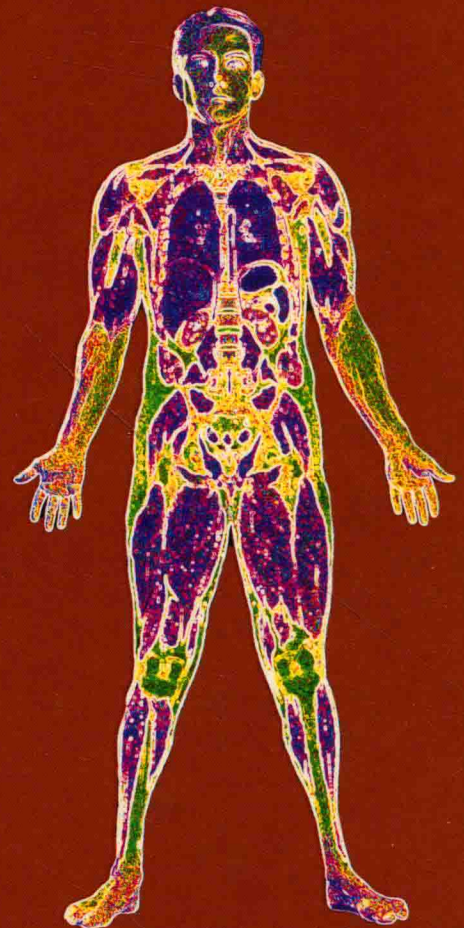


UPDATE

Human Anatomy

Elaine N. Marieb
Jon Mallatt



Third Edition

Human Anatomy

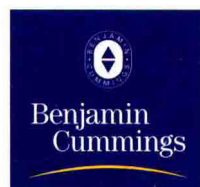
Third Edition Update

Elaine N. Marieb, R.N., Ph.D.

Holyoke Community College

Jon Mallatt, Ph.D.

Washington State University



San Francisco Boston New York
Cape Town Hong Kong London Madrid Mexico City
Montreal Munich Paris Singapore Sydney Tokyo Toronto

Publisher: Daryl Fox
Editorial Managing Editor: Kay Ueno
Senior Developmental Editor: Mark Wales
Production Managing Editor: Wendy Earl
Project Editors: Susan Teahan and Mary Ann Murray
Production Supervisors: Karen Gulliver and Michele Mangelli
Art and Design Director: Bradley Burch
Art Manager: Michele Mangelli
Principal Artists/Studio for 3rd edition: Wendy Hiller Gee,
Imagineering Scientific and Technical Artworks, Inc.,
Kristin Mount, Tomo Narashima, Nadine Sokol
Developmental and Copy Editor: Alan Titche
Art and Photo Coordinator: David Novak
Assistant Art Coordinator: Anne Hikido
Photo Research: Stuart Kenter Associates and Bradley Burch
Text Designer and Cover Design: f. tani Hasegawa
Manufacturing Coordinator: Stacey Weinberger
Senior Marketing Manager: Lauren Harp

Photography and illustration credits appear following the Appendices.

Library of Congress Cataloging-in-Publication Data

Marieb, Elaine Nicpon

Human anatomy / Elaine N. Marieb, Jon Mallatt.—3rd ed. update
p. cm.

Includes index.

ISBN 0-8053-5335-6

1. Human anatomy. I. Mallatt, Jon.

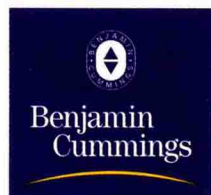
QM23.2 .M348 2001

611—dc21

00-034063

Copyright © 2003 by Pearson Education, Inc., publishing as Benjamin Cummings, 1301 Sansome St., San Francisco, CA 94111. All rights reserved. Manufactured in the United States of America. This publication is protected by Copyright and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. To obtain permission(s) to use material from this work, please submit a written request to Pearson Education, Inc., Permission Department, 1900 E. Lake Ave., Glenview, IL 60025. For information regarding permissions, call (847) 486-2635.

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and the publisher was aware of trademark claim, the designations have been printed in initial caps or all caps.



ISBN 0-8053-5334-8 (For sale copy with CD-ROM)
ISBN 0-8053-5361-5 (Professional copy with CD-ROM)

2 3 4 5 6 7 8 9 10-QWV-06 05 04 03

www.aw.com/bc

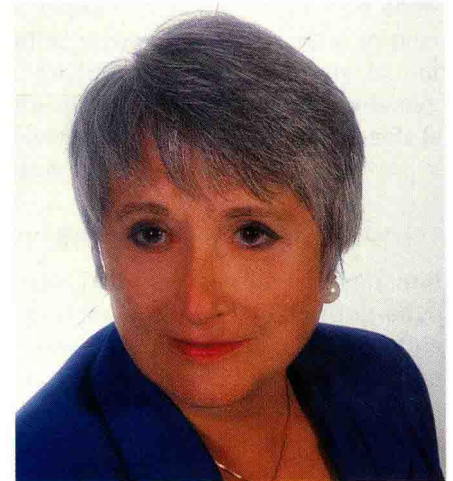
ABOUT THE AUTHORS

Elaine N. Marieb and Jon Mallatt are keenly aware of the challenges faced by all anatomy instructors. It is important to communicate a vast amount of information to students in a way that stimulates their interest. Forty-nine combined years of teaching experience in both the laboratory and the classroom have enhanced the authors' sensibilities about pedagogy and presentation. The insights gained from this experience are distilled in this thoroughly revised Third Edition Update of *Human Anatomy*—a book that aims to address the problems students encounter in this course.

