# EXERCISE PHYSIOLOGY

SECOND EDITION

## Human Bioenergetics and Its Applications

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*To our sons: Alex, Daniel, Mikey, Randy, Timmy, Timmy, and Tommy.*
*They are the inspiration to this and other works.*

# PREFACE

The first edition of *Exercise Physiology: Human Bioenergetics and Its Applications* was a departure from existing texts in the field. When it was published in 1984, the field of exercise biochemistry was just coming into its own. It was growing and expanding rapidly. With publication of the text, we achieved our goal of participating in its evolution. Key elements of that branch of science allowed us to focus on human bioenergetics and to describe performance in terms of energy transduction from cell to whole-body levels.

In some ways, publication of *Exercise Physiology* was a watershed event. A comparison of texts from the 1970s with those published today would reveal major differences in coverage and sophistication, particularly with regard to metabolism. Further, the existence of several fine contemporary texts on exercise physiology not only reflects developments in the field but, we feel, results from precedents set in *Exercise Physiology.* That our text has remained a standard for more than a decade is testament to its originality and importance. It has served as a model for others and, in several respects, it has never been surpassed.

Of course, since publication of that first edition, the field has continued to grow in every way. Thus, a second edition became inevitable, and we enlisted our friend and colleague, Tim White, a recognized researcher in the field of muscle physiology, in the immense task of revising our text.

In writing or revising a textbook, there are many challenges—and a few rewards. The challenges include dealing with the enormous volume of scientific data available, the imperative to be factually accurate, and the need to interpret correctly the results of classical, as well as contemporary, studies. Because, at its essence, science involves controversy, our judgments in some areas are likely to be controversial. And although we believe our conclusions in particular areas are scientifically correct (for example, the control of substrate utilization during exercise, the lactate shuttle, the role of the mitochondrial reticulum, control of mitochondrial biogenesis, and periodization of training), we recognize that other competent scientists will disagree with our emphases, if not our interpretations. In this respect, our text is no different from any other. Nevertheless, we support our conclusions with original data sets, which we include. We also include original figures, tables, and graphs. We feel that including this information will enable readers to understand how scientific conclusions are limited by available technologies, as well as by available data and their interpretation. Our efforts in undertaking this immense task will be rewarded if the book serves students of the field.

Publishing the first edition of *Exercise Physiology* had several outcomes: some surprising, some not. One comment we heard occasionally was that our work was a "graduate text." Although complimentary, we found this comment perplexing, as it was our experience that graduate students belong in the library reading primary sources and in the laboratory generating new knowledge. We were perplexed also because, then as now, instructors of exercise physiology conduct their own independent research programs and usually require prerequisite work in basic physiology, anatomy, and chemistry. Because we were aware of the level of sophistication in texts required for those prerequisite courses, it was our

judgment that a text in exercise physiology should be at least as extensive and sophisticated. Therefore, this second edition of *Exercise Physiology* is intended to serve as a text for an upper-division undergraduate course, and perhaps also as a reference for beginning graduate students.

We remain extremely enthusiastic about our field. We believe that the greatest interest in studying physiology comes from analyzing human performance during motor activities, particularly when a student's object of study is himself or herself. Many of us are engaged in life-styles that require high-energy outputs, so 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. Thus, this book links the study of physiology to the reader's own self-interest.

Physical performance determines the outcome of many areas of human activity. Our ability to fulfill a busy work schedule and to retain an energy reserve is essential for enjoyment in our lives. Although physical capability no longer plays a determinant role in survival, it contributes largely to the development and maintenance of physique and self-image. In turn, an individual's physical performance is the result of such factors as genetic endowment, state of maturation, nutrition, training, and environment—all areas covered in this book.

In our contemporary society, degenerative diseases—most significantly coronary heart disease (CHD)—have replaced infectious diseases as major causes of debilitation and death. The causes of CHD are complex, but lack of exercise and lack of proper active recreation are involved. Therefore, proper physical exercise is essential not only for physical development in the formative years, but also for maintenance of physical capacity in younger and older adults. Today, exercise is used to diagnose CHD, 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. The use of exercise to diagnose, prevent and treat degenerative diseases is an important aspect of this book.

Many people have helped write this book, including our teachers W. D. McArdle, J. A. Faulkner, R. E. Beyer, K. J. Hittelman, F. M. Henry, G. L. Rarick, and J. H. Wilmore. We have also been inspired by many contemporary and past researchers, who are referenced at the end of our chapters. In addition, we want to thank the authors of other texts that we used as students, including A. C. Guyton, P.-O. Åstrand, V. R. Edgerton, E. Fox, M. Kleiber, R. W. McGilvery, A. J. Vander, J. S. Sherman, and D. S. Luciano. Finally, we want to thank the reviewers of our manuscript, including Patty S. Freedson, University of Massachusetts; Michael C. Meyers, Montana State University; Don Morgan, University of North Carolina, Greensboro; and Phillip B. Watts, Northern Michigan University.

As authors we would appreciate hearing your reviews and opinions of our text. We encourage you to consult the ACSM or FASEB directories and to write us with your criticisms and suggestions, which we will seriously consider for incorporation into subsequent printings and editions of this book.

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