

Frederic H. Martini

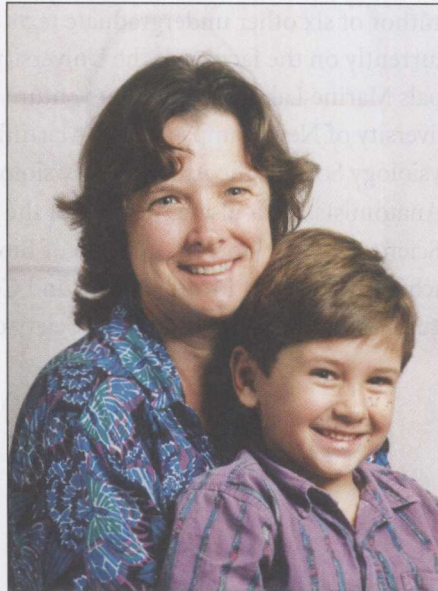
Fundamentals of Anatomy & Physiology



SIXTH
EDITION

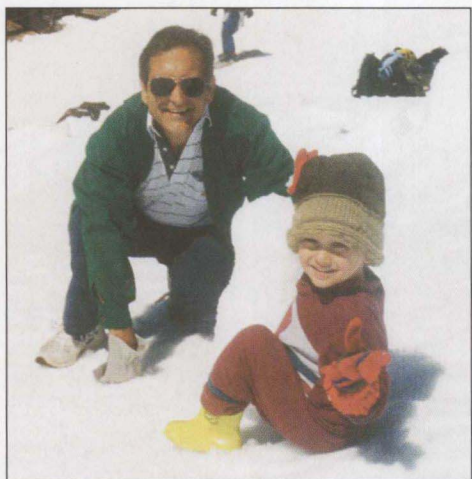
TEXT AND ILLUSTRATION TEAM

Dr. Frederic (Ric) Martini
Author



***To my family, whose support makes this
project possible, and to my readers, whose
thanks and suggestions for improvement
are deeply appreciated.***

TEXT AND ILLUSTRATION TEAM



Dr. Frederic (Ric) Martini
Author

Dr. Martini received his Ph.D. from Cornell University in comparative and functional anatomy. His publications include journal articles, technical reports, magazine articles, and a book for naturalists about the biology and geology of tropical islands. He is the coauthor of six other undergraduate texts on anatomy or anatomy and physiology. He is currently on the faculty of the University of Hawaii and remains affiliated with the Shoals Marine Laboratory, a joint venture between Cornell University and the University of New Hampshire. Dr. Martini is a member of the Human Anatomy and Physiology Society, the American Physiological Society, and the American Association of Anatomists. He is also a member of the American Association for the Advancement of Science, the National Association of Biology Teachers, the Society for College Science Teachers, the Society for Integrative and Comparative Biology, the Western Society of Naturalists, and the International Society of Vertebrate Morphologists.

William C. Ober, M.D.
Art Coordinator and Illustrator

Dr. Ober received his undergraduate degree from Washington and Lee University and his M.D. from the University of Virginia in Charlottesville. While in medical school, he also studied in the Department of Art as Applied to Medicine at Johns Hopkins University. Dr. Ober is currently on the faculty of the University of Virginia in the Department of Sports Medicine. He is also part of the Core Faculty at the Shoals Marine Laboratory.



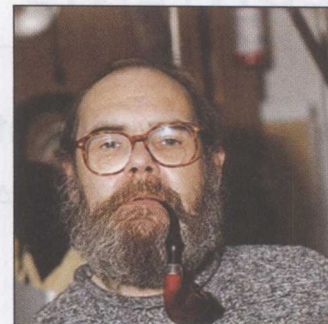
Claire W. Garrison, R.N.
Illustrator

Ms. Garrison practiced pediatric and obstetric nursing for nearly 20 years before turning to medical illustration as a full-time career. She has been Dr. Ober's associate since 1986, following a five-year apprenticeship. Ms. Garrison is also a Core Faculty member at the Shoals Marine Laboratory.