Elaine N. Marieb

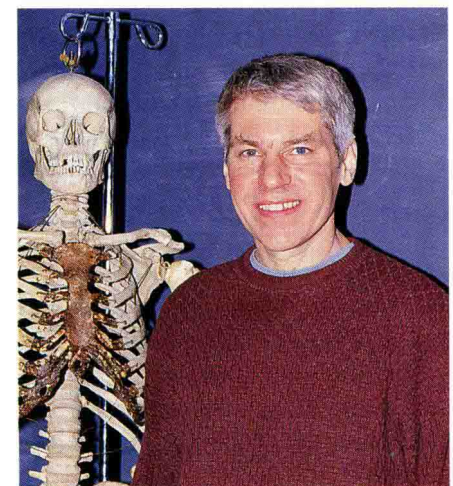
By any measure, Elaine N. Marieb is an accomplished educator and author. Her academic career began at Springfield College, where she taught anatomy and physiology to physical education majors. She joined the faculty of the Biological Science Division of Holyoke Community College in 1969, with a Ph.D. in Zoology from the University of Massachusetts at Amherst. Like other fine, inquisitive teachers, however, Dr. Marieb found there was more to learn—and more to understand—in order to meet the needs of her students, many of whom were pursuing degrees in nursing. To that end, Dr. Marieb, while teaching full time, continued her education, which culminated in both a bachelor and a master of science degree with a clinical specialization in gerontology from the University of Massachusetts. As a result, she gained an understanding of the relationship between the scientific study of the human body and the clinical aspects of nursing practice. From this experience and stories from former students in health careers, Dr. Marieb developed the unique perspective for which her widely used texts and laboratory manuals are known.

While actively engaged as an author, Dr. Marieb also serves as series consultant for the Benjamin Cummings–A.D.A.M.[®] CD-ROM series Interactive Physiology, and she is an active member of the Human Anatomy and Physiology Society (HAPS). In 1994 Dr. Marieb received the Benefactor Award from the National Council for Resource Development, American Association of Community Colleges in recognition of her ongoing sponsorship of student scholarships, faculty teaching awards, and other academic contributions to her community college. In May, 2000, Holyoke Community College renamed the Science Building in Dr. Marieb's honor.



Jon Mallatt

With a Ph.D. in Anatomy from the University of Chicago, Dr. Mallatt is currently an Associate Professor of Biological Sciences at Washington State University, where he has been teaching human anatomy to undergraduates of all backgrounds for 20 years. He is also a member of the department of Basic Medical Sciences, where he teaches courses in Histology and Anatomy of the Trunk in the WWAMI Medical Program. WWAMI honored him with their "Excellence in Teaching Award" in 1992, 1993, and 1995. Additionally Dr. Mallatt holds a position as adjunct Associate Professor in the department of Biological Structure at the University of Washington. His particular areas of expertise in the study of anatomy are histology, comparative anatomy, and anatomical drawing, although his research now focuses on the origin of vertebrate animals and molecular phylogeny. Dr. Mallatt is an accomplished researcher with 30 publications in the fields of anatomy and molecular phylogeny to his credit.



PREFACE

The general philosophy behind this updated third edition of *Human Anatomy* remains the same as in the previous editions. As an instructor, you know that teaching anatomy is not just the presentation of facts. You must provide information in a framework that encourages genuine understanding, devise new presentations to help students remember large amounts of material, and help students apply what they have learned to new situations. All the while you hope that you inspire in the students a love of the subject.

After many years of teaching human anatomy, we became convinced that new approaches to the subject could excite and challenge the students' natural curiosity. That is why we decided to write this book. We are fortunate to have collaborated with Benjamin Cummings, a publisher that shares our goal: to set a new standard for pedagogical and visual effectiveness in an anatomy text.

This book is designed for one-semester or one-quarter introductory anatomy courses that serve students in prenursing, premedical, prephysical therapy, radiological technology, physician assistant training, predentistry, pharmacy, and other allied-health fields, as well as physical education, athletic training, and nutrition.

Unique Approach to Anatomy

Since its inception, we have worked diligently to distinguish *Human Anatomy* from the many other anatomy books currently available. This book explains anatomy thoroughly, and its discussions are not merely brief summaries of the art. We have striven to present the basic concepts of anatomy—gross, microscopic, developmental, and clinical—in a manner that is clearly written, effectively organized, up to date, and well illustrated. We realize that learning anatomy involves assimilating gargantuan amounts of material, and we have tried to make our presentation as logical and accessible as possible. To this end, we present anatomy as a “story” that can be explained and understood—convincing the students that the structure of the body makes sense.

It is sometimes claimed that anatomy is a relatively static science and that anatomical knowledge does not grow much from year to year. Although this may be true for descriptive gross anatomy, it is not true for functional anatomy, neuroanatomy, developmental anatomy, nor for the functional aspects of tissue and cellular anatomy, subfields in which knowledge is growing quickly. This edition not only strives to keep up with the knowledge explosion in each of these subfields, but presents anatomy in a way that allows modern biology students,

whose training is becoming ever more molecular and cellular, to anchor their biochemical and medical training in the physical context of the human body. Here, then, are the distinguishing features of our book.

Functional Approach

First, we emphasize strongly the functional anatomy theme, giving careful consideration to the adaptive characteristics of the anatomical structures of the body. Wherever possible, we explain how the shape and composition of the anatomical structures allow them to perform their functions. Such functional anatomy is not physiology (which focuses on biological mechanisms), but is more akin to “design analysis.” This approach is not used by other texts at this level.

Emphasis on Current Research

Both authors read extensively in current clinical and research journals to provide a wealth of cutting-edge information for this book. The best examples of this updating are found in the expanded coverage of the brain in Chapter 13 and of the immune system in Chapter 20, but all chapters include information that is not present in other textbooks at this level.

