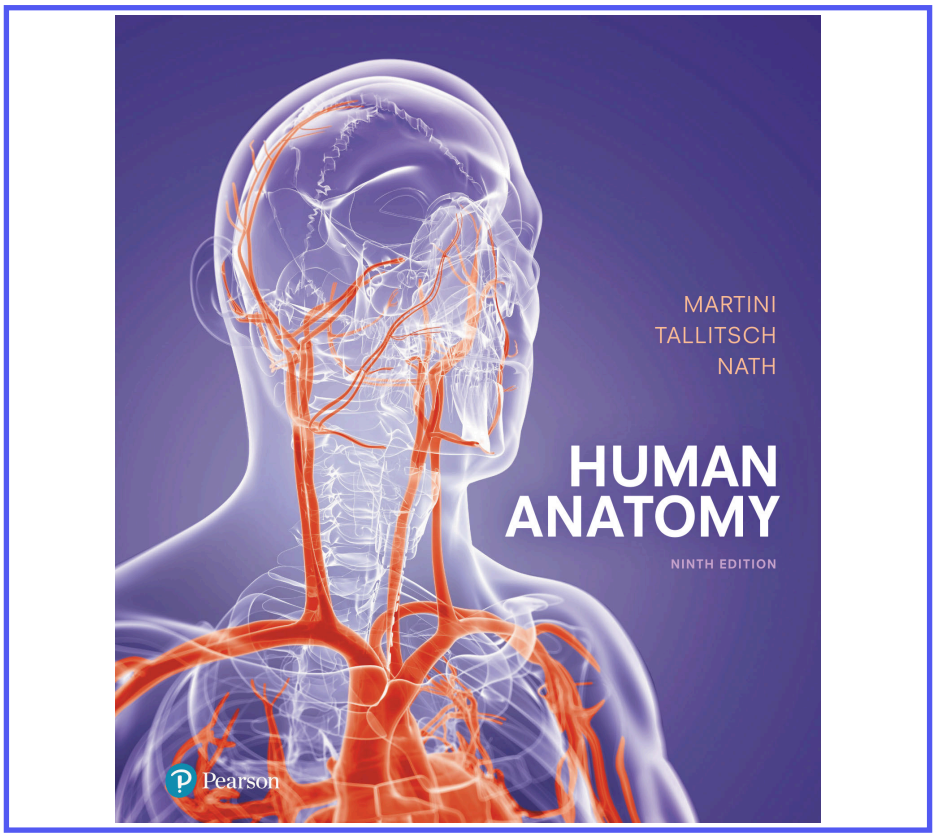


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Author and Illustration Team



Frederic (Ric) Martini

Author

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 ten undergraduate texts on anatomy and physiology or anatomy. 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. He has been active in the Human Anatomy and Physiology Society (HAPS) for over 24 years and was a member of the committee that established the course curriculum guidelines for A&P. He is now a President Emeritus of HAPS after serving as President-Elect, President, and Past-President over 2005–2007. Dr. Martini is also a member of the American Physiological Society, the American Association of Anatomists, the Society for Integrative and Comparative Biology, the Australia/New Zealand Association of Clinical Anatomists, the Hawaii Academy of Science, the American Association for the Advancement of Science, and the International Society of Vertebrate Morphologists.



Robert B. Tallitsch

Author

Dr. Tallitsch received his Ph.D. in physiology with an anatomy minor from the University of Wisconsin–Madison at the ripe old age of 24. Dr. Tallitsch has been on the biology faculty at Augustana College (Illinois) since 1975. His teaching responsibilities include human anatomy, neuroanatomy, histology, and cadaver dissection. He is also a member of the Asian Studies faculty at Augustana College, teaching a course in traditional Chinese medicine. Dr. Tallitsch has been designated as one of the "unofficial teachers of the year" by the graduating seniors at Augustana 19 out of the last 20 years. Dr. Tallitsch is a member of the American Association of Anatomists, where he serves as a Career Development Mentor; the American Association of Clinical Anatomists; and the Human Anatomy and Physiology Society. In addition to his teaching responsibilities, Dr. Tallitsch currently serves as a reviewer for the Problem-Based Learning Clearinghouse and has served as a visiting faculty member at the Beijing University of Chinese Medicine and Pharmacology (Beijing, PRC), the Foreign Languages Faculty at Central China Normal University (Wuhan, PRC), and in the Biology Department at Central China Normal University (Wuhan, PRC).



