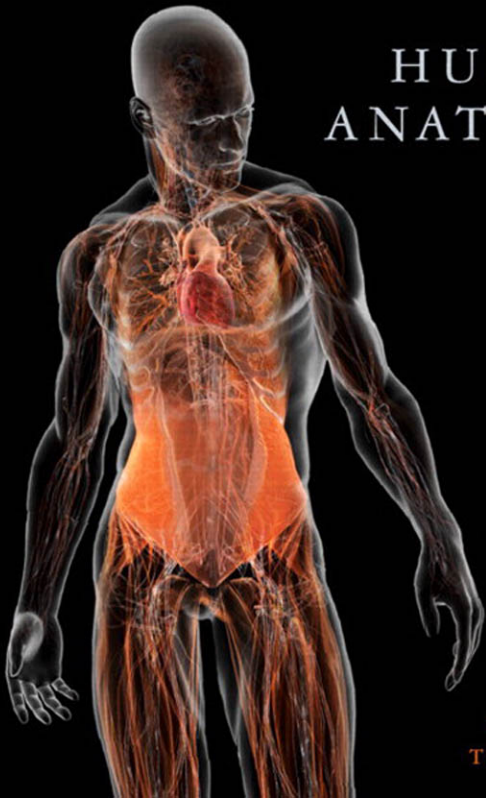


# HUMAN ANATOMY

*Seventh Edition*



MARTINI  
TIMMONS  
TALLITSCH

# HUMAN ANATOMY

*Seventh Edition*

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**Library of Congress Cataloging-in-Publication Data**

Martini, Frederic.  
Human anatomy/Frederic H. Martini, Michael J. Timmons, Robert B. Tallitsch; with William C. Ober, art coordinator and illustrator; Claire W. Garrison, illustrator; Kathleen Welch, clinical consultant; Ralph T. Hutchings, biomedical photographer.—7th ed.  
p. ; cm.  
Includes bibliographical references and index.  
ISBN-13: 978-0-321-68815-6 (student ed.)  
ISBN-10: 0-321-68815-5 (student ed.)  
ISBN-13: 978-0-321-73064-0 (exam copy)  
ISBN-10: 0-321-73064-X (exam copy)  
1. Human anatomy. 2. Human anatomy—Atlases. I. Timmons, Michael J. II. Tallitsch, Robert B. III. Title.  
[DNLM: 1. Anatomy—Atlases. QS 17 M386h 2012]  
QM23.2.M356 2012  
612—dc22

2010022870

**Benjamin Cummings**  
is an imprint of



[www.pearsonhighered.com](http://www.pearsonhighered.com)

ISBN 10: 0-321-68815-5 (Student edition)  
ISBN 13: 978-0-321-68815-6 (Student edition)  
ISBN 10: 0-321-76626-1 (Exam copy)  
ISBN 13: 978-0-321-76626-7 (Exam copy)

1 2 3 4 5 6 7 8 9 10—DOW—14 13 12 11 10

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Dr. Martini received his Ph.D. from Cornell University in comparative and functional anatomy for work on the pathophysiology of stress. In addition to professional publications that include journal articles and contributed chapters, technical reports, and magazine articles, he is the lead author of nine undergraduate texts on anatomy or anatomy and physiology. Dr. Martini is currently affiliated with the University of Hawaii at Manoa and has a long-standing bond with the Shoals Marine Laboratory, a joint venture between Cornell University and the University of New Hampshire. Dr. Martini is a President Emeritus of the Human Anatomy and Physiology Society, and he is a member of the American Association of Anatomists, the American Physiological Society, the Society for Integrative and Comparative Biology, and the International Society of Vertebrate Morphologists.