Moreover, to emphasize some of the most exciting new information, certain findings are highlighted and labeled “Advances in Understanding,” a feature that is spread throughout the chapters of this edition.

Microscopic Anatomy

We have worked to provide an especially effective treatment of microscopic anatomy. Many undergraduate texts treat histology as a specialized and minor subfield that takes a back seat to gross anatomy. This is unfortunate, because most physiological and disease processes take place at the cell and tissue level, and most allied-health students require a solid background in histology and subcellular structure to prepare them for their physiology courses. Microscopic anatomy is one of Dr. Mallatt's research areas, and he has taught histology to University of Washington medical students for over 20 years.

Embryology

Our text is designed to present embryology in the most effective and logical way. Currently, all competing texts describe the embryology of each organ system in the relevant chapters, yet do not provide the fundamentals of embryology until the very end of the book, in the section

on the female reproductive organs. This approach seems backward to us. We are convinced that the fundamentals should be presented early in the text, before the more advanced discussions of the developing organ systems in the relevant chapters. Therefore, we wrote Chapter 3 as a basic introduction to embryology. Because a comprehensive presentation of embryology early in the book could be intimidating to some students, we have used a “velvet glove approach,” providing only the most important concepts in a concise, understandable way, and visually reinforced with exceptionally clear new art.

Life Span Approach

Most chapters in this book close with a “Throughout Life” section that first summarizes the embryonic development of organs of the system and then examines how these organs change across one’s life span. Diseases particularly common during certain periods of life are pointed out, and effects of aging are considered. The implications of aging are particularly important to students in the health-related curricula because many of their patients will be in the senior age group. Because aging is a fast-moving field of research, the “Throughout Life” sections are some of the most extensively updated parts of this edition.

Interactive Learning

This book is an interactive learning tool that encourages understanding; it is not an encyclopedia that encourages rote memorization. Whereas many scientific textbooks read like long lists of terms, this book reads like an instructor talking to, explaining to, and challenging the student. Many of the chapters include special topic boxes entitled “A Closer Look,” which present clinical and topical information in a lighter, more inviting format. For those organs and systems with especially many components (e.g., skeletal muscles, cranial nerves, sensory receptors), we present these components in illustrated tables that organize the information in a logical way. In-text Critical Reasoning questions and Clinical Applications boxes are provided to challenge the student and to encourage synthesis of information.

Organization

This text conforms to the organization of most anatomy courses, starting with several introductory chapters followed by skeletal, muscular, nervous, and circulatory chapters, and then chapters on the various systems of visceral organs (see the Table of Contents). We also retain the following unique organizational features of previous editions of this book.

- As mentioned, we introduce basic embryology early (Chapter 3), a position that provides students with the background they need to understand the development of specific organ systems in later chapters.
- We present the endocrine system late (Chapter 25), after students have learned the visceral systems that the endocrine system controls. Nonetheless, we realize that many courses teach endocrine system anatomy with the nervous system, so we designed the endocrine system chapter so that it can also be interjected and understood at an earlier point in the course.
- We cover surface anatomy last (Chapter 26) so that we can discuss more of the clinical information related to body surface features. Books that place this chapter earlier, after bone and muscles, cannot logically discuss the surface anatomy of blood vessels (pulse points), lymph nodes, nerves, and the visceral organs. Our coverage of surface anatomy is the book’s capstone, offering students a uniquely practical summary of the entire body.

Outstanding Illustration Program

Art plays a critical role in helping students visualize anatomical structures and concepts, and over the years we have diligently striven to maintain the hallmark accuracy of *Human Anatomy*’s art. Thus, in response to reviewer comments of instructors from colleges and universities across the country, we have incorporated art that is larger, sharper, and richer looking. We have taken advantage of technical advances in scientific and medical illustration to produce images with enhanced clarity and color, and with greater contrast among structures. This, combined with clear layouts, enlarged art size, and improved three-dimensional details, greatly enhances the presentation of the material and will help students in their understanding of human anatomy.

We have continued to refine other aspects of our illustration program, too. As in previous editions, we use color not only for aesthetic purposes but also to denote the functional characteristics of certain anatomical structures. More illustrations than ever feature orientation diagrams, simple “thumbnail” sketches that clarify an illustration’s anatomical perspective or pinpoint the location of an organ within the body. Not only are light and scanning electron micrographs used abundantly, but images produced by modern medical scanning techniques (CT, PET, MRI) are included where appropriate to enhance the student’s grasp of anatomical structures. We have continued to augment key illustrations with the highly acclaimed Bassett photographs of dissected cadavers. Moreover, the skeletal system chapters now include an assort-

ment of newly prepared bone photographs provided by the distinguished anatomy photographer Ralph T. Hutchings.

Hallmark Features

Spotlighting Special Information

We took care to make important information and subsidiary themes stand out in each chapter's coverage. As mentioned previously, recent research findings are highlighted via the Advances in Understanding boxes found throughout most chapters. To provide even more topical and clinical information, we've included a total of 21 A CLOSER LOOK boxes in the Third Edition Update, covering such topics as the use of stem cells in tissue engineering (Chapter 4); tattoos (Chapter 5); harvesting blood stem cells from umbilical cords (Chapter 17), polycystic kidney disease (Chapter 23), and sexually transmitted diseases (Chapter 24).

Clinical Applications and Critical Reasoning

Students entering the allied-health fields always enjoy clinical information because it teaches them anatomy in the context in which they are most interested. In response, we have augmented *Human Anatomy* with clinically-oriented features and exercises that are both timely and relevant. Disorders discussions appear near the end of most chapters, and highlighted Clinical Applications paragraphs are woven into the text at appropriate places. Noteworthy among all the clinical information is the coverage of traumatic and sports-related injuries in the bone and joint chapters, and of cancers in the chapters on visceral organs.

