

EXERCISE PHYSIOLOGY

Human Bioenergetics and Its Applications

FOURTH EDITION

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EXERCISE PHYSIOLOGY: HUMAN BIOENERGETICS AND ITS APPLICATIONS

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*To our Mentors: John A. Faulkner, Charles M. Tipton,
and the late G. Lawrence Rarick.*

PREFACE

In several major ways the first edition of *Exercise Physiology: Human Bioenergetics and Its Applications* was a departure from existing texts in the field. The text was unique in terms of focusing on human bioenergetics and attempting to describe muscle performance in terms of energy transduction at cellular levels. Our approach came out of the then (early 1980s) burgeoning field of exercise biochemistry. In the fourth edition of *Exercise Physiology* this theme has been retained, but the approach has become increasingly mechanistic due to many developments, including the use of molecular and cellular biology and isotope tracer technology in the field.

Such is the pace of current discovery that for the third and fourth editions it was necessary to add Dr. Kenneth M. Baldwin as a coauthor. Dr. Baldwin is an acknowledged leader in studies of muscular adaption to exercise stress. Our thematic emphasis, our original scientific contributions using both the tools and techniques of contemporary biology and classical performance physiology, as well as our overall familiarity with the field, have allowed us to respond to the challenge of providing an up-to-date text for students of the field. The first three editions of *Exercise Physiology* found widespread use in institutions of higher learning in the United States and Canada. We hope that the current edition will also merit extended use, not only in North America, but elsewhere as well.

The ever-increasing pace of progress in biological sciences can be traced to the development and application of tools and strategies of *in vivo* metabolic biochemistry and cell and molecular biology. Many scientists and science administrators have written about these changes in the biological sci-

ences. In his article titled "Research in sports medicine and exercise sciences in the 21st century," which appeared in the American College of Sports Medicine bulletin (vol. 34, no. 3, p. 9), Ken Baldwin wrote about "the times that are a-changing." To quote Ken, "Within the next five to eight years the complete genomes for the mouse, rat, and human will be deciphered. These genetic maps will serve as the blueprints for evolving the science that will unfold; and with the new molecular tools coming aboard it will be possible to decipher clusters of genes involved in various disorders such as obesity, the metabolic syndrome, as well as ascertaining why our muscles waste away as one ages." In preparing the fourth edition of *Exercise Physiology*, we have utilized the information available and anticipated "the exciting research initiatives ready to explode in the twenty-first century." Specifically, with regard to the rapidly developing influences of cell and molecular biology techniques and experimental approaches on exercise physiology, the reader is referred to sections on muscle membrane lactate transporters (Chapter 5) and influences of exercise overload on myosin expression (Chapter 17).

In writing or revising a textbook there are many challenges. Beyond dealing with the volume of ever-changing science, a far greater challenge lies in appropriately interpreting the results of classical as well as contemporary studies. Continually we re-evaluate appropriateness of our theme: exercise as bioenergetic events. At its essence, scientific discovery involves disputation and thus, in some areas, our judgments may be controversial. Notwithstanding, we believe we are scientifically justified in

presenting concepts in particular areas, although we recognize that some scientists and educators will disagree with our emphases and interpretations. The student must realize, however, that in this respect our textbook is no different from any other. To minimize influences of our biases in composing the text, we have consciously included many original data sets. The intent in providing many figures and tables from the literature is to provide the impetus for students to recognize that the viability of the conclusions we reach is limited by the technologies available. Further, we have included original materials so that readers will be able to discuss the limitations in data and its interpretation. Anecdotally, with regard to the area of energy substrate utilization during exercise (Chapters 5–10), it is a great relief to know now that many of the conclusions reached on the basis of experiments with rodents in the 1970s and 1980s were correct for humans. Nonetheless, species differences are a real concern, and thus some of our interpretations (for example, the importance of lipid and amino acid oxidation for human muscular exercise, Chapters 7 and 9) have needed to be modified. Fortunately, a burgeoning of recent literature employing stable, nonradioactive isotope technology has allowed the conclusions in that section of the book to be based on results of experiments on men and women, not just lab animals.