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*Illustrator*

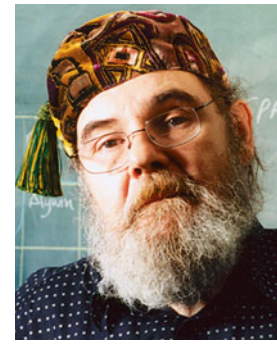
Claire W. Garrison, R.N., B.A., practiced pediatric and obstetric nursing before turning to medical illustration as a full-time career. She returned to school at Mary Baldwin College where she received her degree with distinction in studio art. Following a five-year apprenticeship, she has worked as Dr. Ober's partner in Medical & Scientific Illustration since 1986. She is on the Core Faculty at Shoals Marine Laboratory and co-teaches the Biological Illustration course.



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Dr. Welch received her M.D. from the University of Washington in Seattle and did her residency at the University of North Carolina in Chapel Hill. For two years she served as Director of Maternal and Child Health at the LBJ Tropical Medical Center in American Samoa and subsequently was a member of the Department of Family Practice at the Kaiser Permanente Clinic in Lahaina, Hawaii. She has been in private practice since 1987. Dr. Welch is a Fellow of the American Academy of Family Practice and a member of the Hawaii Medical Association and the Human Anatomy and Physiology Society.



### **Ralph T. Hutchings**

*Biomedical Photographer*

Mr. Hutchings was associated with The Royal College of Surgeons of England for 20 years. An engineer by training, he has focused for years on photographing the structure of the human body. The result has been a series of color atlases, including the *Color Atlas of Human Anatomy*, the *Color Atlas of Surface Anatomy*, and *The Human Skeleton* (all published by Mosby-Yearbook Publishing). For his anatomical portrayal of the human body, the International Photographers Association has chosen Mr. Hutchings as the best photographer of humans in the twentieth century. He lives in North London, where he tries to balance the demands of his photographic assignments with his hobbies of early motor cars and airplanes.



# Welcome to the Seventh Edition of *Human Anatomy*!

THROUGH SEVEN EDITIONS, the authors and illustrators have continued to build on this text's hallmark qualities: its distinctive atlas-style format and its unsurpassed visual presentation of anatomy and anatomical concepts. Our approach for this text has been to provide a seamless learning system with closely integrated art and text. The illustrations do more than provide occasional support for the narrative; they are partners with the text in conveying information and helping students understand structures and relationships in a way that distinguishes this human anatomy textbook from all others.

## New to the Seventh Edition

In approaching this Seventh Edition, we paid particular attention to the most difficult topics in human anatomy and to areas identified by students and reviewers. Our primary goal was to build upon the strengths of the previous edition while addressing the changing needs of today's students. The changes described below are intended to enhance student learning and increase student engagement.

- **A more visual and dynamic presentation of clinical information.** Select **Clinical Notes**

covering key clinical topics now feature new, dramatic layouts that integrate illustrations, photos, and text in a way that makes reading easy and science relevant

(see pp. 108–109, 127,

132–133). **Clinical Cases**,

which appear at the end of

each body system section, now

include patient photos and

diagnostic images (see

pp. 110–111, 501–502, 602–604).