Also, as part of the book's interactive pedagogy, a number of Critical Reasoning questions can be found in the text columns of most chapters, with an answer following each question. This feature asks students to synthesize information from previous reading, or to draw on their own experience. Although some of the Critical Reasoning questions are anatomically oriented, most are clinical in nature. Additional Critical Reasoning questions are included in the Review Questions found at the end of each chapter.

Presentation of the Skeleton



The presentation of the bones of the skeleton has been split into two chapters: The Axial Skeleton (Chapter 7) and The Appendicular Skeleton (Chapter 8). This dual-chapter approach better fits the way in which bones are taught in most anatomy courses, and it provides students with twice the amount of end-of-chapter review material and questions on the skeleton. Equally important, we have added a number of full-page bone illustrations: the bones of the elbow and posterior views of

the hand. Given the frequency of injuries to the ankle, there is also a fully illustrated consideration of the ankle joint to Chapter 9.

Helpful Presentation of Terminology

The complex terminology of anatomy is one of the most difficult aspects of the subject to make interesting and accessible. To this end, we highlight important terms in **boldfaced type**, and we provide the pronunciations of more terms than do many competing texts. Also, we include the Latin or Greek translations of almost every term at the point where the term is introduced in the text. This promotes learning by showing students that difficult terms actually have simple, logical derivations. Furthermore, we call attention to clinical terminology in Related Clinical Terms, a section found at the conclusion of most chapters. A helpful glossary and pronunciation guide is located at the end of the text.

Practical Study Tools

On each chapter's vividly designed opening pages, readers will find student objectives amalgamated with a basic chapter outline. The popular chapter summaries now feature special icons that direct students to related interactive art exercises on the Study Partner CD  or to supplementary illustrations found in the A.D.A.M.® Interactive Anatomy Student Package CD . Students have more testing opportunities than ever before, too. Chapters conclude with our three-part review question section offering questions in multiple choice and matching, short answer and essay, and critical reasoning and clinical applications formats. Many chapters also feature questions linked to the A.D.A.M.® Interactive Anatomy Student Package CD. What is more, a 35-question quiz for each chapter can be found on the Study Partner CD, and students can access a 50-question exam for each chapter on the Anatomy and Physiology Place website. (Please see the discussion of electronic media supplements for more information.)

Electronic Media Supplements

The Anatomy & Physiology Place

From the home page of the Anatomy & Physiology Place (www.anatomyandphysiology.com), you and your students can access a Special Edition for *Human Anatomy*, Third Edition Update, which features the following resources and activities:

- 50-question practice quizzes in every chapter
- Interactive clinical case studies
- Labeling and matching exercises
- Illustrated bone anatomy quiz
- Web research activities

- On-line histology tutor
- Pronunciation glossary with an audio feature
- Anatomy-related news articles

A free 12-month subscription to this powerful website is included with each new student copy of the text. An Instructor's Resource section (available only to instructors) includes an electronic version of the *Instructor's Guide for Human Anatomy* as well as jpeg files of art from the text. A 3-day trial option is also available at the website. Access directions, along with student access codes, are attached inside the front cover.

Instructor's Art Presentation CD-ROM

This teaching resource features all of the illustrations (excluding photomicrographs) from the book—approximately 650 images in all. Each illustration can be utilized for lecture presentation or testing purposes, and are available in PowerPoint® and as jpegs in three formats: art with leaders and labels, art with leaders only, and art without leaders and labels.

Study Partner CD-ROM

This helpful interactive learning tool is designed to engage your students as they study and review the main concepts of anatomy. The Study Partner contains 53 interactive illustrated exercises along with quizzes for each chapter. A random testing feature allows students to construct tests that cover multiple chapters, with the total score revealed at the end of the test. Students can also access a comprehensive Pronunciation Glossary with audio feature. Special **SP** icons appearing within the book's end-of-chapter summaries alert students to specific, related exercises on the Study Partner. A copy of the Study Partner is attached to the inside back cover of the student and instructor versions of each textbook.

Test Bank CD-ROM

The test bank accompanying the Third Edition Update offers two 25-question multiple-choice exams per chapter as well as two final exams, each consisting of over 200 multiple-choice questions. The electronic test bank is formatted on a cross-platform CD-ROM in TestGen-EQ. This versatile software allows instructors to generate tests via a user-friendly interface in which they can easily view, edit, sort, and add questions. QuizMaster-EQ makes testing even easier for instructors. This free and fully networkable program enables the instructor to create and save tests and quizzes using TestGen-EQ so that students can take tests or quizzes on a computer network. The program automatically grades exams and

allows the instructor to view or print reports for individual students, classes, or courses. The test bank also is available in print.

A.D.A.M.® Interactive Anatomy Student Package

A.D.A.M.® Interactive Anatomy (AIA), version 3.0, is now available packaged with Lafferty and Panella's A.D.A.M.® Interactive Anatomy Student Lab Guide, Second Edition, for a very special price. With over 20,000 dissectible, atlas, and 3D anatomy images, AIA also features female and male anatomical structures, cadaver dissections, and 3D models of the heart, skull, and lungs. Special **AIA** icons appearing within most of the end-of-chapter summaries provide specific directions for locating related images on the A.D.A.M.® Interactive CD-ROM. What is more, AIA-related anatomy review questions are located at the conclusion of most chapters of the text.

A.D.A.M.® Anatomy Practice

This CD-ROM is designed to augment your students' laboratory experience. Anatomy Practice features 500 pinned anatomical images, and it includes more than 15,000 practice test questions. Students will find a wide variety of options to review anatomical images and take randomly generated tests with time limits, just as in the lab.

