutrition Online link to a Web page on choking and the Heimlich maneuver.
3. Identified the roles of the goblet cells in the mucosa of the GI tract and the specialized duodenal glands that secrete alkaline mucus into the small intestine.
4. Defined the spleen.
5. Revised the discussion of the neural control of GI functions for greater precision and clarity.
6. Added a brief discussion and photograph of gallstones.
7. Thoroughly updated the discussions of non-celiac gluten sensitivity and irritable bowel syndrome, including the potential role of FODMAP foods.
8. Included CT colonography as one of the colon cancer screening tools available.
9. Comprehensively revised the Nutrition Myth or Fact essay on the microbiome and probiotics/prebiotics/synbiotics.

Chapter 4

1. Changed the chemical structure of galactose in Figures 4.2 and 4.3 to the form of galactose in foods.
2. Revised and restructured the Highlight called Are All Forms of Sugar the Same? to improve flow and readability. Deleted the table, and added information on coconut sugar.
3. Revised and restructured the section, How Does the Body Regulate Blood Glucose Levels? to improve readability and comprehension of key concepts.
4. Added a section on fructose and its role in insulin release.
5. Added a new graph on the effect of high vs low glycemic foods on blood sugar, and combined this with the figure on glycemic index values of foods.

6. Revised and restructured the section, Carbohydrates Provide Energy for Daily Activities and Exercise to improve readability and comprehension of key concepts.
7. Expanded the sections on Sugar and Blood Lipids, Sugar and Diabetes, and Sugar and Obesity.
8. Revised the sections, How Much Fiber Do We Need, and What Are the Best Sources? to improve readability and comprehension of key concepts.
9. Added information on fiber intake of Americans, including revised Meals Focus Figure highlighting the fiber content in comparison of the two diets.
10. Discussed monk fruit as a non-nutritive sweetener.
11. Added a section on the three blood tests used to diagnose diabetes, including a figure illustrating these tests and the values used to diagnose diabetes and prediabetes.
12. Revised and restructured the section, You Can Reduce Your Risk for Type 2 Diabetes to improve readability and comprehension of key concepts.
13. Added section on metabolic syndrome within discussion of risk factors for type 2 diabetes.
14. Added photo of amputation in the section discussing complications of unmanaged diabetes.
15. Enhanced section on how lifestyle changes reduce a person's risk for type 2 diabetes.
16. Added a section called Dietary Counseling Can Help People Living with Diabetes.
17. Updated the photo of monitoring blood glucose to be more realistic.
18. Updated and restructured the Nutrition Myth or Fact? feature on whether added sugars are the cause of the obesity epidemic, including recent findings related to how consumption of sugar-sweetened beverages are decreasing in the United States (and why this might be the case).

Chapter 4.5

1. Reorganized the beginning of the chapter to define alcohol and explain its absorption and metabolism first.
2. Added a discussion on the chemistry of alcohol production and the sources of alcohol used in commercial production of alcoholic beverages.
3. Included data on how many Americans do NOT consume alcohol.
4. Added brief discussion related to the mixing of alcoholic beverages with caffeinated energy drinks.
5. Replaced the figure of the Calorie content of alcoholic beverages with a new figure.
6. Moved the content on metabolic and functional tolerance into the discussion of alcohol dependence.
7. Expanded discussion of the impact of alcohol intake (low, moderate, and high levels) to chronic disease risk, including potential mechanisms by which alcohol abuse might contribute to increased risk for cancer.
8. Discussed mandatory government warning label on alcoholic beverages.
9. Added a section on options for the treatment of AUD.

Chapter 5

1. Included coconut oil in Figure 5.5, and added information on the health-related properties of coconut oil.
2. Added information on medium-chain triglycerides preferential use for energy and reduced storage as adipose tissue.
3. Deleted the Highlight on butter vs margarine in light of the new FDA determination that PHOs are not GRAS, and the ban on PHOs in processed foods.
4. Included new content about satiety and fats.
5. Included new section on fat blockers such as chitosan and orlistat.
6. Included new section on emerging biomarkers for cardiovascular disease.
7. In the Nutrition Myth or Fact essay on the controversy related to the health effects of saturated fats, discussed the recent PURE study.

Chapter 6

1. Revised Figure 6.9 illustrating how protein shape determines function.
2. Added more detail on amino-acid hormones.
3. Reorganized, tightened, and increased detail provided on roles of protein to improve readability and understanding.
4. Updated information on higher protein needs for active people within the chapter narrative and the end of chapter Nutrition Myth or Fact? feature.
5. Added updated Focus Figure 6.16 that includes percentage of energy from protein for the meals illustrated.
6. Added more information on plant-based and vegan eating patterns.
7. Added new Figure 6.17, comparing the energy and macronutrient content of a vegan-based meal with a meat-based meal.