Every Clinical Case begins with a

photo of the patient and his/her

background information, making

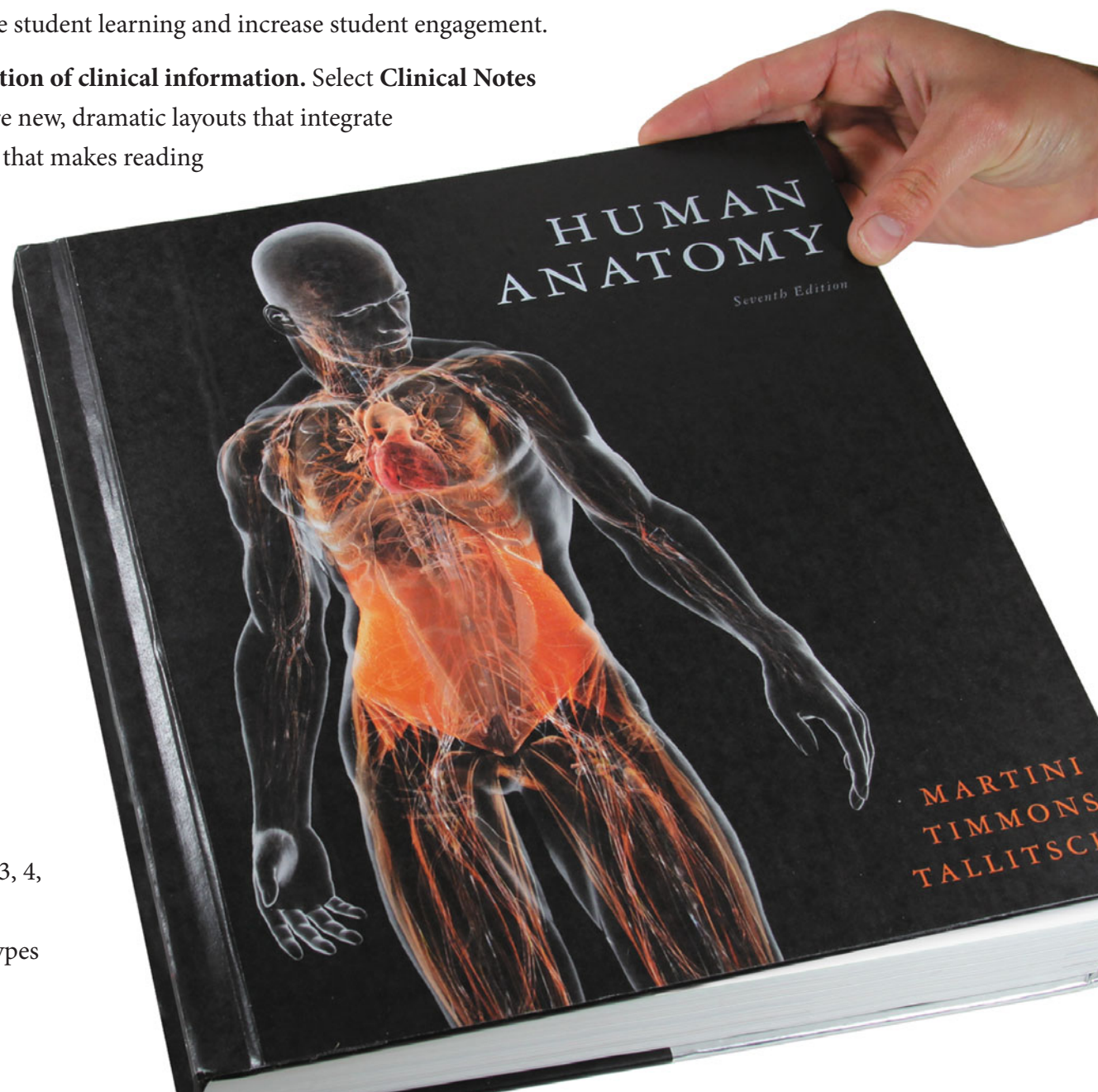
the case personal and real to the

students. Diagnostic images (photos,

x-rays, and MRI scans) also appear

within the narrative.

- **Over 65 new and visually stunning histology photomicrographs.** These photomicrographs appear in chapters 3, 4, 5, 13, 19–21, and 23–27. The slides prepared for these photos match the types



of slides that beginning students will encounter in the anatomy lab.

- **New spiral scans.** Using the most up-to-date imaging technique available, these spiral scans (see Figures 8.16 and 22.16) provide students with unparalleled views of anatomical structures and introduce them to a new imaging technique that is increasingly used in clinical settings. These spiral scan images have been provided by Fovia, Inc., and by TeraRecon, Inc.
- **Improved presentation of figures.** Figure legends now appear consistently above figures, and the detailed figure captions that describe parts within figures now appear within the figures. This new figure presentation style guides students through multi-part figures and compels them to read the part captions as they view each part of a figure. The result is easier reading and improved understanding of figures.
- **A reorganized and streamlined presentation of the nervous system chapters (Chapters 13–18).** These chapters have been reorganized to take a “bottom up” rather than a “top down” approach to make the nervous system easier for instructors to present and students to understand. Specifically, the discussion of the spinal cord started in Chapter 14 (The Nervous System: The Spinal Cord and Spinal Nerves) now continues in Chapter 15 (The Nervous System: Sensory and Motor Tracts of the Spinal Cord) so that sensory and motor tracts of the spinal cord are covered *before* the brain and cranial nerves in Chapter 16 (The Nervous System: The Brain and Cranial Nerves). Additionally, Chapter 16 also presents the brain and cranial nerve information in a “bottom up” sequence, starting with the brain stem and ending with the cerebrum.

