

# ADVANCED HUMAN NUTRITION

**FOURTH EDITION**

**Denis M. Medeiros,  
PhD, RD, LD**

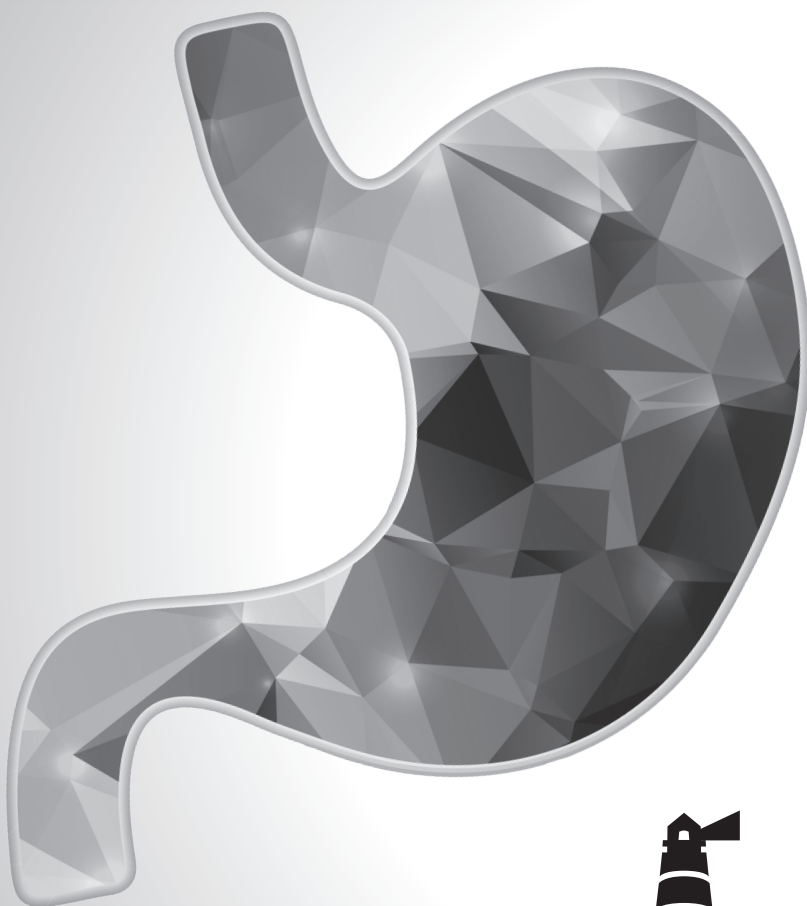
Dean Emeritus of the School of  
Graduate Studies  
Professor Emeritus of Biochemistry  
and Molecular Biology  
University of Missouri at Kansas City  
Kansas City, Missouri

And

Professor Emeritus  
Department of Food, Nutrition,  
Dietetics, and Health  
Kansas State University  
Manhattan, Kansas

**Robert E. C. Wildman,  
PhD, RD, LD, FISSN**

Department of Nutrition and Food  
Sciences  
Texas Woman's University  
Denton, Texas



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*To my wife, Susan, for her patience and love; and my mother, Rita Wilkie, a proud member of "the greatest generation," for her belief in higher education. Also to my daughter, Kathryn, my stepfather, the late William P. Wilkie, and my father, the late Joseph Medeiros, for their support and love through the years.*

**-D.M.M.**

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*To my children: Gage and Bryn for your love, patience, and support. Also, to my father, Dave, and nephew, Jack, as well as eternal inspiration from my brother, David, and my mother, Carol.*

**-R.W.**

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# Preface

In the preface to the last two editions, we posed the question, “Why a book on advanced human nutrition?” We responded that there was, and continues to be, a limited number of intermediate and advanced textbooks that detail why nutrients are important from a biochemical, physiologic, and molecular perspective. Today, the same shortage exists with the exception of *Advanced Human Nutrition*, whose initial success and adaptations exceeded our expectations.

Nutrition is a relatively new science, having evolved from several other scientific disciplines in the 20th century, and it continues to evolve today. The expansion of nutritional knowledge has been astounding. At the beginning of the 20th century, work conducted on food and food components was carried out by only a handful of scientists. As the 20th century progressed into its first few decades, many of the now well-known vitamins were discovered, their structures defined, and synthesis techniques developed. The metabolic mechanisms of macronutrients, particularly carbohydrates, lipids, and proteins, as well as energy metabolism in general, became the subject of intense research. The scientists who carried out such research came from a wide variety of disciplines, including organic and inorganic chemistry, agricultural chemistry, physiological chemistry, medicine, and animal sciences.

