MOORE

Clinically Oriented Anatomy

EIGHTH EDITION

KEITH L. MOORE
ARTHUR F. DALLEY
ANNE M. R. AGUR

Wolters Kluwer

Clinically Oriented Anatomy

EIGHTH EDITION

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In Loving Memory of Marion

To my lovely wife and best friend for her endless support and patience. Her forbearance allowed me to spend countless hours in isolation to write the first three editions of the Clinically Oriented Anatomy. Marion received a BA in 1977, and she carefully read every line of the manuscripts. Wonderful memories keep her in my heart and mind. I am grateful to my daughter Pam (B.Ed.) who assumed the office duties and to my son-in-law, Ron Crowe, for his technical skills. Both have helped me in reviewing the manuscript for this book. • **(KLM)**

To Our Children and Grandchildren

I am very proud of our five children—Warren, Pam, Karen, Laurel, and Kate, and our nine grandchildren—Kristin, Lauren, Caitlin, Mitchel, Jayme, Courtney, Brooke, Melissa, Alicia, and the First Great Grandchild, James. • **(KLM)**

To Muriel and Our Family

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To Enno and Our Family

To my husband, Enno, and to my family, Kristina, Erik, and Amy, for their support and encouragement. • **(AMRA)**

To Our Students

We hope you will enjoy reading this book, increase your understanding of clinically oriented anatomy, pass your exams,

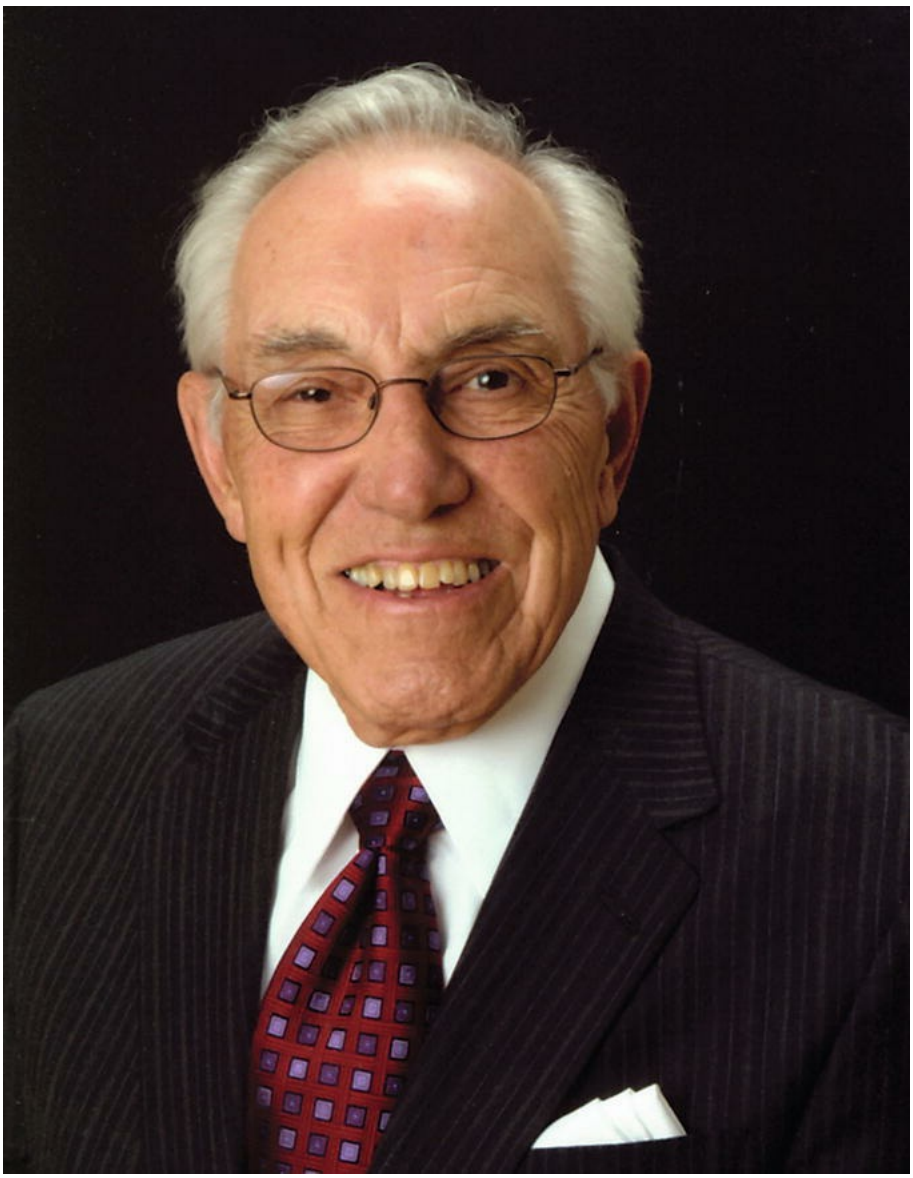
and be excited and well prepared for your careers in patient care, research, and teaching. You will remember some of what you hear, much of what you read, more of what you see, and almost all of what you experience and understand fully.