Course Management Options

In addition to the offering Web CT and Blackboard, two of the leading course management systems, we also offer CourseCompass™, a nationally hosted course management system that combines the strength of Benjamin Cummings content with state-of-the-art eLearning tools.

AWL Tutoring Center

Free tutoring is available to students who purchase a copy of *Human Anatomy*, Third Edition Update. The AWL Tutoring Center is staffed by qualified anatomy instructors who can tutor students on all the material covered in the text, including the art and multiple choice/matching questions at the end of each chapter. Tutoring content is restricted to text material, and tutors will only discuss answers that are provided in the textbook. Students can contact the Tutoring Center by phone, fax, e-mail, or the Web. The Tutoring Center is open Sunday through Thursday, 5:00 PM to 12:00 AM EST. Instructors should contact their local Benjamin Cummings sales representative for instructions about how to authorize student access to the Tutoring Center.

Printed Supplements

Full-Color Transparency Acetates

The transparency acetates package includes every key illustration in the book (except for photomicrographs)—approximately 450 in all. The illustrations in every transparency have been color enhanced and then enlarged for easy viewing in the classroom or lecture hall. The acetate package is available free to adopters of the text.

A Brief Atlas of the Human Body

This new photographic atlas of the human body includes 43 soft tissue photographs, plus all of the 104 bone images from *The Atlas of the Human Skeleton*. Each four-color image is clearly labeled and beautifully photographed by Ralph T. Hutchings. The Atlas superbly compliments the Third Edition Update, and is packaged free with each new textbook.

Instructor's Guide

The Instructor's Guide to the Third Edition Update of *Human Anatomy* features an innovative Teaching with Art feature that explains how to interpret a key illustration in each chapter during lecture. This feature also provides an art-related exercise and a visual critical reasoning challenge for students. As before, the Instructor's Guide offers a host of useful features such as student objectives, suggested lecture outlines, and lecture hints. Each chapter lists the available transparencies and provides lists of media resources, suggested readings, and classroom discussion topics and activities. You will also find answers to the text's short answer and essay questions and critical reasoning questions. Each chapter concludes with a Supplementary Student Materials section that contains study-tips pages that you may elect to photocopy and distribute to your students.

Human Anatomy Laboratory Manual

Elaine N. Marieb's widely used Human Anatomy Laboratory Manual with Cat Dissection, Third Edition, accompanies this text. The manual contains 29 gross anatomy and histology exercises for all major body systems. Illustrated in full color, with a convenient spiral binding, the lab manual has an accompanying *Instructor's Guide* by Linda Kollett of Massasoit Community College.

Additional Supplements Available from Benjamin Cummings

Human Cadaver Dissection Videos
By Rose Leigh Vines, et al.

Anatomy Flashcards
By Glenn Bastian

The Anatomy Coloring Book, Third Edition
By Kapit and Elson

A Color Atlas of Histology
By Dennis Strete

Histology for the Life Sciences
By Allen Bell and Victor Eroshenko

Contact your Benjamin Cummings sales representative or your campus bookstore for more information.

ACKNOWLEDGMENTS

An excellent group of people has helped us with *Human Anatomy*. First, we thank Daryl Fox, Vice President for Anatomy and Physiology, for launching the project. Kay Ueno, as Marieb project manager, oversaw the revision process; her calm and fair manner, confidence, and encouragement guided us through some hectic times and are greatly appreciated. Amy Folsom, the sponsoring editor, and Claire Brassert, the developmental editor for the first seven months of the project, were extremely kind, pleasant, and fair, and we appreciate the free hand that Claire gave Dr. Mallatt in updating the chapters. Mark Wales, a remarkably talented individual, served as developmental editor for all the art and for the text of Chapters 1–4, for the final eleven months of the project. We appreciate his vast experience, his dedication to detail, hard work, and his many creative ideas. Mark was involved with all aspects of the project and tied it all together, while bearing the brunt of the heaviest deadline pressures, as he also assembled the extensive package of supplements. He taught us much about art presentation, and Mark and Dr. Mallatt developed a special synergy that greatly improved the art and the book as a whole. Alan Titcher, who was the developmental editor for the text of Chapters 5–26, brought an extremely logical mind to the project. He increased the clarity of many written passages, improved the organization and explanatory effectiveness of many sections, helped with the reorganization of the clinical material, and revealed a talent for excellent scientific writing in his own right. Tiffany Barnes and Richard Gallagher were editorial assistants who kept the project moving through endless copying and mailing, all with flawless efficiency.

Wendy Earl and her team of experts at Wendy Earl Productions produced this edition of *Human Anatomy*. This group also produced previous editions of this book, and when we heard Wendy Earl Productions would be back for this edition, we knew the book would look good. Bradley Burch, who served as art and design director (and incidentally, chose the fine new color palette for the art), and David Novak, who was the photo coordinator and coordinator of supplements, are both extremely friendly and were a joy to work with. Special thanks, too, to Michele Mangelli, our art manager, whose ability to work hard while remaining helpful and pleasant are, frankly, astounding; she laughed off the pressure and pushed onward. Anne Hikido did a fine job as assistant art coordinator, mailing all the art back and forth across country to the bicoastal coauthors again and again. Art coordination interns from “across the pond” Charlotte Ross and Olivia Ross kept everyone’s spirits up.

We also thank Stuart Kenter, Rachael Epstein, and Bradley Burch, who as photo researchers found many fine new photos, including some especially good clinical shots and photomicrographs.