Chapter 7

1. Added a new Focus Figure providing an overview of metabolic Intersections.
2. Moved figure on oxidation/reduction reactions from Chapter 10 here.
3. Expanded and updated the discussion of ketogenic diets.
4. Clarified content on how foods and food components might impact energy balance.
5. Thoroughly revised the Highlight on carnitine.

Chapter 7.5

1. In the nutrient analysis in Meal Focus Figure 1, replaced niacin with potassium and corrected sodium content.
2. Expanded the discussion of the role of vitamin supplements in the prevention of chronic disease.
3. Added an overview of micronutrient functions.
4. Linked the description of minerals to their placement in the Period Table of Elements.

Chapter 8

1. Added thiamin diphosphate (TDP) to Figure 8.1.
2. Expanded the information on forms of folate and folate digestion, absorption, and transport.
3. Expanded Figure 8.12 to illustrate alternate forms of folate and folate metabolism.

Chapter 9

1. Revised Figures 9.7, 9.9, and 9.10 to reflect the color bands of the food groups of My Plate.
2. Revised discussion and figure of fluid regulation to highlight the role of the hypothalamus in the thirst response.
3. Added a discussion on the potential increased risk for cancer with prolonged consumption of very hot beverages.
4. Added a discussion of the potential benefits of coffee on cognition.
5. Expanded the discussion of coconut water, including its potential toxicity.
6. Expanded the number of tips for decreasing sodium intake.
7. Expanded the number of tips for increasing potassium intake.
8. Added a new visual of the DASH diet plan.
9. Expanded the discussion on sodium intake and chronic disease risks.
10. Discussed the water conserving adaptation seen with high salt intake.
11. Provided new diagnostic categories for normal BP, elevated BP, and Stages 1 and 2 hypertension.
12. Expanded the discussion of energy drinks and their potential dangers.
13. Restructured beverage section to clarify groupings.
14. Expanded the discussion of dehydration-related heat illnesses.

Chapter 10

1. Deleted figure of oxidation–reduction reactions, as this figure is now included in Chapter 7 where this concept is first introduced.
2. Added more information on collagen and its role in scurvy.
3. Added new Figure 10.6 on collagen.
4. Added new Figure 10.7, photo indicating scurvy.
5. Added new photo to Figure 10.12, more clearly indicating the deforming arthritis resulting from Kashin-Beck disease.
6. Added new Figure 10.15 of carotenosis.
7. Added more information on vitamin A derivatives and treating acne.
8. Added new Figure 10.20 on follicular hyperkeratosis.
9. Added new information on cancer diagnosis and treatment.
10. Changed the topic of the *Nutrition Myth or Fact?* essay from dietary supplements (now covered in In Depth 10.5) to phytochemicals.

Chapter 10.5

1. Changed the topic of this In Depth from phytochemicals (now covered in the Chapter 10 *Nutrition Myth or Fact?* essay) to dietary supplements.
2. Added new Figure 1 showing mandatory supplement bottle labelling.
3. Added new Figure 2 showing USP Verified Mark.
4. Expanded the information on interactions between supplements and prescription drugs.
5. Updated entries in Table 1 on herbs with potential for severe adverse effects, and replaced willow bark with sage.
6. Added two new Nutrition Online links for information on supplements linked to liver injury and weight-loss supplement scams.

Chapter 11

1. Revised chapter introduction to enhance relevance to audience.
2. Corrected error in photo in DXA Figure 11.4.
3. Reorganized the structure of sections discussing nutrients involved in bone health to improve clarity and flow, and ensure consistency across chapters.
4. Updated latest findings regarding possible mechanisms explaining association between obesity and lower levels of circulating vitamin D.
5. Provided latest evidence linked with the controversy of widespread vitamin D deficiency in the United States, and whether there is evidence to support an increase in current vitamin D recommendations.
6. Added information about vitamin K1 and vitamin K2, and their differential impact on bone health.
7. Reorganized section on osteoporosis to clarify subtopics.
8. Added information on type I and type II osteoporosis.
9. Corrected error in photo of X-ray of hip, Figure 11.17.
10. Moved Figure 11.19, illustrating how bone mineral density in women declines with age, from Chapter 19 here. Removed former Figure 11.19 of EPA poster on UV safety.
11. Updated latest information on alcohol, caffeine, sodium, and osteoporosis risk.
12. Updated information on the role of protein in bone health.
13. Expanded section on the role of exercise in reducing osteoporosis risk.
14. Updated the Nutrition Myth or Fact, highlighting the latest findings linked with the controversy around the effectiveness of calcium and vitamin D supplements on bone health.