Dr. Kathleen Welch
Clinical Consultant

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 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.



Dr. Kathleen Anne Ireland
Contributor and Media Consultant

Dr. Ireland currently teaches biology at Seabury Hall, a private college preparatory school on the island of Maui. She has taught at state universities, community colleges, and private college preparatory schools for over 15 years. Dr. Ireland has an extensive background in teaching traditional as well as television and Internet courses. In the early 1990s she began one of the first completely on-line Internet A&P courses, offered through Iowa State University—a course that became the center of her doctoral studies. Dr. Ireland also has many years of experience in agricultural genetics, medical physiology, and marine biology. “Dr. Kate,” as her students call her, continues her research on the integration of technology into the science curriculum in both secondary and post-secondary education. An active member of HAPS, AAAS, HSTA and MSET, she is also a dedicated runner, swim team coach, and mother of two sons, Greg and Marc.

PREFACE

To the Instructor

You will find many changes in this edition, starting right here in the Preface. You may or may not be familiar with earlier editions of this book, so I will focus on things that I'd want to know about if I were considering a text for use in one of my classes.

WHAT SETS THIS TEXT APART FROM THE OTHERS?

I have often heard people say, “all A & P books are the same.” Well, certainly the available texts are about the same size and length, and they all have a similar organization, feature colorful illustrations, and include an assortment of supplements. But they differ widely in the way they organize information and present complex information. I will cite four specifics that set this text apart from all others on the market:

■ THE ART PROGRAM

Most texts are illustrated by a dozen or more different artists and studios, all working in relative isolation. There are no common conventions, no consistent presentation or theme. This is the only text that has all of the art done by a pair of medical illustrators, Bill Ober, M.D., and Claire Garrison, R.N. (see the biographical notes on p. iv). Bill and Claire have worked with me since the start of the first edition illustration program in 1986. They know the material, they know the text, and as they work they know how they will illustrate related topics in later chapters. As a result, the art flows as smoothly as the text.


■ THE PRESENTATION STYLE OF THE NARRATIVE

I believe that it is important to organize material so that it can easily be studied, understood, and reviewed for exams. This is not a novel that will be read for fun. It is a resource that will help students to accomplish a specific task—mastering the material—as efficiently as possible. The narrative has been structured accordingly, with special attention paid to those features that have been shown to aid in the actual learning process:

- Overviews that help students to see the big picture
- Navigator figures that provide a roadmap through complex discussions
- Lists that make it easier to organize information and focus on key facts and concepts
- Tables that summarize information concisely, in a format that makes it easy to memorize when memorization is required.

■ THE PEDAGOGICAL FRAMEWORK

This focus on the real needs of real students is reflected in many pedagogical devices used throughout the text:

- Students can check their progress periodically by answering short Concept Check questions at the ends of major sections.
- When material relates to topics presented earlier, link icons  p. 000 with specific page numbers are provided to facilitate review.
- The end-of-chapter Study Outlines are unusually comprehensive.
- The end-of-chapter questions are organized in increasing levels of difficulty and sophistication, so that students can test their mastery first of facts and terminology, then of concepts, and finally of critical thinking and clinical applications.

■ THE ANCILLARIES PROVIDED WITH THE TEXT

Today, no single text, no matter how good or how comprehensive, can provide all the resources that students should be able to draw on for help in mastering this demanding subject. Accordingly, this book has been designed as the central component of a fully integrated learning system that includes both print and media components. The complete package includes five additional components, all of which are bundled with the text:

- *InterActive Physiology*® CD-ROM, which uses animations, tutorials, and quizzes to teach the most difficult physiological concepts.
- *3-D Anatomy* CD-ROM, featuring rotatable, layered visualizations derived from the Visible Human Project of the National Library of Medicine, “Hot Spot” roll-over labeling, and three-dimensional Fly-Throughs of specific anatomical structures.
- An *Applications Manual*, organized to parallel the text, that includes discussions of clinically important disorders for each of the body's organ systems, together with information about the relevant diagnostic techniques, laboratory tests, and treatment options.
- *Martini's Atlas of the Human Body*, containing 120 anatomical photographs, a scanning atlas with 51 images produced by a variety of modern radiological techniques, and 21 embryology summaries.
- A passcode to the associated website, *Martini Online*, where students will find a variety of interactive self-quizzes for each chapter and an online e-book version of *Fundamentals of Anatomy & Physiology*.