Judi L. Nath

Author

Dr. Judi Nath is a biology professor and the writer-in-residence at Lourdes University, where she teaches at both the undergraduate and graduate levels. Primary courses include anatomy, physiology, pathophysiology, medical terminology, and science writing. She received her Bachelor's and Master's degrees from Bowling Green State University, which included study abroad at the University of Salzburg in Austria. Her doctoral work focused on autoimmunity, and she completed her Ph.D. from the University of Toledo. Dr. Nath is devoted to her students and strives to convey the intricacies of science in captivating ways that are meaningful, interactive, and exciting. She has won the Faculty Excellence Award—an accolade recognizing effective teaching, scholarship, and community service—multiple times and in 2013 was named as an Ohio Memorable Educator. She is active in many professional organizations, notably the Human Anatomy and Physiology Society (HAPS), where she has served several terms on the board of directors. Dr. Nath is a coauthor of *Fundamentals of Anatomy & Physiology, Visual Anatomy & Physiology, Visual Essentials of Anatomy & Physiology,* and *Anatomy & Physiology* (published by Pearson); and she is the sole author of *Using Medical Terminology* and *Stedman's Medical Terminology* (published by Wolters Kluwer). Her favorite charities are those that have significantly affected her life, including the local Humane Society, the Cystic Fibrosis Foundation, and the ALS Association. In 2015, she and her husband established the Nath Science Scholarship at Lourdes University to assist students pursuing science-based careers. When not working, days are filled with family

William C. Ober

Art Coordinator and Illustrator



Dr. Ober received his undergraduate degree from Washington and Lee University and his M.D. from the University of Virginia. He also studied in the Department of Art as Applied to Medicine at Johns Hopkins University. After graduation, Dr. Ober completed a residency in Family Practice and later was on the faculty at the University of Virginia in the Department of Family Medicine and in the Department of Sports Medicine. He also served as Chief of Medicine of Martha Jefferson Hospital in Charlottesville, VA. He is currently a Visiting Professor of Biology at Washington and Lee University, where he has taught several courses and led student trips to the Galápagos Islands. He was on the Core Faculty at Shoals Marine Laboratory for 24 years, where he taught Biological Illustration every summer. Dr. Ober has collaborated with Dr. Martini on all of his textbooks in every edition.

Claire E. Ober

Illustrator



Claire E. Ober, R.N., B.A., practiced family, 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 at Medical & Scientific Illustration since 1986. She was on the Core Faculty at Shoals Marine Laboratory and co-taught the Biological Illustration course with Dr. Ober for 24 years. The textbooks illustrated by Medical & Scientific Illustration have won numerous design and illustration awards.

Kathleen Welch

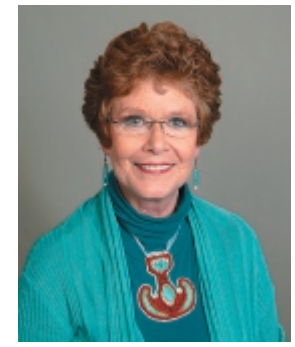
Clinical Consultant



Dr. Welch received her B.A. from the University of Wisconsin–Madison and her M.D. from the University of Washington in Seattle, and did her residency in Family Practice at the University of North Carolina in Chapel Hill. Participating in the Seattle WWAMI regional medical education program, she studied in Fairbanks, Anchorage, and Juneau, Alaska, with time in Boise, Idaho, and Anacortes, Washington, as well. 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, and on the staff at Maui Memorial Hospital. She was in private practice from 1987 until her retirement in 2012. Dr. Welch is a Fellow of the American Academy of Family Practice and a member of the Hawaii Medical Association, the Maui County Medical Association, and the Human Anatomy and Physiology Society (HAPS). With Dr. Martini, she has coauthored both a textbook on anatomy and physiology and the *A&P Applications Manual*. She and Dr. Martini were married in 1979, and they have one son.