Originally, nutritional research was conducted by men and women simply for the love of science. Later, during the 1940s, the federal government took a more active role in scientific research, including nutrition. A high rate of rejection of military conscripts due to nutrition-related conditions prompted the establishment of the first U.S. Recommended Dietary Allowances (RDAs) in 1941. The RDAs have continued to be modified ever since; the Dietary Reference Intakes (DRIs) are the most recent version.

Research had been carried out with the indirect support of the federal government before the establishment of the RDAs. Nutrition research occurred at the land-grant institutions created by Abraham Lincoln in the 1860s through the Morrill Act. Modern nutrition evolved from agricultural, medical, and basic sciences into a discipline of its own. One of the early fathers of nutrition was a Kansas native, E. V. McCollum, who

introduced the laboratory rat as a useful model in scientific research when studying vitamin A. Similarly, poultry scientists used chicks as a research model and made contributions to medical sciences. Much of the research on fiber began with animal scientists studying forages and feeds of livestock.

Research pertaining to minerals, their composition in the human diet, and their physiologic roles took form in the 20th century. Most of the earlier mineral research efforts focused on the major minerals, such as calcium, phosphorus, sodium, potassium, chloride, and magnesium. However, some work relating to the role of iron and the development of iron deficiency appeared in the earlier decades of the 20th century.

In the 1960s and 1970s, rapid advances in technology allowed for the ability to detect small quantities of trace minerals, such as selenium, zinc, copper, iron, fluoride, chromium, manganese, and iodine. Although the role of iodine in preventing goiters was already known, as was the potential for deleterious health effects from selenium toxicity, there was limited information on the role of many trace elements in optimizing human health. New technologies, such as neutron activation and atomic absorption spectrophotometry, allowed for detection of trace minerals in the part-per-billion or microgram-per-liter range. An explosion of knowledge regarding trace minerals occurred in the latter part of the 20th century.

As the 20th century came to a close, it was known that many nutrients functioned at the gene level, an idea that was unheard of at the beginning of the 20th century. Today, in the 21st century, new research was and is currently being carried out on the identification of new compounds in the diet, such as plant chemicals (phytochemicals). This area has led to the identification of compounds that promote health and prevent disease.

## ► Approach of this Text

In all of our previous editions, we sought to use a conversational approach in our writing to allow the reader to better grasp nutritional concepts, as opposed

to the more encyclopedic writing style common among advanced texts in science disciplines. We have been mindful of pedagogical tools that facilitate student learning. Many students have not mastered the optimal manner in which to read a textbook compared with literary works. A student needs to comprehend what he or she reads. Each chapter contains a series of “Before You Go On...” features in which the reader is asked a series of questions that can be answered from the material covered in the previous section. This tool can be used to help the student comprehend and focus on what is important in the text and to develop better study skills. The student is urged to answer each of the questions before proceeding with the next section of the chapter.

In the third edition of the text, two additional chapters were developed: one on fiber, which was previously part of the carbohydrates chapter; and a second on nutraceuticals and functional foods. Nutraceuticals—nutrients in foods that provide physiologic benefit beyond basic daily needs and/or support disease prevention or treatment—have been studied extensively in the last 15 years, and much has been discovered about their health benefits and mechanism of action. Fiber is one group of phytochemicals (plant-based nutraceuticals) where this information has expanded. Phytochemicals have been used to develop and produce functional foods either as supplements or as food. Thus, separate, in-depth attention to each of these still-evolving topics is needed for the student of nutrition to stay current. We include updated material to these two chapters.

As we did in previous editions, chapters are developed further by combining the scientific basis of why the basic nutrients are required with some applied concepts throughout. We accomplished this by integrating “Special Features” on focused topics to add depth to the chapters and to allow the student to view applications of the basic science. New special features have been added to this edition and existing ones have been updated based on new information in the scientific literature. The first edition was designed both as a textbook and a reference book, but the second, third, and now fourth editions are clearly designed as textbooks for college-level courses in human nutrition. The book assumes that students have completed courses in introductory nutrition, biochemistry, and some anatomy and physiology. Many students who are dietetics and nutrition majors, or who are beginning Master of Science degrees, will find this book appropriate for their level.

We have updated the figures and redesigned the text with the student in mind so that visual and textual, comprehension and study tools are available to reinforce concepts. This new edition has even more

figures than the *Third Edition*; these were added after consultation with professors throughout the United States who are actively teaching advanced human nutrition courses, some of whom had been using the previous editions and some of whom had not. The goal here was to broaden the scope of concepts deemed significant for the student to comprehend. However, we took extra care to design the figures to balance simplicity with sufficient detail needed for an advanced treatment of the content.