All of these components are completely integrated with the text through icons and specific references that appear both within the chapters and in the Chapter Reviews. More complete descriptions appear below in the “Supplements” section.

WHAT'S DIFFERENT ABOUT THE SIXTH EDITION?

The basic chapter sequence and organization of the text remains largely unchanged. However, you will find several new organizational features within the narrative, as well as refinements to

(and more generous use of) features that have been highly praised by students and instructors:

- In response to feedback from users of the text, I have nearly doubled the number of **Navigator figures** to help students keep track of their progress through difficult physiological material. In this edition, Navigators will be found in Chapters 10 (muscle physiology), 12 (neurophysiology), 20 (cardiac physiology and cardiac output), 21 (cardiovascular physiology), 22 (immunity), 23 (respiratory physiology), 25 (cellular metabolism), and 26 (renal physiology). A comparable pattern of presentation—overview followed by blocks of text and art, accompanied by strategically positioned summary tables—has been used throughout, even in chapters that do not contain Navigators.
- A **Systems Overview** section, which provides basic information about the major body systems and their components, has been inserted after the introductory material on the chemical, cellular, and tissue levels but before the systems are treated individually. This unique feature is designed to help prepare students for the in-depth chapters to follow.
- **System in Perspective** sections, one per body system, which:
 - ◆ summarize the components and functions of each organ system
 - ◆ discuss the integration between each system and other systems
 - ◆ introduce key clinical patterns in the disorders characteristic of each system
 - ◆ provide Media Connections exercises that draw on the *InterActive Physiology*® CD-ROM, and relevant websites.
- The **Media Connections** were developed by Kathleen Ireland, Ph.D. Kate has extensive research and teaching experience in anatomy and physiology, and she specializes in media use and instructional design. (Her brief biography appears on p. v.) It is our hope that this feature will enable instructors to capitalize on the wealth of Web-based content, as it provides students with alternative learning opportunities.
- **Concept check questions**, which provide an opportunity for review of important material within a chapter, are now accompanied by **references to relevant exercises** on the *InterActive Physiology*® CD-ROM, the *3-D Anatomy* CD-ROM, and the *Companion Website*.
- **Summary sections** that provide an overview linked to a comprehensive table and, in many cases, an associated illustration, have been added in key locations.

Clinical material in the new edition has been reorganized to integrate it more organically with the text and increase its pedagogical value.

Short **Clinical Notes**, embedded in the text but identified with a caduceus icon, deal with pathologies that shed particular light on the principles of normal physiological function.

Longer, boxed **Clinical Discussions** deal with topics of particular medical or social importance (such as cancer and AIDS) that require more extended exploration.

The **Applications Manual** packaged with the text contains an abundance of supplementary clinical material. It includes

authoritative discussions of a broad range of diseases (both those mentioned in the text and many others), together with extensive information about the relevant laboratory tests, diagnostic procedures, and treatments. Organized to parallel the text, system by system and chapter by chapter, the *Applications Manual* is designed to be used as a supplement to the text, as a reference, or as a resource for those students who want to learn more about clinical topics.

Perhaps the most far-reaching change to the narrative has been the reorganization and rescripting of the chapters dealing with the nervous system. For many years I have been troubled by the tendency to treat this system as a collection of parts or functions; the isolation of the autonomic nervous system is one particularly obvious example of this approach. In this edition, the presentation of the nervous system follows functional patterns and stresses the integration of information. The new sequence of topics is:

- Chapter 12: neural tissue and neurophysiology
- Chapter 13: the spinal cord, the spinal nerves, and the wiring of spinal reflexes
- Chapter 14: the brain (with structures considered in inferior-to-superior sequence), the cranial nerves, and the wiring of cranial reflexes
- Chapter 15: somatic and visceral sensory pathways and somatic motor pathways (the SNS)
- Chapter 16: visceral motor pathways (the ANS) and higher order functions
- Chapter 17: the special senses

The process of revising and rewriting these key chapters resulted in extensive changes to the art program as well. In addition to the beautiful illustrations produced by Bill Ober and Claire Garrison, I have been lucky enough to work with Ralph Hutchings, a biomedical photographer. Ralph was recently cited as one of the best photographers of the twentieth century for his anatomical portrayals of the human body. His photos, many of them new to this edition, appear throughout the textbook, the media, and the new companion *Atlas*.