The talents of our artists are also appreciated, as we worked them quite hard! Tomo Narashima painted several showcase pieces of reflective cell biology and anatomical art, and the team of illustrators at Imagineering produced the large amount of computer-rendered art that is new to this edition. Anatomical art must be some of the most difficult art to render digitally, given its complexity, detail, and three-dimensional nature, yet these computer artists showed remarkable ability. We especially appreciate how well they were able to follow our suggestions for polishing the rough art into accurate, finished pieces. Our thanks as well to Wendy Hiller Gee and to Kristin Mount, who breathed new life into the bone and muscle art in this edition, Karl Miyajima, who acted as our production artist, and Jack Haley, project manager at Imagineering. Finally we want to thank E. tani Hasegawa, who designed the impressive cover and vivid chapter openers, and who is responsible for the Third Edition’s spacious new look.

Karen Gulliver served as the production supervisor, directing the transformation of our messy manuscript into final pages. As a calm, competent, and supportive person, she was a joy to talk to. The professionals at GTS Publishing Services assembled the dummy and final pages under a tight schedule, and we were most impressed at how they set so much text with so few errors from such a heavily revised manuscript. This book also benefited from the fine work of Kristin Barendsen as the copy editor, and we are grateful for the work of our eagle-eyed proofreaders, Dave Rich and Anita Wagner. Finally our thanks to Shane-Armstrong Information Systems for a splendid new index.

We would also like to thank our reviewers, colleagues from across the United States and Canada who devoted much effort to this book, pointed out mistakes, made helpful suggestions, and believed in us. A complete list of these reviewers appears on the next page.

Lastly, we would like to thank our spouses, Marisa de los Santos and Harvey Howell, who supported us through the entire project. We also treasure the memory of “Zeb” Marieb, beloved husband, who was an inspiration for the early versions of this book.

Jon Mallatt
Elaine Marieb

REVIEWERS

Text and Art Reviewers

Kathleen Andersen
University of Iowa College of Medicine

Steven Basset
Southeast Community College

Robert Bauman
Amarillo College

Leann Blem
Virginia Commonwealth University

Kishori Chaubal
University of the Pacific

Joe Coelho
Culver-Stockton College

Danielle Desroches
William Paterson University

David Deutsch
Kent State University

Roisheen Doherty
University College of Fraser Valley

George S. Dougherty
Indiana University

Patrick B. Fulks
Bakersfield College

Larry Ganion
Ball State University

Glenn Gorelick
Citrus College

Frank Nagy
Wright State University

Christine Iltis
Salt Lake Community College

Anne Johnson
Southern Illinois University

Jamie King
Craven Community College

Karen LaFleur
Greenville Technical College

Steven Lewis
Penn Valley Community College

Jerri K. Lindsey
Tarrant County Junior College

Theresa Martin
College of San Mateo

Robin McFarland
Cabrillo College

Patricia Munn
Longview Community College

Gail Patt
Boston University

John O. Reiss
Humboldt State University

Bill Sattarelli
Central Michigan University

Robert Seegmiller
Brigham Young University

Mary Lynne Stephanou
Santa Monica College

Deborah Taylor
Kansas City Community College

Gail C. Turner
Virginia Commonwealth University

Christine K. Wade
University of Wyoming

Jeff Wanderer
West Hills Community College

Ophelia I. Weeks
Florida International University

Toni Yates
Seminole State College

Joan E. Zuckerman
Long Beach City College

Instructor Art Focus Group

Billie S. Lane
Chattanooga State Technical College

Gail O. McKenzie
Samford University

Robert J. McDonough
Georgia Perimeter College

Andrew J. Penniman
Georgia Perimeter College

Benjamin R. Wall, Jr.
Bevill State College, Walker College Campus

Anatomy Art Advisory Board

Linda Adamchak
Hudson Valley Community College

Patricia Ahanotu
Georgia Perimeter College, Central

Roger Biduaka
St. Phillips College

Ed Bradel
Raymond Walters College

Kenneth Bynum
University of North Carolina, Chapel Hill

Russell Garcia
San Antonio College

Delaine Gilcrease
Mesa Community College

Edwin Gines-Candelaria
Miami Dade Community College, Wolfson

James Horwitz
Palm Beach Community College

Christine Ilitis
Salt Lake Community College

Bonnie Kallison
Mesa Community College

Alice Mills
Middle Tennessee State University

Betsy Ott
Tyler Junior College, Texas

Linda Powell
Community College of Philadelphia

Robert Seegmiller
Brigham Young University

Sharon Simpson
Broward Community College

R. W. Stevens
Old Dominion University

Pamela Vaughn
Laredo Community College

Michael Vitale
Daytona Beach Community College

Deloris Wenzel
University of Georgia

Art Zeitlin
Kingsborough Community College

HAPS 1999 Focus Group

Steven Lewis
Penn Valley Community College

Gail Turner
Virginia Commonwealth University

Bobby Baldrige
Ashbury College

BRIEF CONTENTS

1	The Human Body: An Orientation	1
2	Cells: The Living Units	27
3	Basic Embryology	57
4	Tissues	75
5	The Integumentary System	111
6	Bones and Skeletal Tissues	129
7	Bones: The Axial Skeleton	151
8	Bones: The Appendicular Skeleton	185
9	Joints	211
10	Muscle Tissue	243
11	Muscles of the Body	265
12	Fundamentals of the Nervous System and Nervous Tissue	335
13	The Central Nervous System	359
14	The Peripheral Nervous System	409
15	The Autonomic Nervous System and Visceral Sensory Neurons	443
16	The Special Senses	465
17	Blood	503
18	The Heart	521
19	Blood Vessels	543
20	The Lymphatic and Immune Systems	583
21	The Respiratory System	603
22	The Digestive System	633
23	The Urinary System	675
24	The Reproductive System	701
25	The Endocrine System	743
26	Surface Anatomy	769
	Appendix A The Metric System	799
	Appendix B Answers to Multiple Choice and Matching Questions	801
	Glossary	803
	Photography and Illustration Credits	815
	Index	819