Chapter 12

1. Altered the structure of the discussion of iron homeostasis to clarify for students the five mechanisms of absorption, transport, storage, excretion, and recycling.
2. Modestly expanded information on zinc losses, reabsorption, and storage.
3. Added information on clotting time as assessment of vitamin K status.

4. Deleted graph showing prevalence of spina bifida following folate fortification of foods (formerly Figure 12.9).
5. Added a new figure comparing the development of healthy red blood cells to the development of microcytic and macrocytic anemias.
6. Added new discussion of the role of the GI flora in immune health, including the role of probiotics and prebiotics.
7. Significantly expanded information about nutrients and immune function.

Chapter 13

1. Revised chapter opener to enhance relevance and timeliness.
2. Added information on class 1, class 2, and class 3 obesity.
3. Deleted Figure 13.4 on determining fat patterning consistent with user feedback that this is rarely covered or used; retained information in narrative on measuring waist circumference and health implications for measurements.
4. Deleted Figure 13.7 on lean body mass across different body weights and body fat levels due to user feedback that this concept was unclear and not useful.
5. Added a brief overview of ranges of percentage body fat values.
6. Added information on non-exercise activity thermogenesis (NEAT).
7. Updated information on genetics and obesity.
8. Enhanced information on evidence supporting the set-point hypothesis.
9. Added a section on the protein leverage hypothesis.
10. Added a section on the drifty gene hypothesis.
11. Incorporated new information on uncoupling proteins and their association with obesity.
12. Restructured the section on sociocultural factors affecting food choices and body weight to improve flow and enhance clarity.
13. Added information on obesity, inflammation, and its association with the metabolic syndrome.
14. Added new close-up to Figure 13.6 on abdominal obesity and metabolic syndrome.
15. Added information on risk factors resulting from bariatric surgery.
16. Expanded information on appropriate behavioral modifications to promote weight loss.
17. Updated end of chapter *Nutrition Myth or Fact?* essay to include recent information on whether individuals can be obese and metabolically healthy, whether low-carbohydrate diets are effective in supporting long-term weight loss, and additional details on the Atkins diet literature.

Chapter 14

1. Expanded the list of benefits of regular physical activity.
2. Restructured and expanded section on How Much Physical Activity Is Enough?
3. Added the new *2018 Physical Activity Guidelines Advisory Committee Scientific Report* and updated the guidelines based on this report.
4. Updated information on importance of enjoyment to maintain regular engagement in physical activity.
5. Added information on using fitness and pedometer apps to track physical activity.
6. Increased details on exercise intensity and reducing body fat.
7. Updated DRIs for carbohydrate for athletes and added information on amount and timing of carbohydrate consumption.
8. Added information on whether high-fat diets can support exercise training and athletic performance.
9. Enhanced and updated section on fluid replacement and use of sports beverages.
10. Expanded Figure 14.9 to include graph comparing contribution of fat and carbohydrate as energy sources during activities varying in exercise intensity.
11. Updated and revised Figure 14.11 to enhance clarity and understanding of the concept of a low-carbohydrate diet on muscle glycogen stores.
12. Expanded Nutrition Myth or Fact on ergogenic aids to include HMB, sodium bicarbonate, and nitrate.

Chapter 14.5

1. Included a new discussion of body image disorders such as body dysmorphic disorder.
2. Included a new discussion of excessive exercise (exercise addiction).
3. Expanded section on emerging syndromes of disordered eating, including night-eating syndrome, purging disorder, atypical anorexia nervosa, orthorexia nervosa, and relative energy deficiency in sports (RED-S), which includes the female athlete triad.
4. Updated Figure 3 to illustrate RED-S and its relationship with the female athlete triad.
5. Expanded material on how genetic and environmental factors interact to contribute to eating disorders.