Dramatic improvements in the illustration program for this edition include the following:

- Chapters 10, 12, 13, 14, 18, 20, 21, 22, 26, and 28 (among others): New anatomical art and new physiological diagrams have been added to accompany a revised coverage of neurophysiology, endocrine physiology, cardiovascular function, immune function, and renal function.
- *Fundamentals of Anatomy & Physiology* pioneered the use of step lists in text and art. In this edition, we have increased the number of such figures while continuing to ensure that the steps in the text are unambiguously tied to the related art.
- Linking the art and photos in the text with new photographs in the companion *Atlas* and the anatomical simulations on the *3-D Anatomy* CD-ROM will give students a better understanding of the three-dimensional structure of the body.

THE SUPPLEMENTS PACKAGE

The supplements team consists of talented A & P instructors, most of whom have been using this textbook since its first or second edition. Their efforts are coordinated by the supplements editors and multimedia editors at Prentice Hall and at Benjamin Cummings. During the development of the Sixth Edition, the supplements team has worked with me as an extra team of reviewers. In return, I have provided additional suggestions and comments while their revisions were under way.

■ FOR THE INSTRUCTOR

Lecture Presentation Box (0-13-046169-5)

Benjamin Cummings and I have tried to simplify the task of preparing lectures for this course. The Lecture Presentation Box contains three sets of materials for each chapter. The first set contains traditional Instructor's Manual materials, including detailed lecture notes and an organizational grid of visual resources by chapter. This first set also contains suggested demonstrations, analogies, answers to end-of-chapter questions, and mnemonic activities designed to engage students' interest and to provide some additional flavor for your lectures. The second set contains student handouts, including crossword puzzles and Quiz Art (line art without labels) for each chapter. The third set contains all the transparency acetates, organized by chapter. Also included is a *Lecture Presentation Notebook* to help you organize your lecture material.

Instructor's Manual (0-13-046409-0)

This useful resource includes a wealth of materials to help you prepare and organize your lectures, such as lecture notes, vocabulary aids, applications, and classroom demonstrations. To help you organize all the visual resources provided in the supplements package, this manual also includes a detailed grid that correlates each section of the textbook with the visual aids that support that section. At a glance you can determine which transparencies, animations, and CD-ROM images are available for your lecture. New to this edition are Media Connections Instructor Notes, designed to ensure successful and meaningful use of the Media Connections activities found in chapters that precede System in Perspective sections.

Transparencies (0-13-046172-5)

The transparency set has been significantly improved and expanded. More than 800 acetates are included, with art and labels enlarged for use in large lecture halls. Where possible, complex figures have been divided into separate transparencies for improved clarity and teaching effectiveness. The selection of acetates and the quality of each image have been assessed by faculty reviewers to ensure that we offer the best possible presentation.

Printed Test Bank and Computerized Test Bank

(Print format: 0-13-046173-3)

(Software: Cross-Platform CD-ROM 0-13-046168-7)

The Test Bank has been thoroughly revised and reorganized for easier selection of questions for every objective in the textbook. A test bank of more than 3000 questions organized around the three-level learning system (as seen in the textbook and *Study Guide*) will help you design a variety of tests and quizzes.

Instructor's Resource CD-ROM (0-13-046171-7)

This cross-platform CD-ROM includes all the illustrations from the textbook, which can be edited and customized for lecture presentation or testing purposes. These images are available for easy use in PowerPoint or on the Web in three formats: images with labels and leaders, images with leaders only, and images with no labels or leaders. In addition, the CD includes 3-D animations plus all 160 photographic images (with and without labels) from *Martini's Atlas of the Human Body*—creating a powerful teaching tool.

