

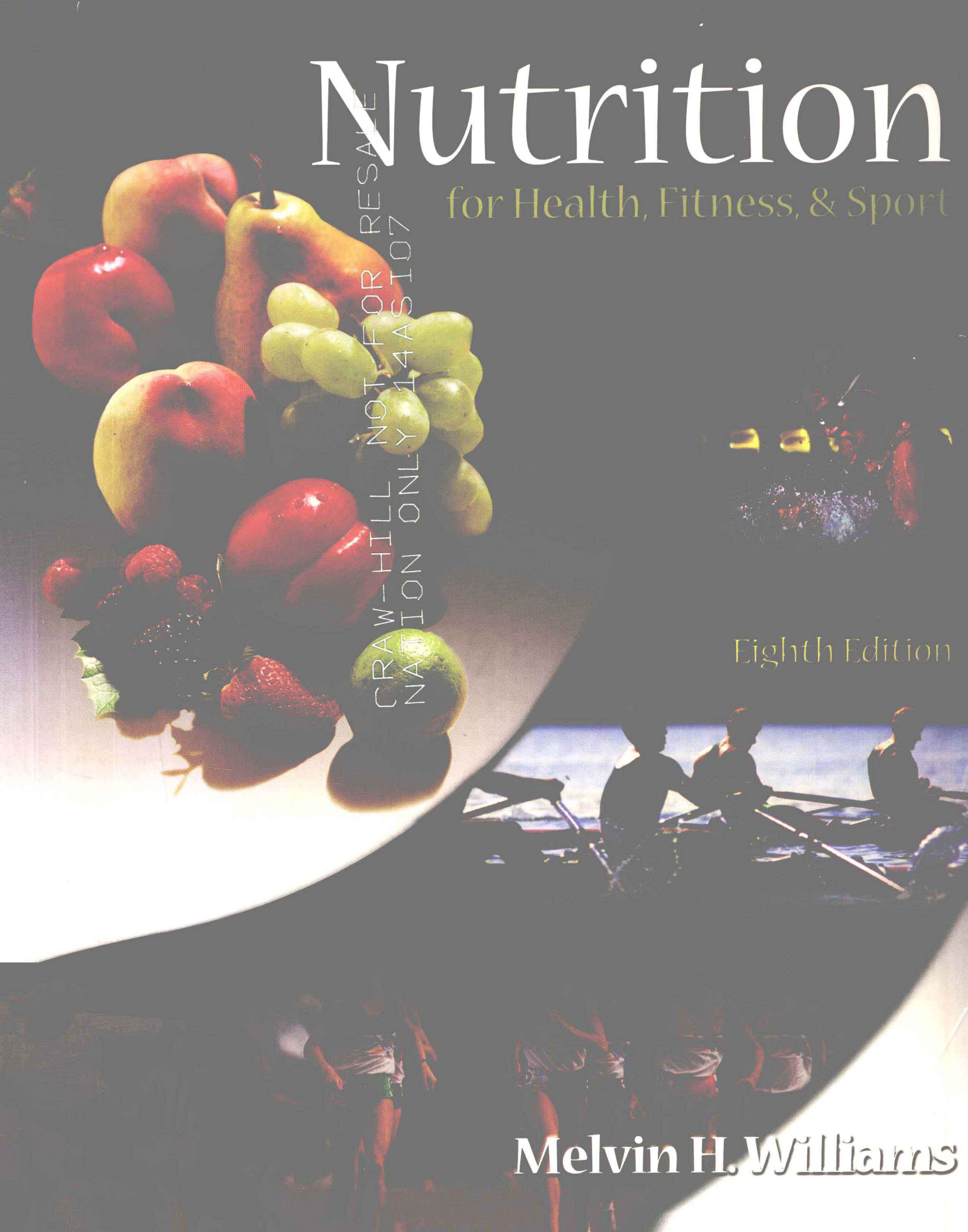
# Nutrition

for Health, Fitness, & Sport

Eighth Edition

Melvin H. Williams

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**Eighth Edition**

# NUTRITION

**FOR HEALTH, FITNESS, & SPORT**

**Melvin H. Williams**

*Old Dominion University*



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Marketing Manager: *Tami Petsche*

