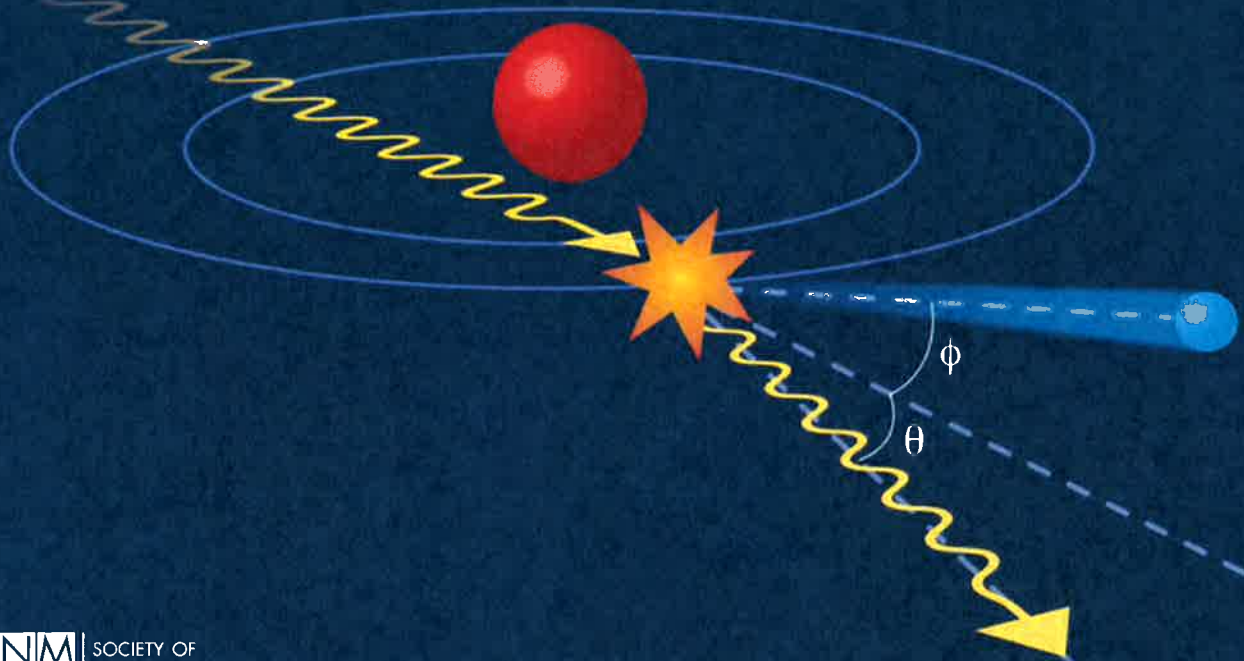


BASIC SCIENCE OF NUCLEAR MEDICINE

The Bare Bone Essentials

Kai H. Lee, PhD

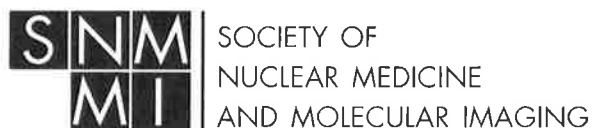


BASIC SCIENCE OF NUCLEAR MEDICINE

The Bare Bone Essentials

Kai H. Lee, PhD

Keck School of Medicine
University of Southern California
Los Angeles, California



TECHNOLOGIST SECTION
1850 Samuel Morse Drive, Reston, VA 20190

Library of Congress Cataloging-in-Publication Data

Lee, Kai H., author.

Basic science of nuclear medicine : the bare bone essentials / Kai H. Lee.

p. ; cm.

Includes bibliographical references and index.