Martini Online (www.aw.com/martini)

The Companion Website provides a wealth of materials to help enhance courses, including the Syllabus tool, which enables instructors to easily put their syllabuses online. The website also includes Instructor Resources, which offers instructors the ability to download media and print supplements. And the site allows students to link from a quiz question to the corresponding eBook by clicking on a "hint" button.

The new website has been designed to make it easier to incorporate Web-based activities into the core curriculum. One of the key advances is the inclusion of chapter-based Media Connections. Media Connections provide specific, time-constrained exercises with clearly stated objectives that relate the Web-based activities to the chapter content. These exercises have been designed (1) to enable instructors to capitalize on the wealth of Web-based content and (2) to provide alternative learning opportunities. To help you implement these Media Connections in your course, the *Instructor's Manual* offers instructions for their use.

The website also includes clinical case studies organized into steps that give you the opportunity to practice and apply your knowledge of anatomy and physiology in a practical and realistic way. These case studies, derived from actual case histories, support problem-based learning.

In addition to the basic tools available on the Companion Website for this textbook, Benjamin Cummings provides rich and thorough online course material in major course management systems, including **Blackboard**, **CourseCompass** (Pearson's nationally hosted version of **Blackboard**) and **WebCT**.

I hope that as the year passes, you will use the Companion Website or my email address, listed at the end of the Preface, to contact me with suggestions for future improvements, new illustrations, or news of interesting research developments.

Distance is no longer a limiting factor in our “global A & P village,” and I hope that even more instructors and students will participate in the development of future editions.

■ FOR THE STUDENT

Applications Manual (0-13-047811-3)

Each new copy of the text comes packaged with an *Applications Manual*, which is written in collaboration with Kathleen Welch, M.D., my wife, who is also the clinical consultant for the text. This unique supplement provides access to interesting and relevant clinical and diagnostic information, and it presents that information in a framework that helps students develop problem-solving skills. The book begins with an overview of the way diseases are diagnosed, and this leads to a discussion of the scientific method and to the use of logic and reasoning to evaluate health-related statements and claims. It then provides background information about chemical, cellular, and molecular disorders and techniques. Finally, it presents the major categories of disorders and important diagnostic techniques for each body system. Although it can be read separately from the textbook, each major topic in the *Applications Manual* is cross-referenced to specific pages in the textbook.

The *Applications Manual* is designed to demonstrate the relevance of key concepts presented in the textbook. By placing the material in a separate volume, topics can be covered in greater depth—or skipped—without interrupting the flow of information in the textbook. Few instructors will require their students to read the entire *Applications Manual*. The *Manual* is available so that each student can refer to segments of particular importance to his or her career plans or personal or family health. In subsequent courses, the *Applications Manual* becomes an invaluable reference for students, linking the topics covered in advanced courses with the basic anatomy and physiology covered in students' introductory-level courses.

InterActive Physiology CD-ROM (0-8053-5999-0)

3-D Anatomy CD-ROM (0-321-17028-8)

Two powerful media resources accompany the Sixth Edition: the *InterActive Physiology*® CD-ROM and the new *3-D Anatomy* CD-ROM.

Inside the back cover of the textbook, students will find the award-winning *InterActive Physiology*® CD-ROM. Complete with animations, tutorials, and quizzes, IP is referenced throughout the text in appropriate Concept Check boxes, end-of-chapter Study Outlines, and end-of-body-system Media Connections. IP offers an indispensable resource for enhancing physiological topics covered within the text.

The second media resource, bound in *Martini's Atlas of the Human Body*, is the *3-D Anatomy* CD-ROM. The anatomical renderings and animations presented on the *3-D Anatomy*

CD-ROM were developed with data from the Visible Human Project, sponsored by the National Library of Medicine. Students and instructors can rotate images, providing powerful views of internal structures.