Project Manager: *April R. Southwood*

Senior Production Supervisor: *Kara Kudronowicz*

Senior Media Producer: *Jeffrey Schmitt*

Designer: *Rick D. Noel*

Cover Designer: *John Rokusek*

Lead Photo Research Coordinator: *Carrie K. Burger*

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**Dietary Reference Intakes (DRIs): Recommended Intakes for Individuals, Elements**  
Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Calcium (mg/d)	Chromium (µg/d)	Copper (µg/d)	Fluoride (mg/d)	Iodine (µg/d)	Iron (mg/d)	Magnesium (mg/d)	Manganese (mg/d)	Molybdenum (µg/d)	Phosphorus (mg/d)	Selenium (µg/d)	Zinc (mg/d)
<b>Infants</b>												
0-6 mo	210*	0.2*	200*	0.01*	110*	0.27*	30*	0.003*	2*	100*	1.5*	2*
7-12 mo	270*	5.5*	220*	0.5*	130*	11	75*	0.6*	3*	275*	20*	3
<b>Children</b>												
1-3 y	500*	11*	340	0.7*	90	7	80	1.2*	17	460	20	3
4-8 y	800*	15*	440	1*	90	10	130	1.5*	22	500	30	5
<b>Males</b>												
9-13 y	1,300*	25*	700	2*	120	8	240	1.9*	34	1,250	40	8
14-18 y	1,300*	35*	890	3*	150	11	410	2.2*	43	1,250	55	11
19-30 y	1,000*	35*	900	4*	150	8	400	2.3*	45	700	55	11
31-50 y	1,000*	35*	900	4*	150	8	420	2.3*	45	700	55	11
51-70 y	1,200*	30*	900	4*	150	8	420	2.3*	45	700	55	11
>70 y	1,200*	30*	900	4*	150	8	420	2.3*	45	700	55	11
<b>Females</b>												
9-13 y	1,300*	21*	700	2*	120	8	240	1.6*	34	1,250	40	8
14-18 y	1,300*	24*	890	3*	150	15	360	1.6*	43	1,250	55	9
19-30 y	1,000*	25*	900	3*	150	18	310	1.8*	45	700	55	8
31-50 y	1,000*	25*	900	3*	150	18	320	1.8*	45	700	55	8
51-70 y	1,200*	20*	900	3*	150	8	320	1.8*	45	700	55	8
>70 y	1,200*	20*	900	3*	150	8	320	1.8*	45	700	55	8
<b>Pregnancy</b>												
≤18 y	1,300*	29*	1,000	3*	220	27	400	2.0*	50	1,250	60	12
19-30 y	1,000*	30*	1,000	3*	220	27	350	2.0*	50	700	60	11
31-50 y	1,000*	30*	1,000	3*	220	27	360	2.0*	50	700	60	11
<b>Lactation</b>												
≤18 y	1,300*	44*	1,300	3*	290	10	360	2.6*	50	1,250	70	13
19-30 y	1,000*	45*	1,300	3*	290	9	310	2.6*	50	700	70	12
31-50 y	1,000*	45*	1,300	3*	290	9	320	2.6*	50	700	70	12

NOTE: This table presents Recommended Dietary Allowances (RDAs) in bold type and Adequate Intakes (AIs) in ordinary type followed by an asterisk (\*). RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97 to 98 percent) individuals in a group. For healthy breastfed infants, the AI is the mean intake. The AI for other life stage and gender groups is believed to cover needs of all individuals in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.

SOURCES: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (1997); Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B-6, Folate, Vitamin B-12, Pantothenic Acid, Biotin, and Choline (1998); Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000); and Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2001). These reports may be accessed via [www.nap.edu](http://www.nap.edu).

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# Dietary Reference Intakes (DRIs): Recommended Intakes for Individuals, Macronutrients

Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Carbohydrate (g/d)	Total Fiber (g/d)	Fat (g/d)	Linoleic Acid (g/d)	$\alpha$ -Linolenic Acid (g/d)	Protein <sup>a</sup> (g/d)
<b>Infants</b>						
0-6 mo	60*	ND	31*	4.4*	0.5*	9.1*
7-12 mo	95*	ND	30*	4.6*	0.5*	13.5
<b>Children</b>						
1-3 y	130	19*	ND <sup>b</sup>	7*	0.7*	13
4-8 y	130	25*	ND	10*	0.9*	19
<b>Males</b>						
9-13 y	130	31*	ND	12*	1.2*	34
14-18 y	130	38*	ND	16*	1.6*	52
19-30 y	130	38*	ND	17*	1.6*	56
31-50 y	130	38*	ND	17*	1.6*	56
51-70 y	130	30*	ND	14*	1.6*	56
>70 y	130	30*	ND	14*	1.6*	56
<b>Females</b>						
9-13 y	130	26*	ND	10*	1.0*	34
14-18 y	130	26*	ND	11*	1.1*	46
19-30 y	130	25*	ND	12*	1.1*	46
31-50 y	130	25*	ND	12*	1.1*	46
51-70 y	130	21*	ND	11*	1.1*	46
>70 y	130	21*	ND	11*	1.1*	46
<b>Pregnancy</b>						
14-18 y	175	28*	ND	13*	1.4*	71
19-30 y	175	28*	ND	13*	1.4*	71
31-50 y	175	28*	ND	13*	1.4*	71
<b>Lactation</b>						
14-18 y	210	29*	ND	13*	1.3*	71
19-30 y	210	29*	ND	13*	1.3*	71
31-50 y	210	29*	ND	13*	1.3*	71