- **New “Hot Topics: What’s New in Anatomy” highlight current research.** These brief boxes introduce students to new peer-reviewed anatomical research findings that have been published within the past two years. This feature appears in chapters 2–5, 10, 13, 19, 21, and 23–28.
- **Increased focus on learning methodology.** Each chapter now opens with concrete *Student Learning Outcomes* instead of learning objectives.

In addition, approximately 85 percent of the figures in this edition are either new or have been revised. Some figures were updated for increased visual appeal to students (see Figures 1.1, 4.1, and 4.12). In many figures, areas of detail have been revised to improve clarity. All bone photos in chapters 6 and 7 received a new silhouette treatment that results in a cleaner, more contemporary look and makes bone markings easier to see. The presentation of boxes and banners has been improved to better organize many figures (see Figures 9.11, 26.6, and 23.7). The overlay of illustrations on surface anatomy photos has been continued in this edition to provide students with a better understanding of where structures are located within the human body. The information derived from superficial and deep dissections is more easily understood as a result of a new heading style that has been continued in many of the figures (see Figure 23.14b).

The following section provides a detailed description of this edition’s chapter-by-chapter revisions.

# Chapter-by-Chapter Revisions

Specific chapter-by-chapter revisions, with select examples, include:

## 1 Foundations: An Introduction to Anatomy

- Twelve illustrations are either new or have been significantly revised.
- Changes were made in terminology according to the *Terminologia Anatomica (TA)*.

## 2 Foundations: The Cell

- Fifteen illustrations are either new or have been significantly revised.
- Changes were made in terminology according to the *TA* and *Terminologia Histologica (TH)*.
- The presentation order of some material was rearranged in order to facilitate student learning.

## 3 Foundations: Tissues and Early Embryology

- Nineteen illustrations are either new or have been significantly revised.
- Seventeen new photomicrographs were added.
- Changes were made in terminology according to the *TA* and *TH*.
- The presentation order of some material was rearranged in order to facilitate student learning.
- New material was added to update the chapter according to current histological research.

## 4 The Integumentary System

- Fourteen illustrations are either new or have been significantly revised.
- Four new photomicrographs were added.
- Changes were made in terminology according to the *TA* and *TH*.
- New material was added to the discussion of the epidermis, and the existing material was revised for easier comprehension.

## 5 The Skeletal System: Osseous Tissue and Skeletal Structure

- Eleven illustrations are either new or have been significantly revised.
- Two new photomicrographs were added.
- New material was added to the discussion of bone remodeling and repair, and the existing material was revised for easier reading and comprehension.
- New material was added to the discussion of the cells of bone to match current histological terminology and research.

## 6 The Skeletal System: Axial Division

- Twenty-three illustrations are either new or have been significantly revised.
- New material was added to the discussion of the bones of the cranium to match current anatomical terminology and research.
- New material was added, and existing material has been clarified, in the discussions of the vertebral regions.

## 7 The Skeletal System: Appendicular Division

- Twenty-one illustrations are either new or have been significantly revised.

- New material was added, and existing material has been clarified, in the discussions of the clavicle, scapula, humerus, pelvic girdle, patella, tibia, and the arches of the foot.

## 8 The Skeletal System: Articulations

- Seven illustrations are either new or have been significantly revised.
- New material was added and existing material clarified for better student comprehension.

## 9 The Muscular System: Skeletal Muscle Tissue and Muscle Organization

- Eight illustrations are either new or have been significantly revised.
- Considerable material within the chapter was revised to better facilitate student comprehension and learning.