As with the first edition, we remain extremely enthusiastic about our field. We believe that no greater interest can be generated for the study of physiology than that involved in analyzing human performance during motor activities, particularly when the student's object of study is himself or herself. Because so many of us are engaged in lifestyles that require high-energy outputs, it is important that we understand our physiological capacities for exercise, which largely determine our success and enjoyment in many areas. Studying exercise physiology not only allows students to understand the mechanisms governing their own performance, but also enables them to be aware of performance in athletics, work, the performing arts, recreation, and preventive and rehabilitative medicine. Importantly, for students going on to careers in clinical professions, this work teaches about the scope of

human metabolic responses and the range of plasticity in cell and system adaptations. Thus this book links the student of physiology to the reader's self-interest and professional interests.

In terms of its potential to enhance and promote the general health and well-being of the population, we are equally enthusiastic about potential applications of information from the field of exercise physiology. In our contemporary society, chronic degenerative diseases have replaced infectious diseases as major causes of debilitation and death—most notably coronary heart disease (CHD) and Type II diabetes (NIDDM). The causes of CHD and NIDDM are complex, but lack of physical exercise as well as mal- over-nutrition are certainly involved. Recognition of the relationship between degenerative diseases and physical inactivity on the bases of epidemiological and intervention studies led to the Surgeon General's Report on Physical Activity and Health. As well, most recently in its *Macronutrient Report* (IOM, 2002), the Institute of Medicine decided to base dietary recommendations on energy expenditure. Hence, for the first time, a specific physical activity recommendation became integral to dietary recommendations. Therefore, as described in Chapter 1 and throughout the text, not only is proper physical exercise essential for somatic development in the formative years, but it is also necessary for maintenance of physical capacity and healthy body composition in adults. Today, exercise is used to diagnose coronary heart disease, to retard its development, and to treat it. Exercise conditioning and other forms of physical therapy are used to assist and improve recuperation from injury to, and surgery on, muscles and joints. It is our hope that the Surgeon General's and Institute of Medicine's advocacies are not too late—for the incidence of obesity, CHD, NIDDM, and related pathologies is ever-increasing, reaching epidemic proportions in contemporary Western societies.

Our considerable experience in the field has, we hope, engendered us with wisdom to interpret events shaping the field of exercise physiology and to place and portray those events within the broader discipline of biological science. Therefore, in the introductory chapter we have expanded the section

on the history of exercise physiology, its events, and its personalities. In addition, we have written about the emergence of the American College of Sports Medicine and its coalition with other scholarly, clinical, and public health organizations that produced the Surgeon General's report. Also of note is the emergence of the European College of Sports Science and similar organizations around the world.

Many people have inspired this book, including our teachers, W. D. McArdle, J. A. Faulkner, R. E. Beyer, K. J. Hittelman, F. M. Henry, G. L. Rarick, C. M. Tipton, and J. H. Wilmore. We have been inspired by many contemporary and past researchers, whose work is referenced in our chapters. We also thank the authors of other texts, which we as students have used, including A. C. Guyton, A. L. Lehninger, P. O. Åstrand, V. R. Edgerton, E. Fox, M. Kleiber, A. J. Vander, J. S. Sherman, and D. S. Luciano. We also thank reviewers of past editions as well as Stephen Glass (Grand Valley State Univer-

sity), Michael Godard (Kansas State University), Fred Kolkhorst (San Diego State University), and Christopher J. Womack (Michigan State University), who commented on the third edition. So far as our research careers are concerned, those careers in science have served to lay the bases upon which we wrote this text. Therefore, we thank our many colleagues, research associates, students, and postdoctoral fellows in research with whom we have enjoyed working and who have helped our careers to prosper. They have supported us, inspired us, cheered us, and filled our lives with challenge and satisfaction. The ideas and efforts of all of these individuals are contained in our text.

As authors we would appreciate hearing your reviews and opinions of our text. We encourage you to write us with your criticisms and suggestions, which will be seriously considered for incorporation into subsequent printings and editions of this book.

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