NOTE: This table presents Recommended Dietary Allowances (RDAs) in bold type and Adequate Intakes (AIs) in ordinary type followed by an asterisk (\*). RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97 to 98 percent) individuals in a group. For healthy breastfed infants, the AI is the mean intake. The AI for other life stage and gender groups is believed to cover needs of all individuals in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.

<sup>a</sup>Based on 0.8g protein/kg body weight for reference body weight.

<sup>b</sup>ND = not determinable at this time

SOURCES: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002). This report may be accessed via [www.nap.edu](http://www.nap.edu). Copyright 2002 by the National Academy of Sciences. All rights reserved.

To Jeanne,  
Sara and Nik May  
Serena, Jeff, and Daniel Newsom  
and

To My Teachers,  
Colleagues, and Students



# Preface

In this new millennium, our love affair with fitness and sports continues to grow. Worldwide, although physical inactivity is still very prevalent in developed nations, more of us are joining fitness facilities or initiating fitness programs, such as bicycling, running, swimming, walking, and weight training. Improvement in health and fitness is one of the major reasons that more and more people initiate an exercise program. Research has shown that adults who become physically active also may become more interested in other aspects of their lifestyles—particularly nutrition—that may affect their health in a positive way.

Nutrition is the study of foods and their effects upon health, development, and performance. Although a relatively young science, nutrition research has made a significant contribution to our knowledge of essential nutrient needs. During the first part of the twentieth century, most nutrition research focused on identification of essential nutrients and amounts needed to prevent nutrient-deficiency diseases, such as scurvy from inadequate vitamin C. More recently, medical researchers have focused on the effects of foods and their specific constituents as a means to help prevent major chronic diseases, such as heart disease and cancer, that are epidemic in developed countries. *Nutriceutical* is a relatively new term used to characterize the drug, or medical, effects of a particular nutrient. Recent research findings continue to indicate that our diet is one of the most important determinants of our health status, and although individual nutrients are still being evaluated for possible health benefits, research is also focusing on dietary patterns, or the totality of the diet, and resultant health benefits.

Other than the health benefits of exercise and fitness, many physically active individuals also are finding the joy of athletic competition, participating in local sport events such as golf tournaments, tennis matches, triathlons, and road races. Individuals who compete athletically are always looking for a means to improve performance, be it a new piece of equipment or an improved training method. In this regard, proper nutrition may be a very important factor in improving exercise and sport performance. The United States Anti-Doping Agency (USADA), in its *Optimal Dietary Intake* guidelines for competitive athletes, notes that now more than ever, athletes need accurate sports nutrition information, indicating that optimal nutrition is an integral part of peak performance, while an inadequate diet and lack of fuel can limit an athlete's potential for maximum performance. Although the effect of diet on sport and exercise performance had been studied only sporadically prior to 1970, subsequently numerous sport scientists and sport nutritionists have studied the performance-enhancing effects of nutrition, such as diet composition and dietary

supplements. Results of these studies have provided nutritional guidance to enhance performance in specific athletic endeavors.

With the completion of the Human Genome Project, gene therapies are currently being developed for the medical treatment of various health problems. Moreover, some contend that genetic manipulations may be used to enhance sports performance. For example, gene doping to increase insulin-like growth factor, which can stimulate muscle growth, may be applied to sport.

Our personal genetic code plays an important role in determining our health status and our sports abilities, and futurists speculate that one day each of us will carry our own genetic chip that will enable us to tailor food selection and exercise programs to optimize our health and sport performance. Such may be the case, but for the time being we must depend on available scientific evidence to provide us with prudent guidelines.

Each year literally thousands of published studies and reviews analyze the effects of nutrition on health or exercise and sports performance. The major purpose of this text is to evaluate these scientific data and present prudent recommendations for individuals who want to modify their diet for optimal health or exercise/sport performance.