Martini's Atlas of the Human Body (0-13-146123-0)

This new, spiral-bound *Atlas* contains a wealth of information that augments the figures in the text. Most prominently, it includes 160 anatomical plates, 53 of them new to this edition, as well as 53 high-quality radiological images produced by CT, MRI, and contrast X-ray techniques. Each image is cross-referenced to figures in *Fundamentals of Anatomy & Physiology* through icons that appear in the figure captions. In addition, the *Atlas* contains 36 pages of full-color Embryology Summaries, dealing with the developmental origins of each body system, and is bundled with the new *3-D Anatomy* CD-ROM.

Study Guide (0-13-046407-4)

This very popular *Study Guide*, written by Charles Seiger, is an excellent way to review basic facts and concepts as well as to develop problem-solving skills. A variety of questions, including labeling and concept mapping, are keyed to every learning objective in the textbook and are organized around the same three-level learning system.

Video Tutor for Anatomy and Physiology (0-13-751843-9)

This videotape offers high-quality tutorials for anyone with access to a VCR. Each segment includes a professionally narrated animation that walks you through the most difficult physiological concepts and offers self-check questions that allow you to test your understanding of the material. Segments of the Video Tutor include membrane transport, protein synthesis, muscle contraction, action potential propagation, vision, auditory function, heart function, urine formation, and the immune response.

■ FOR THE LABORATORY

Benjamin Cummings publishes a variety of laboratory manuals to meet the diverse needs of anatomy and physiology labs. Please see your Benjamin Cummings sales representative for more details. Here is a list of those manuals:

Laboratory Textbook of Anatomy and Physiology, Second Edition, by Michael G. Wood. This full-color, 700-page lab manual has been designed to complement *Fundamentals of Anatomy and Physiology*. It features cat dissections. (0-13-019694-0)

Laboratory Exercises in Anatomy and Physiology with Cat Dissections, Seventh Edition, by Gerard J. Tortora and Robert J. Amatrano. This full-color manual features cat dissections and graphics. (0-13-047791-5)

Anatomy and Physiology Laboratory Manual, Sixth Edition, by Gerard J. Tortora and Robert J. Amatrano. This full-color manual offers a variety of laboratory exercises with minimal mammalian dissections. (0-13-089670-5)

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This textbook is not the product of any single individual; rather, it represents a group effort, and the members of the group deserve to be acknowledged. Foremost on my thank-you list are the faculty and reviewers throughout the world who offered suggestions that helped guide me through the revision process. Their interest in the subject, concern for the accuracy and method of presentation, and experience with students of widely varying abilities and backgrounds made the revision process an educational experience for me. To them, I express my sincere thanks and best wishes:

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Focus groups and casual meetings with students around the world helped me concentrate on the needs of individual students. I first undertook this project in 1983 to address the needs of my own students, and their feedback continues to be very important to me. I also thank the many instructors and students who took the time to contact me by phone or e-mail with specific suggestions, kudos, questions, or problems.

Over time, a textbook evolves. As with organisms, each evolutionary step builds on a preexisting framework. Thus, I also thank the individuals who helped with the development of previous editions. That list includes the following:

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Virtually without exception, reviewers stressed the importance of accurate, integrated, and visually attractive illustrations in aiding the students to understand essential material. The revision of the art program was directed by Bill Ober, M.D., and Claire Garrison, R.N. Their suggestions about topics of clinical importance, presentation sequence, and revisions to the proposed art were of incalculable value to me and to the project.

Many of the text's illustrations include color photographs or micrographs collected from a variety of sources. The striking anatomical photos in the text, in *Martini's Atlas of the Human Body*, and the Wood lab manual were the work of Ralph Hutchings, whose efforts on this project are deeply appreciated. Much of the work in tracking down micrographs and other visual materials was performed by Yvonne Gerin; I greatly value her help. Dr. Eugene C. Wasson, III, and the staff of Maui Radiology Consultants, Inc., provided valuable assistance in the selection and printing of the CT and MRI scans that are included in the new *Atlas*.