ISBN 978-0-932004-90-1

I. Society of Nuclear Medicine and Molecular Imaging, publisher. II. Title.

[DNLM: 1. Nuclear Medicine—methods. 2. Image Interpretation, Computer-Assisted—
methods. WN 440]

RC78.7.N83

616.07'548—dc23

2014044762

Society of Nuclear Medicine and Molecular Imaging Technologist Section
1850 Samuel Morse Drive, Reston, VA 20190-5316

©2015 by the Society of Nuclear Medicine and Molecular Imaging Inc. All rights reserved. This book is protected by copyright. No part of it may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the publisher.

Made in the United States of America.

This book is dedicated to my wife Susanna.

CONTENTS

Dedication/iii

Preface/vii

Chapter 1. Atomic and Nuclear Structures/1

Chapter 2. Radioactive Decay Mechanisms/13

Chapter 3. Production of Radionuclides/29

Chapter 4. Calculation of Radioactivity/43

Chapter 5. Interaction of Radiation with Matter/59

Chapter 6. Radiation Detection and Measurements/73

Chapter 7. Principles of Gamma Cameras/87

Chapter 8. Single Photon Emission Computed Tomography/105

Chapter 9. Computed Tomography and SPECT/CT/131

Chapter 10. Positron Emission Tomography/167

Chapter 11. Positron Emission Tomography/Magnetic Resonance
Imaging/189

Chapter 12. Quality Assurance of Nuclear Medicine
Instruments/231

Chapter 13. Fundamentals of Counting Statistics/265

Chapter 14. Radiation Safety and Regulations of Ionization
Radiation/283

Chapter 15. Dosimetry of Internally Deposited Radionuclides/313

Chapter 16. Radiation Dosimetry and CT Dose Reduction
Techniques/331

Glossary/343

Bibliography/359

Index/363

PREFACE

This book is an outgrowth of a set of lecture notes that I prepared for the nuclear medicine student technologists and resident physicians. Over the years in teaching the basic science of nuclear medicine, I found many students lost track of the important points while wading through all the comprehensive texts. My lecture notes were prepared to direct the students' attention to principles I believed were important to understand the science behind nuclear medicine. Accuracy was often sacrificed in the notes to simplify the explanation. Similarly, in this textbook I have generalized many key principles for the sake of understandability instead of dwelling on minute technicalities. If a picture is worth a thousand words, extensive information graphics were called upon to supplement the explanation of abstract physics concepts. I also exercised my amateur photography skill to take pictures of items in my collection of parts discarded by the service engineers to give the readers a physical feel for how theory is translated to technology.

The readers may find many concept descriptions repeated throughout the text. This was done on purpose. One technique I found very effective in teaching difficult concepts was repetition. Many readers may have heard the proverbial saying that the only way to bring a point across to people is: "Tell them what you want to tell them, tell them again, and repeat what you told them." I took this technique to heart as my style of teaching. Since I never heard comments in my years of teaching that my repetitive lectures sounded like broken records, I extended the redundancy approach to this writing. Because the intent of this text is to give a bare bone minimum introduction to the basic science behind nuclear medicine, some readers may find certain topics missing or lacking in detail. An up-to-date list of references is included at the end of the book for the interested readers to pursue in-depth discussions on topics of their interest.

One bold assumption I made at the onset is that most of my readers have severe allergic reactions to mathematics. I thus strived toward

keeping mathematics to the minimum necessary to show where certain “must know” equations came from. When I had to subject readers to heavy-duty equations, I fully explained them step by step with detailed descriptions and elaborated on the meaning of the final equation.

Converting class notes to an organized textbook required far greater thought and the help of experts than I initially anticipated. Unlike class notes, the author is not there to explain if the reader does not understand what is written in the text. I am therefore very grateful to the members of the Editorial Board of the Society of Nuclear Medicine and Molecular Imaging who thoroughly reviewed the manuscript and offered numerous suggestions for improving the readability and clarity of the text. I want to thank Lynn Jacobs, CNMT, Sudha Challa, MD, and Patrick Colletti, MD, for their initial reading of the manuscript.

I also want to thank Amy Lee Ketchum for making the beautiful drawings and for her patience in making the changes that I demanded.