## Textbook Overview

This book uses a question-answer approach, which is convenient when you may have occasional short periods to study, such as riding a bus or during a lunch break. In addition, the questions are arranged in a logical sequence, the answer to one question often leading into the question that follows. Where appropriate, cross-referencing within the text is used to expand the discussion. No deep scientific background is needed for the chemical aspects of nutrition and energy expenditure, as these have been simplified. Instructors who use this book as a course text may add details of biochemistry as they feel necessary.

Chapter 1 introduces you to the general effects of exercise and nutrition on health-related and sports-related fitness, including the importance of well-controlled scientific research. Chapter 2 provides a broad overview of sound guidelines relative to nutrition for optimal health and physical performance. Chapter 3 focuses upon energy and energy pathways in the body, the key to all exercise and sport activities.

Chapters 4 through 9 deal with the six basic nutrients—carbohydrate, fat, protein, vitamins, minerals, and water—with emphasis on the health and performance implications for the

physically active individual. Chapters 10 through 12 review concepts of body composition and weight control, with suggestions on how to gain or lose body weight through diet and exercise, as well as the implications of such changes for health and athletic performance. Chapter 13 is a new chapter for this edition, covering several drug foods, such as alcohol and caffeine, and other related dietary supplements that previously had been integrated in other chapters. Instructors who prefer to adhere to the chapter content of previous editions may have students read the relevant sections of chapter 13. Several appendixes complement the text, providing data on caloric expenditure during exercise, methods to determine body composition, nutritional value of fast foods, and other information pertinent to physically active individuals.

## New to the Eight Edition

The content throughout each chapter of the book has been updated, where merited, based on contemporary research findings regarding the effects of nutritional practices on health, fitness, and sport performance. Over 450 new references, including clinical studies, reviews, and meta-analyses, have been added to the text. Some key changes regarding specific chapters follow.

### *Chapter 1—Introduction to Nutrition for Health, Fitness, and Sports Performance*

- New reviews on the role of exercise may play as a means to enhance health.

### *Chapter 2—Healthful Nutrition for Fitness and Sport*

- Detailed coverage for the new *MyPyramid* food guide, the United States Department of Agriculture's sixth edition detailing healthy eating guidelines for Americans.
- New information on food colors and potential health benefits.

### *Chapter 3—Human Energy*

- New information on factors contributing to fatigue during exercise, including overreaching and overtraining.

### *Chapter 4—Carbohydrate: The Main Energy Food*

- New viewpoints on how impaired carbohydrate stores in the body may contribute to fatigue during exercise.
- Optimizing the type of carbohydrate to ingest during exercise as a means to enhance performance.
- Expanded discussion of the role of *healthy* carbohydrates in the diet.

### *Chapter 5—Fat: An Important Energy Source during Exercise*

- Enhanced discussion of the role that modification of dietary fat intake, such as *trans* fat and omega-3 fatty acids, may play in determining health status.
- New National Cholesterol Education Program guidelines involving when it may be appropriate to recommend use of drugs to reduce serum cholesterol.

### *Chapter 6—Protein: The Tissue Builder*

- Updated information on protein and carbohydrate intake to promote protein synthesis following exercise.
- New research findings with branched-chain amino acid supplementation and glucosamine-chondroitin supplementation.

- Updated research findings regarding creatine supplementation and its effect on exercise performance and health status.

### *Chapter 7—Vitamins: The Organic Regulators*

- New viewpoints on the possible role of vitamin D in health.
- New research findings regarding the limitations to health improvement or performance enhancement from antioxidant vitamin supplementation.

### *Chapter 8—Minerals: The Inorganic Regulators*

- An evaluation of the role that dietary calcium may play in weight control.
- Discussion of the new American College of Sports Medicine position stand on physical activity and bone health.

### *Chapter 9—Water, Electrolytes, and Temperature Regulation*

- An expanded discussion of exercise-associated hyponatremia (EAH), including its etiology and potential dangers.
- Discussion of the new American College of Sports Medicine position stand on exercise and hypertension.

### *Chapter 10—Body Weight and Composition for Health and Sport*

- Updated discussion of the relationship of body mass index (BMI) and waist circumference to health status and mortality.
- Updated information on the role of dietary supplements in weight loss.

### *Chapter 11—Weight Maintenance and Loss through Proper Nutrition and Exercise*

- Recent research comparing the effectiveness of various diets, such as low-fat and low-carbohydrate, for weight loss.
- Twenty ways to decrease caloric intake.