Chapter 15

1. Revised chapter opening to discuss the 2018 multistate *E.coli* outbreak involving romaine lettuce.
2. Introduced content on the Hazard Analysis and Critical Control Points system.
3. Introduced content on the Safe Drinking Water Act and the Bioterrorism Act.
4. Added brief passages identifying foods and settings most commonly implicated in foodborne illness.
5. Slightly expanded content on harmful algal blooms.
6. Added a list of tips on how to pack a food-safe lunch.
7. Revised content on "BEST if used by" and "USE by" dates on foods.
8. Added a photo figure to emphasize the safe temperatures for cooking animal-based foods.
9. Added a brief discussion of the meaning of the claim "No added nitrites" on food labels.
10. Expanded the information on lead contamination of water, including a brief passage on the Flint, Michigan, crisis.
11. Slightly expanded the discussion of poly- and perfluoroakyl substances.

Chapter 16

1. Deleted the FAO hunger map because the FAO is no longer updating this graphic.
2. Revised and expanded the discussion of how climate change affects food security.
3. Reorganized and expanded the section called How Could Limited Access to Nourishing Food Promote Obesity?, including a new discussion of the WHO term, the *double burden of malnutrition* and the USDA term *low-access census tracts* (commonly called food deserts).
4. Expanded the discussion of the Supplemental Nutrition Assistance Program (SNAP), including information on eligibility criteria, and added information on the Summer Food Service Program.
5. Added a Nutrition Milestone on the history of foods stamps/SNAP.
6. Added a Nutrition Online link to the USDA's food security survey.
7. Briefly mentioned the problem of food insecurity among college students and added a Web link to the College and University Food Bank Alliance.
8. Briefly mentioned the importance of avoiding "poverty porn" in discussing how students can help address global hunger.

Chapter 17

1. Added definitions for the terms *critical period* and *high birth weight*.
2. Replaced the Highlight on pica to one on the topic of 2017 NIAID guidelines for reducing the risk for childhood food allergies.
3. Added a new Meal Focus Figure comparing two sets of meals for breastfeeding women.
4. Slightly restructured the discussion on food choking hazards for infants to increase emphasis of this important topic.
5. Discussed the potential concerns related to arsenic contamination of rice used in the production of infant rice cereal.
6. Added a new figure (Figure 17.8) illustrating foods linked to an increased risk of listeriosis in pregnant women.

Chapter 18

1. Expanded roster of calcium-rich foods and beverages appropriate for vegetarian, vegan, and dairy-free dietary patterns in families with children.
2. Expanded roster of protein-rich foods and beverages appropriate for vegetarian and vegan dietary patterns in families with children.
3. Expanded the discussion of the interrelationships between lead toxicity and malnutrition.
4. Added a new discussion of the health problems linked to pediatric obesity.
5. Revised discussion of adolescent acne and diet.
6. Added information related to body image concerns among children and adolescents.
7. Deleted the Highlight on the topic of the importance of breakfast.
8. Updated the Nutrition Facts panel in Figure 18.2 to reflect the new FDA label guidelines.
9. Deleted information on the *We Can!* program, which is outdated.

Chapter 19

1. Replaced Figure 19.1 with a new graph illustrating the age-related demographics of the U.S. population.
2. Moved former Figure 19.2 on bone mineral density to the discussion of osteoporosis in Chapter 11.
3. Added information on osteosarcopenic obesity syndrome within the discussion of age-related body composition changes.
4. Added a brief discussion of osteoarthritis.
5. Added a short section on gout, with an accompanying photo.
6. Expanded information about Alzheimer's disease and the MIND (Mediterranean-DASH Intervention for Neurodegenerative Delay) diet and its potential impact on risk for cognitive decline and Alzheimer's disease.
7. Expanded information related to community nutrition programs for older adults.

Appendices, Front Matter, and Back Matter

- **New** Appendix G, "The USDA Food Guide Evolution" has been added.

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Brief Contents

Contents

8 Nutrients Involved in Energy Metabolism 308

19 Nutrition Through the Life Cycle: The Later Years 742

Appendices

Special Features

Focus Figures

Meal Focus Figures

You Do the Math

Highlight

Nutri-Case

Nutrition Label Activity

Nutrition Myth Or Fact?

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THE SCIENCE OF

NUTRITION

FIFTH EDITION

1 The Science of Nutrition
Linking Food, Function, and Health

WHAT DO YOU THINK?

True or False?

1 A Calorie is a measure of the amount of fat in a food.

T or F

2 Proteins are not a primary source of energy for the body.

T or F

3 All vitamins must be consumed daily to support optimal health.

T or F

4 The Recommended Dietary Allowance is the maximum amount of a vitamin or other food component that people should consume to support normal body functions.

T or F

5 Results from observational studies do not indicate cause and effect.

T or F

What Do You Think? answers are located in the Study Plan.