To Professors

May our book be a helpful resource for you. We appreciate the numerous constructive comments we have received over the years from you. Your remarks have been invaluable to us in improving this edition.

To Anatomical Donors

With sincere appreciation to all those who donate their bodies for anatomical study and research, without whom anatomical textbooks and atlases, and anatomical study in general would not be possible.



Keith L. Moore, MSc, PhD, Hon. DSc, FIAC, FRSM, FAAA

Dr. Moore has been the recipient of many prestigious awards and recognitions. He has received the highest awards for excellence in human anatomy education at the medical, dental, graduate, and undergraduate levels—and for his remarkable record of textbook publications in clinically oriented anatomy and embryology—from both the American Association of Anatomists (AAA: Distinguished Educator Award, 2007) and the American Association of Clinical Anatomists (AACA: Honored Member Award, 1994). In 2008, Dr. Moore was inducted as a Fellow of the American Association of Anatomists. The rank of Fellow honors distinguished members who have demonstrated excellence in science and their overall contributions to the medical sciences. In 2012, Dr. Moore received an honorary Doctor of Science degrees from The Ohio State University and the University of Western Ontario, the Queen Elizabeth II

Diamond Jubilee Medal honoring significant contributions and achievements by Canadians, and the R. Benton Adkins, Jr. Distinguished Service Award for his outstanding record of service to the American Association of Clinical Anatomists.

Arthur F. Dalley II

Arthur F. Dalley II, PhD, FAAA

Anne M.R. Agur, BSc (OT), MSc, PhD

Preface

A third of a century has passed since the first edition of *Clinically Oriented Anatomy* appeared on bookstore shelves. Although the factual basis of anatomy is remarkable among basic sciences for its longevity and consistency, this book has evolved markedly since its inception. This is a reflection of changes in the clinical application of anatomy, new imaging technologies that reveal living anatomy in new ways, and improvements in graphic and publication technology that enable superior demonstration of this information. Efforts continue to make this book even more student friendly and authoritative. The eighth edition has been thoroughly reviewed by students, anatomists, and clinicians for accuracy and relevance and revised with significant new changes and updates.

KEY FEATURES

Clinically Oriented Anatomy has been widely acclaimed for the relevance of its clinical correlations. As in previous editions, the eighth edition places clinical emphasis on anatomy that is important in physical diagnosis for primary care, interpretation of diagnostic imaging, and understanding the anatomical basis of emergency medicine and general surgery. Special attention has been directed toward assisting students in learning the anatomy they will need to know in the 21st century, and to this end, new features have been added and existing features updated.

EXTENSIVE ART PROGRAM

The extensive revision of the art program that distinguished the seventh edition continues into the eighth edition. Most illustrations were revised for the seventh edition, improving accuracy and consistency and giving classical art derived from *Grant's Atlas of Anatomy* a fresh, vital, new appearance. The eighth edition includes further updates to figures and labeling to maximize clarity and

efficiency. Efforts started with the fourth edition continue to ensure that all the anatomy presented and covered in the text is also illustrated. The text and illustrations were developed to work together for optimum pedagogical effect, aiding the learning process, and markedly reducing the amount of searching required to find structures. The great majority of the clinical conditions are supported by photographs and/or color illustrations; multipart illustrations often combine dissections, line art, and medical images; and tables are accompanied by illustrations to aid the student's understanding of the structures efficiently described.

CLINICAL BLUE BOXES

Widely known as "blue boxes," the highlighted clinical correlations are now titled "Clinical Blue Boxes." They have evolved with changes in practice, and many of them are supported by photographs and/or dynamic color illustrations to help with understanding the practical value of anatomy. In this edition, the clinical boxes have undergone extensive review and revision and reflect many recent medical advances. Topics in the Clinical Blue Boxes are classified by the following icons to indicate the type of clinical information covered:

Anatomical variations feature anatomical variations that may be encountered in the dissection lab or in practice, emphasizing the clinical importance of awareness of such variations.