## 10 The Muscular System: Axial Musculature

- Five illustrations are either new or have been significantly revised.
- Two new photomicrographs were added.
- The sections entitled “Muscles of the Vertebral Column” and “Muscles of the Perineum and the Pelvic Diaphragm” have been updated and clarified.

## 11 The Muscular System: Appendicular Musculature

- Nine illustrations are either new or have been significantly revised.
- A new section entitled “Factors Affecting Appendicular Muscle Function” was added to this chapter in the Sixth Edition and has been revised for this Seventh Edition. This section helps students work through the process of *understanding* the actions of skeletal muscles at a joint. This section also explains the concept of the *action line of a muscle*, and how students, once they have determined the action line, may apply three simple rules in order to determine the action of a muscle at that joint.

## 12 Surface Anatomy and Cross-Sectional Anatomy

- Nine illustrations are either new or have been significantly revised.

## 13 The Nervous System: Neural Tissue

- Five illustrations are either new or have been significantly revised.
- Two new photomicrographs were added.
- The sections entitled “Neuroglia of the CNS” and “Synaptic Communication” were updated in order to match current research findings in the field.

## 14 The Nervous System: The Spinal Cord and Spinal Nerves

- Seven illustrations are either new or have been significantly revised.
- The discussion of the meninges of the spinal cord was expanded.
- The discussion of the sectional anatomy of the spinal cord was expanded, with particular emphasis on the revision of the section on “Organization of the Gray Matter.”
- The section on “Spinal Nerves” has been rewritten in order to facilitate student learning and comprehension.



- The sections on “The Brachial Plexus” and “The Lumbar and Sacral Plexuses” were rewritten to make them easier to understand.

## **15 The Nervous System: Sensory and Motor Tracts of the Spinal Cord**

- Two new illustrations have been included and eight others have been significantly revised.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.
- At the request of reviewers and instructors, the section dealing with Higher-Order Functions has been deleted.

## **16 The Nervous System: The Brain and Cranial Nerves**

- Ten illustrations have been significantly revised.

## **17 The Nervous System: Autonomic Division**

- Seven illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **18 The Nervous System: General and Special Senses**

- Seven illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **19 The Endocrine System**

- Five illustrations are either new or have been significantly revised.
- Five new photomicrographs were added.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **20 The Cardiovascular System: Blood**

- Six illustrations are either new or have been significantly revised.
- Five new photomicrographs were added.
- All sections of this chapter were updated in order to match current research findings in the field.

## **21 The Cardiovascular System: The Heart**

- Eight illustrations are either new or have been significantly revised.
- One new photomicrograph was added.
- The sections on “The Intercalated Discs” and “Coronary Blood Vessels” were rewritten in order to reflect new research findings in the field and to make them easier to understand.

## **22 The Cardiovascular System: Vessels and Circulation**

- Eleven illustrations are either new or have been significantly revised.
- All sections of this chapter were updated in order to match current research findings in the field.

- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **23 The Lymphoid System**

- Eight illustrations are either new or have been significantly revised.
- Four new photomicrographs were added.
- All sections of this chapter were updated in order to match current research findings in the field.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **24 The Respiratory System**

- Seven illustrations are either new or have been significantly revised.
- Two new photomicrographs were added.
- Revisions were made to reflect the current histological information on the respiratory system.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **25 The Digestive System**

- Thirteen illustrations are either new or have been significantly revised.
- Thirteen new photomicrographs were added.
- Revisions were made to reflect the current histological information on the various organs of the digestive system.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **26 The Urinary System**

- Seven illustrations are either new or have been significantly revised.
- Six new photomicrographs were added.
- Revisions were made to reflect the current histological information on the various organs of the urinary system.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **27 The Reproductive System**

- Seven illustrations are either new or have been significantly revised.
- Six new photomicrographs were added.
- Revisions were made to reflect the current histological information on the various organs of the male and female reproductive systems.
- All sections of this chapter were revised, either partially or totally, to make them easier to understand.

