Preface

Physics and instrumentation affect all of the subspecialty areas of nuclear medicine. Because of their fundamental importance, they usually are taught as a separate course in nuclear medicine training programs. This book is intended for use in such programs by physicians, technologists, and scientists who desire to become specialists in nuclear medicine and molecular imaging, as well as a reference source for physicians, scientists, and engineers in related fields.

Although there have been substantial and remarkable changes in nuclear medicine, the goal of this book remains the same as it was for the first edition in 1980: to provide an introductory text for such courses, covering the physics and instrumentation of nuclear medicine in sufficient depth to be of permanent value to the trainee or student, but not at such depth as to be of interest only to the physics or instrumentation specialist. The fourth edition includes many recent advances, particularly in single-photon emission computed tomography (SPECT) and positron emission tomography (PET) imaging. As well, a new chapter is included on hybrid imaging techniques that combine the exceptional functional and physiologic imaging capabilities of SPECT and PET with the anatomically detailed techniques of computed tomography (CT) and magnetic resonance imaging (MRI). An introduction to CT scanning is also included in the new chapter.

The fourth edition also marks the first use of color. We hope that this not only adds cosmetic appeal but also improves the clarity of our illustrations.

The organization of this text proceeds from basic principles to more practical aspects. After an introduction to nuclear medicine (Chapter 1), we provide a review of atomic and nuclear physics (Chapter 2) and basic principles of radioactivity and radioactive decay (Chapters 3 and 4). Radionuclide production methods are discussed in Chapter 5, followed by radiation interactions in Chapter 6. Basic principles of radiation detectors (Chapter 7), radiation-counting electronics (Chapter 8), and statistics (Chapter 9) are provided next.

Following the first nine chapters, we move on to detailed discussions of nuclear medicine systems and applications. Pulse-height spectrometry, which plays an important role in many nuclear medicine procedures, is described in Chapter 10, followed by general problems in nuclear radiation counting in Chapter 11. Chapter 12 is devoted to specific types of nuclear radiation-counting instruments, for both in vivo and in vitro measurements.

Chapters 13 through 20 cover topics in radionuclide imaging, beginning with a description of the principles and performance characteristics of gamma cameras (Chapters 13 and 14), which are still the workhorse of many nuclear medicine laboratories. We then discuss general concepts of image quality in nuclear medicine (Chapter 15), followed by an introduction to the basic concepts of reconstruction tomography (Chapter 16).

The instrumentation for and practical implementation of reconstruction tomography are discussed for SPECT in Chapter 17 and for PET in Chapter 18. Hybrid imaging systems, as well as the basic principles of CT scanning, are covered in Chapter 19. Chapter 20 provides a summary of digital image processing techniques, which are important for all systems and applications.

The imaging section of this text focuses primarily on instruments and techniques that now enjoy or appear to have the potential for achieving clinical acceptance. However, nuclear medicine imaging has become increasingly important in the research environment. Therefore we have included some systems that are used for small-animal or other research purposes in these chapters.

We then move on to basic concepts and some applications of tracer kinetic modeling (Chapter 21). Tracer kinetic modeling and its applications embody two of the most important strengths of nuclear medicine techniques: the ability to perform studies with minute (tracer) quantities of labeled molecules and the ability to extract quantitative biologic data from these studies. We describe the main assumptions and mathematical models used and present several examples of the application of these models for calculating physiologic, metabolic, and biochemical parameters

The final two chapters address radiation dose and safety issues. Internal radiation dosimetry is presented in Chapter 22, and the final chapter presents an introduction to the problems of radiation safety and health physics (Chapter 23). We did not deal with more general problems in radiation biology, believing this topic to be of sufficient importance to warrant its own special treatment, as has been done already in several excellent books on the subject.

Additional reading for more detailed information is suggested at the end of each chapter. We also have included sample problems with solutions to illustrate certain quantitative relationships and to demonstrate standard calculations that are required in the practice of nuclear medicine. Systeme Internationale (SI) units are used throughout the text; however, traditional units still appear in a few places in the book, because these units remain in use in day-to-day practice in many laboratories. Appendix A provides a summary of conversion factors between SI and traditional units.

Appendixes B, C, and D present tables of basic properties of elements and radionuclides, and of attenuation properties of some materials of basic relevance to nuclear medicine. Appendix E provides a summary of radiation dose estimates for a number of nuclear medicine procedures. Although much of this information now is available on the Internet, we believe that users of this text will find it useful to have a summary of the indicated quantities and parameters conveniently available.

Appendixes F and G provide more detailed discussions of Fourier transforms and convolutions, both of which are essential components of modern nuclear medicine imaging, especially reconstruction tomography. This is the only part of the book that makes extensive use of calculus.

The fourth edition includes extensive revisions, and we are grateful to our many colleagues and friends who have assisted us with information, data, and figures. Particular gratitude is extended to Hendrik Pretorius, Donald Yapp, Jarek Glodo, Paul Kinahan, David Townsend, Richard Carson, Stephen Mather, and Freek Beekman. We also wish to thank readers who reported errors and inconsistencies in the third edition and brought these to our attention. In particular, we recognize the contributions of Andrew Goertzen, Tim Turkington, Mark Madsen, Ing-Tsung Hsiao, Jyh Cheng Chen, Scott Metzler, Andrew Maidment, Lionel Zuckier, Jerrold Bushberg, Zongjian Cao, Marvin Friedman, and Fred Fahey. This feedback from our readers is critical in ensuring the highest level of accuracy in the text. Naturally, any mistakes that remain in this new edition are entirely our responsibility.

We are grateful to Susie Helton (editorial assistance), and Robert Burnett and Simon Dvorak (graphics), at the University of California–Davis for their dedication to this project. We also appreciate the patience and efforts of the editorial staff at Elsevier, especially Lisa Barnes, Cindy Thoms, and Don Scholz. Finally, we thank our many colleagues who have used this book over the years and who have provided constructive feedback and suggestions for improvements that have helped to shape each new edition.

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