I also express my appreciation to the editors and support staff both at Prentice Hall, with whom I started this revision, and Benjamin Cummings, with whom I finished it. First on the list is Shari Toron, the Production Editor for all of my projects. She somehow managed to handle every crisis, and kept things moving in the right direction, all the while maintaining her poise and sense of humor. Her support, hard work, and patience are deeply appreciated.

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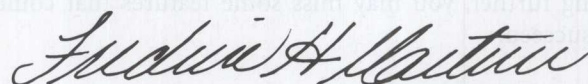
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No one person could expect to produce a flawless textbook of this scope and complexity. Any errors or oversights are strictly my own rather than those of the reviewers, artists, or editors. To help improve future editions, I encourage you to send any pertinent information, suggestions, or comments about the organization or content of this textbook to me directly, using the e-mail address below. I will deeply appreciate any and all comments and suggestions and will carefully consider them in the preparation of the Seventh Edition.



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To the Student

HOW TO GET THE MOST OUT OF THIS PACKAGE

You probably have several reasons for taking this course. Like most people, you probably have many questions about your own body and about the origins of health problems or diseases. Perhaps you also need this course to further your career plans. If you are like most College students, you have two short-term goals in mind: (1) to learn and understand the material, and (2) to be able to demonstrate your mastery to the satisfaction of the instructor. I've tried to build features into the text that will help you reach both of these goals. In many respects, I've assembled this text like an Owner's Manual for the human body—it not only has the important information, but is also designed to help you find that information quickly. As a result, you may find that it is very different from the texts you've used for other classes. In this section, I've tried to give you some advice on how to use the features and unique organization of this text to your advantage. If you charge off into the text without reading further, you may miss some features that could help you succeed.

■ WATCH THE BIG PICTURE

- Each chapter begins with an outline. Use it to get a sense of the scope and organization of the chapter as a whole.
- The major sections are numbered so that you can more easily keep track of your position within the chapter as you proceed.
- Each of these sections begins with a list of objectives. They will give you a preview of the main points that you can expect to learn as you work through the material.
- Many of the chapters include Navigator figures, which function as a kind of roadmap. Use them to help keep track of where you are in a complex discussion without getting lost in the details.

■ LEARN THE TERMINOLOGY

- You will also find that there are a lot of new words to learn. The faster you can learn the terminology, the easier it will be for you to master the concepts. Throughout the text, the most important terms appear in **boldface** print so they are easy to spot. In addition, any time there's a chance of confusion, I've included a pronunciation guide. Accented syllables are in capital letters, and for the vowels:

ā as in tray	a as in track
ē as in tree	e as in help
ī as in spine	i as in ink
ō as in bone	o as in Tom
ū as in use	u as in run
oo as in moon	oy as in boy

■ ALWAYS TRY TO ORGANIZE IMPORTANT INFORMATION

You've got to have a study plan and a method of organizing your notes. Don't try to memorize everything—organize the material, focus on the key points, and look for common themes and patterns.

- Take advantage of the many lists in the text, as well as the abundance of tables. Both of these formats summarize important information in a way that will make it easier for you to grasp and memorize.
- The material in each chapter builds upon the material presented in earlier chapters. Often you will want to review the relevant discussions. To make this easier, I've inserted a symbol with a page reference: ∞ p. 000. To help you proceed directly to the proper page, you will find that the page numbers appear in bold within a color band in the upper margin of each page. (The colors indicate the body system, in case you just need to find a general topic rather than a specific page.)

■ KEEP AN EYE ON THE ART

I've provided a lot of visual support in this package—because, whether you are considering processes or structures, you need to be able to visualize what's being described in the narrative.

There are a LOT of illustrations in the text, and I work closely with the artist, an M.D., who reviews the text before creating the images. Because the text and art are developed together, you will find yourself moving back and forth between the text and the art as you read the chapter. At each spot in the narrative where you are sent to the art, there's a red dot that serves as a place holder—use it to help you find your way back to the point in the text that you left.

Many of the figures show dynamic processes underway in a series of steps; these same steps are also clearly identified and explained in the narrative. Breaking a complex process into stages is one way to make it easier to follow and understand.