Life cycle boxes emphasize prenatal developmental factors that affect postnatal anatomy and anatomical phenomena specifically associated with stages of life—childhood, adolescence, adult, and advanced age.

Trauma boxes feature the effects of traumatic events—such as fractures of bones or dislocations of joints—on normal anatomy and the clinical

manifestations and dysfunction resulting from such injuries.

Diagnostic procedures discuss the anatomical features and observations that play a role in physical diagnosis.

Surgical procedures address such topics as the anatomical basis of surgical procedures, such as the planning of incisions, and the anatomical basis of regional anesthesia.

Pathology boxes cover the effects of disease on normal anatomy, such as cancer of the breast, and anatomical structures or principles involved in the confinement or dissemination of disease within the body.

THE BOTTOM LINE SUMMARIES

Frequent “The Bottom Line” boxes summarize the preceding information, ensuring that primary concepts do not become lost in the many details necessary for thorough understanding. These summaries provide a convenient means of ongoing review and underscore the “big picture” point of view.

ANATOMY DESCRIBED IN A PRACTICAL, FUNCTIONAL CONTEXT

A more realistic approach to the musculoskeletal system emphasizes the action and use of muscles and muscle groups in daily activities, emphasizing gait and grip. The eccentric contraction of muscles, which accounts for much of their activity, is now discussed along with the concentric contraction that is typically the sole focus in anatomy texts. This perspective is important to most health

professionals, including the growing number of physical and occupational therapy students using this book.

SURFACE ANATOMY AND MEDICAL IMAGING

Surface anatomy and medical imaging, formerly presented separately, are integrated into the chapter, presented at the time each region is being discussed, clearly demonstrating anatomy's relationship to physical examination and diagnosis. Both natural views of unobstructed surface anatomy and illustrations superimposing anatomical structures on surface anatomy photographs are components of each regional chapter. Medical images, focusing on normal anatomy, include plain and contrast radiographic, MRI, CT, and ultrasonography studies, often with correlative line art as well as explanatory text, to help prepare future professionals who need to be familiar with diagnostic images.

VIDEOS, CASE STUDIES, AND BOARD REVIEW-STYLE QUESTIONS

Clinical Blue Box videos, case studies, and interactive multiple-choice questions are available to students online at http://thePoint.lww.com. These resources provide a convenient and comprehensive means of review and self-testing.

TERMINOLOGY

The terminology fully adheres to *Terminologia Anatomica: International Anatomical Nomenclature* (1998), generated by the Federative International Programme on Anatomical Terminologies (FIPAT) and approved by the International Federation of Associations of Anatomists (IFAA). Although the official English-equivalent terms are used throughout the book, when new terms are introduced, the Latin form, used in Europe, Asia, and other parts of the world, is also provided. The roots and derivations of terms are provided to help students understand meaning and increase retention. Eponyms, although not

endorsed by the IFAA, appear in parentheses in this edition—for example, sternal angle (angle of Louis)—to assist students who will hear eponymous terms during their clinical studies. The terminology is available online at http://www.unifr.ch/ifaa.

RETAINED AND IMPROVED FEATURES

Students and faculty have told us what they want and expect from *Clinically Oriented Anatomy*, and we listened:

- A comprehensive text enabling students to fill in the blanks, as time allotted for lectures continues to decrease, laboratory guides become exclusively instructional, and multiauthored lecture notes develop inconsistencies in comprehension, fact, and format.
- A resource capable of supporting areas of special interest and emphasis within specific anatomy courses that serves the anatomy needs of students during both the basic science and the clinical phases of their studies.
- Updated organization of the chapters to match that of *Grant's Atlas of Anatomy* and *Grant's Dissector*.
- A thorough introductory chapter (Chapter 1: Overview and Basic Concepts) that covers important systemic information and concepts basic to the understanding of the anatomy presented in the subsequent regional chapters. Students from many countries and backgrounds have written to express their views of this book—gratifyingly, most are congratulatory. Health professional students have more diverse backgrounds and experiences than ever before. Curricular constraints often result in unjustified assumptions concerning the prerequisite information necessary for many students to understand the presented material. The introductory chapter includes efficient summaries of functional systemic anatomy. Students' comments specifically emphasized the need for a systemic description of the nervous system and the peripheral autonomic nervous system (ANS) in particular. The eighth edition is now the first anatomy textbook to acknowledge and describe the structure and function of the enteric nervous system and its unique role in the innervation of the digestive tract.
- Routine facts (such as muscle attachments, innervations, and actions) presented in tables organized to demonstrate shared qualities and illustrated to demonstrate the provided information. *Clinically Oriented Anatomy*

provides more tables than any other anatomy textbook.