DETAILED CONTENTS

1 The Human Body: An Orientation 1

AN OVERVIEW OF ANATOMY 2

Anatomical Terminology 2

Branches of Anatomy 2

Gross Anatomy 2

Microscopic Anatomy 2

Other Branches of Anatomy 2

The Hierarchy of Structural Organization 3

Scale: Length, Volume, and Weight 4

Anatomical Variability 4

GROSS ANATOMY: AN INTRODUCTION 4

The Anatomical Position 4

Directional and Regional Terms 8

Body Planes and Sections 10

The Human Body Plan 12

Body Cavities and Membranes 13

Dorsal Body Cavity 13

Ventral Body Cavity 13

Serous Cavities 14

Other Cavities 14

Abdominal Regions and Quadrants 15

MICROSCOPIC ANATOMY:

AN INTRODUCTION 16

Light and Electron Microscopy 16

Preparing Human Tissue for Microscopy 17

Scanning Electron Microscopy 18

Artifacts 18

CLINICAL ANATOMY: AN INTRODUCTION TO MEDICAL IMAGING TECHNIQUES 19

X Rays 19

Advanced X-Ray Techniques 19

Computed Tomography 19

Digital Subtraction Angiography Imaging 20

Positron Emission Tomography 21

Sonography 21

Magnetic Resonance Imaging 22

CHAPTER SUMMARY 23

REVIEW QUESTIONS 24

CRITICAL REASONING AND CLINICAL
APPLICATION QUESTIONS 25

A.D.A.M.® INTERACTIVE ANATOMY QUESTIONS 26

2 Cells: The Living Units 27

INTRODUCTION TO CELLS 28

THE PLASMA MEMBRANE 29

Structure 29

Functions 30

THE CYTOPLASM 33

Cytosol 33

Cytoplasmic Organelles 33

Mitochondria 33

Ribosomes 34

Endoplasmic Reticulum 35

Rough Endoplasmic Reticulum 35 Smooth Endoplasmic
Reticulum 36

Golgi Apparatus 36

Lysosomes 38

Peroxisomes 39

Cytoskeleton 40

Centrosome and Centrioles 40

Vaults 40

Cytoplasmic Inclusions 40

THE NUCLEUS 41

Nuclear Envelope 42

Chromatin and Chromosomes 42

Nucleoli 45

THE CELL LIFE CYCLE 45

Interphase 45

Cell Division 45

Mitosis 48

Cytokinesis 48

CELLULAR DIVERSITY 48

DEVELOPMENTAL ASPECTS OF CELLS 52

Youth 52

Aging 52

A CLOSER LOOK

Cancer—The Intimate Enemy 50

CLINICAL APPLICATIONS

Hypercholesterolemia 32 Tay-Sachs Disease 38

RELATED CLINICAL TERMS 53**CHAPTER SUMMARY** 53**REVIEW QUESTIONS** 55**CRITICAL REASONING AND CLINICAL APPLICATION QUESTIONS** 56**3 Basic Embryology** 57**THE BASIC BODY PLAN** 59**THE EMBRYONIC PERIOD** 59

Week 1: From Zygote to Blastocyst 59

Week 2: The Two-Layered Embryo 61

Week 3: The Three-Layered Embryo 62

The Primitive Streak and the Three Germ Layers 62*The Notochord* 62*Neurulation* 62*The Mesoderm Begins to Differentiate* 62

Week 4: The Body Takes Shape 66

Folding 66*Derivatives of the Germ Layers* 66

Derivatives of Ectoderm 66 Derivatives of Endoderm 66

Derivatives of Mesoderm and Notochord 67

Weeks 5–8: The Second Month of Embryonic Development 68

THE FETAL PERIOD 68**A CLOSER LOOK**

Focus on Birth Defects 70

RELATED CLINICAL TERMS 72**CHAPTER SUMMARY** 72**REVIEW QUESTIONS** 73**CRITICAL REASONING AND CLINICAL APPLICATIONS QUESTIONS** 74**4 Tissues** 75**EPITHELIA AND GLANDS** 76

Special Characteristics of Epithelia 77

Classification of Epithelia 77

Simple Epithelia 78

Simple Squamous Epithelium 78 Simple Cuboidal Epithelium 78 Simple Columnar Epithelium 78 Pseudo-stratified Columnar Epithelium 78

Stratified Epithelia 78

Stratified Squamous Epithelium 78 Stratified Cuboidal and Columnar Epithelium 83 Transitional Epithelium 83

Epithelial Surface Features 83*Apical Surface Features: Microvilli and Cilia* 83*Lateral Surface Features: Cell Junctions* 84

Desmosomes 84 Tight Junctions 85 Gap Junctions 86

Basal Feature: The Basal Lamina 86**Glands** 86*Exocrine Glands* 87

Unicellular Exocrine Glands 87 Multicellular Exocrine Glands 87

Endocrine Glands 87**CONNECTIVE TISSUE** 88**Connective Tissue Proper** 88*Areolar Tissue: A Model Connective Tissue* 89

Fibers Provide Support 90 Ground Substance Holds Fluid 91 Defense Cells Fight Infection 91 Fat Cells Store Nutrients 97

Other Loose Connective Tissues 97

Adipose Tissue 97 Reticular Connective Tissue 98

Dense Connective Tissue 98

Dense Irregular Connective Tissue 98 Dense Regular Connective Tissue 98

Other Connective Tissues: Cartilage, Bone, and Blood 98*Cartilage* 99*Bone Tissue* 99*Blood* 99**COVERING AND LINING MEMBRANES** 99**MUSCLE TISSUE** 99**NERVOUS TISSUE** 102**TISSUE RESPONSE TO INJURY** 102