## ► Organization of this Text

**Chapter 1** starts with an overview of the cell and examples of how nutrition can play a role in human health. **Chapter 2** is aimed at a rigorous review of the anatomy and physiology of digestion. Both of these chapters are the foundation on which the rest of the book is built. **Chapter 3** focuses on carbohydrates. However, as in the previous edition, fiber is discussed separately in **Chapter 4**. **Chapters 5 and 6** focus on lipids and proteins, respectively, with the latter becoming one of the highest profile nutrient areas at this time. **Chapter 7** focuses on water as a separate nutrient because it is present in our bodies in the largest quantity of all nutrients. **Chapters 8 and 9** focus on energy, weight control, and exercise. **Chapters 10 and 11** are detailed discussions of the fat-soluble and water-soluble vitamins, respectively. The text proceeds with two chapters on minerals: **Chapter 12** on major minerals and **Chapter 13** on minor minerals. We have added quite a bit of updated information to **Chapters 10 through 13** in response to our peer reviewers. **Chapter 14**, titled, “Nutraceuticals and Functional Foods,” proved to be popular by adopters in the *Third Edition*. There have been scores of textbooks written on this topic. For this text, the focus was on understanding what constitutes nutraceuticals and functional foods, how they can be classified, and the nutrient categories of various types.

## ► New to the Fourth Edition

Some of the most significant updates to the *Fourth Edition* include the following:

- Each chapter concludes with a section titled, “Clinical Insights,” in which a topic of clinical relevance is presented, linking the basic nutrition science covered in each chapter. Future clinicians

will find this useful in connecting the basic and applied elements of human nutrition and dietetics, better preparing each student for future courses in clinical nutrition.

- The use of gene editing (referred to as CRISPR) is discussed in Chapter 1, as this technology has the potential to correct genetic mutations that impact nutrition utilization and metabolism.
- Diseases of the gastrointestinal tract that have nutritional relevance in health and disease are now covered in Chapter 2.
- Bariatric surgery procedures used to treat obesity are discussed in Chapter 2, as their popularity has increased in tandem with some potential nutrition problems.
- The controversy of a possible contributing factor to the obesity epidemic due to increased linoleic acid intake is debated in one of the Special Features in Chapter 5.
- Alcohol, as related to disease, is covered in Chapter 5.
- The new American Heart Association and American College of Cardiology algorithms to determine the risk of a cardiac event are included in Chapter 5.
- Protein requirements have been challenged by some scientists as it relates to the RDA, and Chapter 6 incorporates coverage of this controversy. Newly available methods that determine nitrogen requirements compared with traditional nitrogen balance methods have led some to conclude that the RDA for protein should be increased significantly.
- Protein intake, physical activity, and sarcopenia are discussed in Chapter 6.
- Clinical signs and treatment of dehydration are covered in Chapter 7.
- Energy requirements, as estimated by several different algorithms used in clinical settings, are included in Chapter 8.
- Exercise recommendations for both endurance and weight-bearing exercises are featured in Chapter 9.
- The implications of  $\beta$ -carotene cleavage by different enzymes in the small intestine are covered in Chapter 10.
- Coverage of the role of fat-soluble vitamins, particularly vitamin E, in Alzheimer's disease is included in Chapter 10.
- Transport mechanisms for water-soluble vitamins are discussed in Chapter 11.
- Novel roles of phosphorus in nutrition are featured in Chapter 12.

- The health-promoting effects of a group of phytochemicals—stilbenes—are now discussed in Chapter 14.

## ► Instructor Resources

Comprehensive online teaching resources are available to instructors adopting the *Fourth Edition*, including the following:

- LMS-ready Test Bank, featuring more than 550 questions. This represents an increase of more than 100 questions compared with the previous edition. The level of rigor for each question is now indicated.
- Instructor's Manual, including Learning Objectives, Key Terms, Chapter Outlines, Discussion Questions, Lecture Notes, and In-class Activities. These have been heavily revised from previous editions.
- Slides in PowerPoint format, containing more than 750 slides that can be adapted for in-class lectures. For each topic, sample lectures with PowerPoint slides are included to help save time for the instructor in preparation of class materials. These lectures can be modified easily for each instructor's unique needs.
- Image Bank in PowerPoint format, compiling the figures appearing in this text.