- Illustrated clinical correlations that not only describe but also show anatomy as it is applied clinically.
- Illustrations that facilitate orientation. Many orientation figures have been added, along with arrows to indicate the locations of the inset figures (areas shown in close-up views) and viewing sequences. Labels have been placed to minimize the distance between label and object, with leader lines running the most direct course possible.
- **Boldface type** indicates the main entries of anatomical terms, when they are introduced and defined. In the index, the page numbers of these main entries also appear in boldface type, so that the main entries can be easily located. Boldface type is also used to introduce clinical terms in the clinical blue boxes.
- *Italic type* indicates anatomical terms important to the topic and region of study or labeled in an illustration that is being referenced.
- Useful content outlines appear at the beginning of every chapter.

COMMITMENT TO EDUCATING STUDENTS

This book is written for health science students, keeping in mind those who may not have had a previous acquaintance with anatomy. We have tried to present the material in an interesting way so that it can be easily integrated with what will be taught in more detail in other disciplines such as physical diagnosis, medical rehabilitation, and surgery. We hope this text will serve two purposes: to educate and to excite. If students develop enthusiasm for clinical anatomy, the goals of this book will have been fulfilled.

Keith L. Moore
Arthur F. Dalley II
Anne M. R. Agur

ABBREVIATIONS

a., aa. artery, arteries

ant. anterior

b.c.e. before the Common (Christian) era

C cervical

c.e. Common (Christian) era

Co coccygeal

e.g. for example

et al. and others

F female

Fr. French

G. Greek

i.e. that is

inf. inferior

L liter, lumbar

L. Latin

lev. levator

M male

m., mm. muscle, muscles

Mediev. medieval

Mod. modern

post. posterior

S sacral

sup. superior

supf. superficial

T thoracic

TA Terminologia Anatomica

TE Terminologia Embryologica

TH Terminologia Histologica

v., vv. vein, veins

vs. versus

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- *Carol Scott-Conner, EH, MD, PhD, MBA, FACS,* Professor Emeritus, Department of Surgery, University of Iowa Roy J. and Lucille A. Carver College of Medicine, Iowa City, IA

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- *Professor Colin P. Wendell-Smith*, Department of Anatomy and Physiology, University of Tasmania, Hobart, Tasmania, Australia (retired)
- *Dr. Andreas H. Weiglein*, Professor, Institut fur Anatomie, Medical University Graz, Graz, Austria
- *Dr. David G. Whitlock*, Professor of Anatomy, University of Colorado Medical School, Denver, Colorado

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Keith L. Moore
Arthur F. Dalley II
Anne M. R. Agur

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1. OVERVIEW AND BASIC CONCEPTS

Fig. 1.20 Based on Hamill JH, Knutzan K: *Biochemical Basis of Human Movement*, 2nd ed., 2003.

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Fig. B1.4 Based on *Stedman's Medical Dictionary*, 27th ed., 2000 (artist: Neil O. Hardy, Westport, CT).

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2. BACK

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Fig. 2.6E Courtesy of D. Salonen, University of Toronto, Ontario, Canada.

Fig. 2.7C Courtesy of Dr. J. Heslin, University of Toronto, Ontario, Canada; **D** Becker RF, Wilson JW, Gehweiler JA: *Anatomical Basis of Medical Practice*, 1974.

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Fig. 5.52B courtesy of Dr. C.S. Ho, Professor of Medical Imaging, University of Toronto, Toronto, ON, Canada; **C** courtesy of Dr. E.L. Lansdown, Professor of Medical Imaging, University of Toronto, Toronto, Ontario, Canada.

Fig. 5.53 D–F Photos supplied by Anne M.R. Agur, BSc (OT), MSc, PhD.

Fig. 5.55A Courtesy of Dr. E.L. Lansdown, Professor of Medical Imaging, University of Toronto, Toronto, Ontario, Canada; **B** Courtesy of Dr. D.K. Sniderman, University of Toronto, Ontario, Canada.

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Fig. 5.103 Courtesy of Dr. M.A. Haider, University of Toronto, Ontario, Canada.

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