Inflammation 102

Repair 103

THE TISSUES THROUGHOUT LIFE 106

A CLOSER LOOK

Stem Cells: Medical Miracle of the Twenty-First Century? 105

CLINICAL APPLICATIONS

Kartagener's Syndrome 83 Basement Membranes and Diabetes 86 Scurvy 91

RELATED CLINICAL TERMS 106

CHAPTER SUMMARY 107

REVIEW QUESTIONS 109

CRITICAL REASONING AND CLINICAL APPLICATIONS QUESTIONS 110

5 The Integumentary System 111

THE SKIN AND THE HYPODERMIS 112

Epidermis 113

Layers of the Epidermis 114

Stratum Basale 114 Stratum Spinosum 114 Stratum Granulosum 114 Stratum Lucidum 115 Stratum Corneum 115

Dermis 115

Hypodermis 115

Skin Color 116

APPENDAGES OF THE SKIN 117

Hair and Hair Follicles 117

Hair 117

Hair Follicles 117

Types and Growth of Hair 119

Hair Thinning and Baldness 120

Sebaceous Glands 120

Sweat Glands 121

Nails 121

DISORDERS OF THE INTEGUMENTARY SYSTEM 122

Burns 122

Skin Cancer 123

Basal Cell Carcinoma 123

Squamous Cell Carcinoma 124

Melanoma 124

THE SKIN THROUGHOUT LIFE 124

A CLOSER LOOK

Tattoos 116

CLINICAL APPLICATIONS

Skin's Response to Friction 113 Cyanosis 117

Chemotherapy and Hair Loss 120 Acne 121

RELATED CLINICAL TERMS 125

CHAPTER SUMMARY 125

REVIEW QUESTIONS 127

CRITICAL REASONING AND CLINICAL APPLICATIONS QUESTIONS 128

A.D.A.M.® INTERACTIVE ANATOMY QUESTIONS 128

6 Bones and Skeletal Tissues 129

CARTILAGES 130

Location and Basic Structure 130

Types of Cartilage 130

Hyaline Cartilage 130

Elastic Cartilage 130

Fibrocartilage 130

Growth of Cartilage 130

BONES 132

Functions of Bones 132

Classification of Bones 133

Gross Anatomy of Bones 134

Compact and Spongy Bone 134

Structure of a Typical Long Bone 134

Diaphysis and Epiphysis 134 Blood Vessels 134

The Medullary Cavity 134 Membranes 134

Structure of Short, Irregular, and Flat Bones 134

Bone Design and Stress 135

Microscopic Structure of Bone 136

Compact Bone 137

Spongy Bone 137

Chemical Composition of Bone Tissue 137

Bone Development 139

Intramembranous Ossification 139

Endochondral Ossification 139

Anatomy of Epiphyseal Growth Areas 140

Postnatal Growth of Endochondral Bones 141

Bone Remodeling 142

Repair of Bone Fractures 143

DISORDERS OF BONES 143

Osteoporosis 143

Osteomalacia and Rickets 145

Paget's Disease 146

Osteosarcoma 146

THE SKELETON THROUGHOUT LIFE 147

A CLOSER LOOK

The Marvelous Properties of Cartilage 132

RELATED CLINICAL TERMS 147

CHAPTER SUMMARY 148

REVIEW QUESTIONS 149

CRITICAL REASONING AND CLINICAL
APPLICATIONS QUESTIONS 150

A.D.A.M.[®] INTERACTIVE ANATOMY QUESTIONS 150

7 Bones, Part I: The Axial Skeleton 151

THE SKULL 154

Overview of Skull Geography 154

Cranial Bones 154

Frontal Bone 154

Parietal Bones and the Major Sutures 154

Sutural Bones 157

Occipital Bone 157

Temporal Bones 157

Sphenoid Bone 160

Ethmoid Bone 162

Facial Bones 162

Mandible 162

Maxillary Bones 163

Zygomatic Bones 163

Nasal Bones 163

Lacrimal Bones 163

Palatine Bones 163

Vomer 163

Inferior Nasal Conchae 163

Special Parts of the Skull 165

Orbits 165

Nasal Cavity 165

Paranasal Sinuses 167

The Hyoid Bone 167

THE VERTEBRAL COLUMN 170

Intervertebral Discs 170

Regions and Normal Curvatures 172

General Structure of Vertebrae 172

Regional Vertebral Characteristics 173

Cervical Vertebrae 173

Thoracic Vertebrae 173

Lumbar Vertebrae 175

Sacrum 175

Coccyx 177

THE BONY THORAX 177

Sternum 177

Ribs 178

DISORDERS OF THE AXIAL SKELETON 179

Abnormal Spinal Curvatures 179

Stenosis of the Lumbar Spine 179

THE AXIAL SKELETON THROUGHOUT LIFE 179

CLINICAL APPLICATIONS

Fractured Mandible 163 Herniated Disc 171

The Dens and Fatal Trauma 173

RELATED CLINICAL TERMS 182

CHAPTER SUMMARY 182

REVIEW QUESTIONS 183

CRITICAL REASONING AND CLINICAL
APPLICATIONS QUESTIONS 184

A.D.A.M.[®] INTERACTIVE ANATOMY QUESTIONS 184

8 Bones, Part II: The Appendicular Skeleton 185

THE PECTORAL GIRDLE 186

Clavicles 186

Scapulae 186

THE UPPER LIMB 189

Arm 189

Forearm 190

Ulna 190

Radius 190

Hand 190

Carpus 190

Metacarpus 193

Phalanges of the Fingers 196

THE PELVIC GIRDLE 196

Ilium 196

Ischium 196