### *Chapter 12—Weight Gaining through Proper Nutrition and Exercise*

- Incorporated some general guidelines for percent macronutrient (carbohydrate, fat, protein) intake for competitive bodybuilders.

### *Chapter 13—Food Drugs and Related Supplements*

- A new chapter incorporating recent information on alcohol, caffeine, ephedrine, sodium bicarbonate, selected herbals, and anabolic dietary supplements and their effects on health and sport performance.

## Enhanced Pedagogy

Each chapter contains several features to help enhance the learning process. **Chapter Learning Objectives** are presented at the beginning of each chapter, highlighting the key points and serving as a studying guide. **Key Terms** also are listed at the beginning of each chapter, along with the page number on which they are first highlighted and defined. Although some terms may appear in the text before they are defined, a thorough glossary includes the key terms as well as other terms warranting definition. **Key Concept Check** provides a summary of essential information presented in each main section. Students are encouraged to participate in several practical activities to help reinforce learning. **Check for Yourself** includes individual activities, such as checking food labels at the supermarket or measuring your body fat percentage, while the **Application Exercise** at the end of each chapter may involve more extensive involvement, such as a case study in weight control.



involving yourself or a survey of an athletic team. Students may wish to peruse all application exercises at the beginning of the course, as some may take several weeks or months to complete.

The bibliographic references are of three types. *Books* listed provide broad coverage of the major topics in the chapter. *Reviews* are detailed analyses of selected topics, usually involving a synthesis and analysis of specific research studies. The *specific studies* listed are primary research studies. The reference lists have been completely updated for this eighth edition, with the inclusion of nearly 450 new references, and provide the scientific basis for the new concepts or additional support for those concepts previously developed. These references provide greater in-depth reading materials for the interested student. Although the content of this book is based on appropriate scientific studies, a reference-citation style is not used, that is, each statement is not referenced by a bibliographic source. However, names of authors may be used to highlight a reference source where deemed appropriate.

This book is designed primarily to serve as a college text in professional preparation programs in health and physical education, exercise science, athletic training, sports medicine, and sports nutrition. It is also directed to the physically active individual interested in the nutritional aspects of physical and athletic performance.

Those who may desire to initiate a physical training program may also find the nutritional information useful, as well as the guidelines for initiating a training program. This book may serve as a handy reference for coaches, trainers, and athletes. With the tremendous expansion of youth sports programs, parents may find the information valuable relative to the nutritional requirements of their active children.

In summary, the major purpose of this book is to help provide a sound knowledge base relative to the role that nutrition, complemented by exercise, may play in the enhancement of both health and sport performance. Hopefully, the information provided in this text will help the reader develop a more healthful and performance-enhancing diet. Bon appetit!

## Acknowledgements

This book would not be possible without the many medical/health scientists and exercise/sport scientists throughout the world who, through their numerous studies and research, have provided the scientific data that underlie its development. I am fortunate to have developed a friendship with many of you, and I extend my sincere appreciation to all of you.

The reviewers of the seven previous editions have played an integral role in the changes that are made, and this edition is no exception. I wish to extend a special note of appreciation to those who reviewed the seventh edition text and provided many valuable suggestions for improving the eighth edition manuscript.

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Jie Kang

Tom Kelly

George Langford

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Michael J. Webster

*University of Southern  
Mississippi*

Suzy Weems

*Stephen F. Austin State  
University*

Roy Wohl

*Washburn University*

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*Melvin H. Williams  
Norfolk, Virginia*

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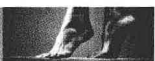
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## CHAPTER ONE

### LEARNING OBJECTIVES

After studying this chapter, you should be able to:

1. Explain the role of both genetics and environment, particularly nutrition and exercise, in the determination of optimal health and successful sport performance.
2. List each of the components of health-related fitness, and then identify the potential health benefits of a physical fitness program designed to enhance both aerobic and musculoskeletal fitness.
3. List the twelve guidelines underlying the Prudent Healthy Diet and discuss, in general, the importance of proper nutrition, including the role of dietary supplements, to optimal health.
4. Understand the importance of proper nutrition, including the role of dietary supplements as ergogenic aids, to sports performance.
5. Define nutritional quackery and understand the various strategies you can use to determine whether the claims of a dietary supplement are valid.
6. Explain what types of research have been used to evaluate the relationship between nutrition and health or sport performance, and evaluate the pros and cons of each type.

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