## **28 The Reproductive System: Embryology and Human Development**

- All of the Embryology Summaries have been revised.

# Acknowledgments

The creative talents brought to this project by our artist team, William Ober, M.D., Claire Garrison, R.N., and Anita Impagliazzo, M.F.A., are inspiring and valuable beyond expression. Bill, Claire, and Anita worked intimately and tirelessly with us, imparting a unity of vision to the book while making each illustration clear and beautiful. Their superb art program is greatly enhanced by the incomparable bone and cadaver photographs of Ralph T. Hutchings, formerly of The Royal College of Surgeons of England. In addition, Dr. Pietro Motta, Professor of Anatomy, University of Roma, La Sapienza, provided several superb SEM images for use in the text. We also gratefully acknowledge Shay Kilby, Ken Fineman, and Steve Sandy of Fovia, Inc., and Donna Wefers and Cormac Donovan of TeraRecon, Inc., for creating and providing the 3-D spiral scans that appear in this edition.

We are deeply indebted to Jim Gibson of Graphic Design Associates for his wonderful work and suggestions in the design aspect of the Seventh Edition of *Human Anatomy*. Jim provided new insight into the design concept, and most of the design changes and innovations in this edition of *Human Anatomy* reflect Jim's expertise.

We would like to acknowledge the many users and reviewers whose advice, comments, and collective wisdom helped shape this text into its final form. Their passion for the subject, their concern for accuracy and method of presentation, and their experience with students of widely varying abilities and backgrounds have made the revision process interesting and educating.

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We are also indebted to the Pearson Benjamin Cummings staff, whose efforts were vital to the creation of this edition. A special note of thanks and appreciation goes to the editorial staff at Benjamin Cummings, especially Leslie Berri-man, Executive Editor, for her dedication to the success of this project, and Katie Seibel, Associate Editor, for her management of the text and its supplements. Thanks also to Barbara Yien, Editorial Development Manager, and Nicole McFadden, Editorial Assistant. We express thanks to Aimee Pavy, Media Producer, and Sarah Young-Dualan, Senior Media Producer, for their work on the media programs that support *Human Anatomy*, especially Mastering A & P™ and Practice Anatomy Lab™ (PAL™). Thanks also to Caroline Ayres, Production Supervisor, for her steady hand managing this complex text; and Debbie Cogan, Norine Strang, Holly Smith, Maureen Spuhler, and Donna Kalal for their roles in the production of the text.

We are very grateful to Paul Corey, President, and Frank Ruggirello, Editorial Director, for their continued enthusiasm and support of this project. We appreciate the contributions of Derek Perrigo, Marketing Manager, who keeps his finger on the pulse of the market and helps us meet the needs of our customers, and the remarkable and tireless Pearson Science sales reps.

We are also grateful that the contributions of all of the aforementioned people have led to this text receiving the following awards: The Association of Medical Illustrators Award, The Text and Academic Authors Award, the New York International Book Fair Award, the 35th Annual Bookbuilders West Award, and the 2010 Text and Academic Authors Association "Texty" Textbook Excellence Award.

We would also like to thank Steven Bassett of Southeast Community College; Kelly Johnson of University of Kansas; Jason LaPres of North Harris College; Agnes Yard of University of Indianapolis; and Michael Yard of Indiana University-Purdue University at Indianapolis for their work on the media and print supplements for this edition.

Finally, we would like to thank our families for their love and support during the revision process. We could not have accomplished this without the help of our wives—Kitty, Judy, and Mary—and the patience of our children—P.K., Molly, Kelly, Patrick, Katie, Ryan, Molly, and Steven.

No three people could expect to produce a flawless textbook of this scope and complexity. Any errors or oversights are strictly our own rather than those of the reviewers, artists, or editors. In an effort to improve future editions, we ask that readers with pertinent information, suggestions, or comments concerning the organization or content of this textbook send their remarks to Robert Tallitsch directly, by the e-mail address below, or care of Publisher, Applied Sciences, Pearson Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.

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