Some figures are accompanied by an icon, **ATLAS**, which directs you to another view of the same structure in *Martini's Atlas of the Human Body* packaged with your text. You'll find that looking at a single anatomical feature from different perspectives or visualized using different techniques is a powerful way of enhancing your understanding of what you are seeing.

■ PACE YOURSELF

It is usually a very bad idea to read a chapter in this textbook as if it were a chapter in a novel—from beginning to end, with no breaks. It's much more efficient to pace yourself and take a few pauses along the way to test your understanding of the material presented thus far. You are building your knowledge base, and there's no use reading the *next* section until you understand what was covered in *this* section.

- At the end of each major section, you will find a few short review questions. Take a moment to answer them. If you find them easy

to answer, you can go on to the next section. If you find them difficult to answer, go back and reread the material. It's like building a house—it's not wise to start working in the second floor if the first floor is shaky.

- Many of these questions are also accompanied by references to tutorials or three-dimensional anatomical views on the *InterActive Physiology*® CD-ROM packaged with your text or the *3-D Anatomy* CD-ROM that accompanies your *Atlas*. Don't hesitate to take advantage of these resources if you feel that you need to reinforce or deepen your understanding of the material you have just covered.

■ CONSIDER WHAT THE INFORMATION MEANS

You probably would not be taking this course if you did not have at least some interest in health and medicine. The text and its ancillaries contain a wealth of clinical material, organized so that you can easily focus on precisely what is relevant to your own or your instructor's concerns:

- Short *Clinical Notes* embedded in the text deal with many kinds of pathologies. These topics have been selected to help you understand the principles of normal function by showing what happens when something goes wrong.
- Topics of great general importance or that require more extended treatment are considered in boxed *Clinical Discussions*.
- Information about a variety of diseases not discussed in the text, as well as additional details about many that are, can be found in the *Applications Manual* that came with your text, together with information about the diagnosis and treatment of these conditions. The *Applications Manual* is organized in exactly the same way as the text to make it as easy as possible for you to consult. Use it as a supplement to the text, as a reference, or just to satisfy your individual curiosity. Look for the blue icon, **AM**, that will direct you to relevant topics in the *Manual*.

■ PUT IT TOGETHER

The human body is an integrated whole, not a collection of isolated systems, so it's important that you be able to see information pertaining to specific systems in a larger context.

- For each body system, you'll find a two-page "System in Perspective" section that summarizes the components and functions of the system, displays its interactions with every other body system, outlines relevant clinical aspects of the system, and provides media-based exercises to deepen your insight or open fresh perspectives. These sections can be an important part of your study, because they not only review the material in an entire chapter (or series of chapters) but integrate the contents of the entire book.

■ ALWAYS REVIEW THE CHAPTER AFTER YOU COMPLETE IT

It might take you a week to work through a chapter, and by the time you reach the end, you may not have a clear perspective on the presentation as a whole. That's the time to review the end-of-chapter-material.

- The *Study Outline* at the end of each chapter gives you an opportunity to review all the chapter's key information and concepts. You can also use it as a jumping-off point for the CD-based tutorials and visualizations referenced within the chapter, because those references are repeated here.
- The *Review Questions* are organized so that you can assess your mastery of the chapter on three levels. You can test your grasp of facts and terminology (Level 1), your understanding of concepts (Level 2), and your ability to apply the material to realistic clinical situations (Level 3). If you need additional practice, there are more self-assessment quizzes in various formats on the **Companion Website** (www.aw.com/martini).

I wrote this book to give you the information you need as clearly as possible. If you find certain sections especially difficult, if you don't find information that you or your instructor would really like to cover, or if you have other comments or suggestions for future editions, please let me know using the e-mail address below.

Good luck and best wishes,
Ric (martini@maui.net)



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SIXTH EDITION

Fundamentals of Anatomy & Physiology

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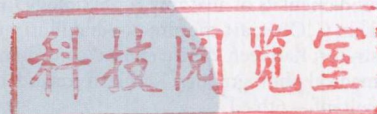
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