## ► In Conclusion

The order and content of information presented in this book are typical of the curricula at most academic institutions where nutrition and dietetics are taught. Both authors have had experience teaching this information in advanced nutrition courses and the materials included come from years of experience. We expect this course to provide students with the necessary skills and background to pursue higher-level nutrition classes; it can also serve as a capstone class. As we stated in the prefaces of previous editions, we continue to believe that students who use this text will go on to research careers in nutrition, perhaps even making contributions to the field that we will then cover in future editions of this text. There are those who used the *First Edition* of this book and went on to have research careers in nutrition and dietetics, and their findings are reported in this edition. We certainly look forward to and encourage such important works from future students.

Denis M. Medeiros

Robert E. C. Wildman

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Professor  
Florida National University  
Miami, FL

**Patricia Davidson, DCN, RDN, CDE, LDN, FAND**

Assistant Professor  
West Chester University  
West Chester, PA

**Michael A. Dunn, PhD**

Associate Professor  
University of Hawaii at Manoa  
Honolulu, HI

**James Gerber, MS, DC**

Associate Professor  
Western States Chiropractic College  
Adjunct Faculty  
University of Bridgeport  
Bridgeport, CT

**Amber Haroldson, PhD, RD**

Assistant Professor  
Ball State University  
Muncie, IN

**Jasminka Ilich, PhD, RD**

Professor  
Florida State University  
Tallahassee, FL

**Monica Lebre, MS, RDN, LDN**

Adjunct Lecturer  
Northeastern University  
Boston, MA

**Dingbo Lin, PhD**

Assistant Professor  
Oklahoma State University  
Stillwater, OK

**Pei-Yang Liu, PhD, RD, LD**

Assistant Professor  
University of Akron  
Akron, OH

**Mindy Maziarz, PhD, RDN, LD**

Assistant Professor  
Texas Woman's University  
Houston, TX

**Susan Muller, PhD**

Professor  
Stephens College  
Columbia, MO

**Nina Roofe, PhD, RDN, LD, FAND**

Dietetic Internship Director and Assistant Professor  
University of Central Arkansas  
Conway, AR

**Robert B. Rucker, PhD**

Distinguished Professor Emeritus  
Department of Nutrition and Department of  
Internal Medicine  
University of California, Davis  
Davis, CA



# About the Authors

**Denis M. Medeiros, PhD, RD, LD**, received his PhD in nutrition from Clemson University in 1981, his MS in physiology from Illinois State University in 1976, and his BS degree from Central Connecticut State University in 1974. He has been on the faculties of Mississippi State University (1981–1984), the University of Wyoming (1984–1989), The Ohio State University (1989–2000), and Kansas State University (2000–2011). He is currently Dean Emeritus of the Graduate School and Professor Emeritus of Molecular Biology and Biochemistry at the University of Missouri at Kansas City. Formerly, Dr. Medeiros was full professor and head of the Department of Human Nutrition, as well as associate dean for scholarship and research, at Kansas State University. He holds the rank of Professor Emeritus of Food, Nutrition, Dietetics, and Health and Associate Dean Emeritus for Scholarship and Research at Kansas State University. He was a former associate dean for research and dean of the College of Human Ecology at The Ohio State University. He has also spent time as a visiting faculty member at the Medical University of South Carolina in Charleston, South Carolina, and at the Washington University School of Medicine in St. Louis, Missouri.

Dr. Medeiros's major research has focused on the role of trace minerals, particularly copper, on the integrity of the cardiovascular system, and on the role of iron in bone integrity. He has received more than \$4 million in grants to support his research endeavors from such institutions as the National Institutes of Health, the U.S. Department

of Agriculture, and the National Science Foundation. He has authored or coauthored more than 125 scientific peer-refereed articles. Additionally, he has served on numerous editorial boards of prominent journals and has held elective offices in scientific societies. He has taught classes, both at the introductory and advanced levels, for undergraduate students and has taught graduate-level courses throughout his career. In addition, Dr. Medeiros has received outstanding teaching awards for his efforts and is both a registered and licensed dietitian.

**Robert E. C. Wildman, PhD, RD, LD, FISSN**, received his PhD in human nutrition from The Ohio State University, his MS in foods and nutrition from The Florida State University, and his BS in dietetics and nutrition from the University of Pittsburgh. He is a fellow of the International Society of Sports Nutrition (ISSN) and is an adjunct faculty member in the Department of Food Science and Human Nutrition at Texas Woman's University in Denton, Texas. His major areas of research include nutrition application to metabolism, body composition, weight control and health, and athletic performance. He has authored or coauthored more than 30 papers and several nutrition books, including *The Nutritionist: Food, Nutrition, and Optimal Health* and *Sport and Fitness Nutrition*; he also edited the *Handbook of Nutraceuticals and Functional Foods*. Dr. Wildman is a registered and licensed dietitian with the Academy of Nutrition and Dietetics and is the creator of TheNutritionDr.com.