Ruth Anne O'Keefe

Clinical Consultant



Dr. O'Keefe did her undergraduate studies at Marquette University, attended graduate school at the University of Wisconsin, and received her M.D. from George Washington University. She was the first woman to study orthopedic surgery at The Ohio State University. She did fellowship training in trauma surgery at Loma Linda University. She has always been passionate about global health and has done orthopedic surgery in high-need areas around the world, taking her own surgical teams to places such as the Dominican Republic, Honduras, Peru, Burkina Faso, and New Zealand. She serves on the board of Global Health Partnerships, a group that partners with a clinic serving 50,000 very poor people in rural Kenya. Dr. O'Keefe has enjoyed teaching at all levels and at all the universities in places where she has lived. She now lives in Albuquerque with her Sweet Ed. She is mother of four, grandmother of thirteen, and foster grandmother to many.

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 chose 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.

Preface

Welcome to the ninth edition of *Human Anatomy*! This edition marks a significant change to the author team with the retirement of Michael Timmons and the addition of a fine colleague and excellent writer, Judi Nath.

We have made significant changes to *every* chapter of the text. As a result, this book—which was already highly visual—is now even more visual and engaging. These changes will enhance students' understanding of the chapters and the intricacies of the human body. Our new and revised visuals will promote student involvement with the figures.

In addition, the author team has revised the chapter narratives to be even more "student friendly" with a lively writing style. We have repositioned figure callouts and tried to place all graphics on the same two-page spread with their anatomical descriptions.

New to the Ninth Edition

Our goal is to build on the strengths of previous editions while meeting the needs of today's students. The author team has paid significant attention to the latest research on the science of teaching and learning. Our reading of this research has informed the revision of both the art program and text narratives in this edition. As a result, we believe this edition will prove even more effective for attracting students' attention, enhancing their understanding, and promoting their retention of anatomical concepts.

- **EVERY ILLUSTRATION** has been revised, either partially or totally.
- **EVERY CHAPTER** has been extensively rewritten to
  - Engage students with an informal, friendly approach
  - Reposition figure callouts for easy reading and understanding
  - Place figures in a logical design that is both attractive and effective
  - Place figures as close to their anatomical descriptions as possible
  - Increase the number of bullet lists and numbered lists to better facilitate student learning
  - Use standardized terminology of the latest editions of *Terminologia Anatomica*, *Terminologia Histologica*, *Terminologia Embryologica*, and *Stedman's Medical Dictionary*

- **NEW Chapter Opener Clinical Cases** have been added to every chapter. These clinical cases increase student interest in the topics and vividly demonstrate the importance of anatomical concepts in the health professions. In addition, all of the existing Clinical Notes features, found within the chapters, have been updated or replaced to reflect current topics and the latest research.
- **NEW Tips & Tools** boxes are concise, catchy memory devices to help students easily remember anatomical facts and concepts.
- **NEW Key Points** boxes give students a quick summary of the material discussed in the upcoming section of the chapter.
- **Improved text-art integration** throughout enhances the readability of figures with the text.
- **NEW MasteringA&P features** include the following:
  - Ready to Go Teaching Modules, created by teachers for teachers, are organized around eight of the toughest topics in human anatomy. They provide suggestions to instructors on which assets in MasteringA&P can best be used before, during, and after class to effectively teach the topic.
  - A Coaching Activity for the new Spotlight Figure in Chapter 17 on the sympathetic nervous system.
  - Revised and updated Dynamic Study Modules.

Chapter-by-Chapter Revisions

In addition to a significant rewriting of every chapter within the text, as outlined above, the following changes have been made in each chapter of the ninth edition of *Human Anatomy*:

1 Foundations: An Introduction to Anatomy

- Nine illustrations either are new or have been significantly revised.
- All Clinical Notes within this chapter have been revised.
- One new Tips & Tools box was added to this chapter.
- The section dealing with sectional anatomy was extensively revised to better facilitate student learning

2 Foundations: The Cell

- Eight illustrations either are new or have been significantly revised.
- The sections dealing with the plasma membrane, cellular cytoskeleton and intercellular attachments were reorganized and revised to better facilitate student learning.

3 Foundations: Tissues and Early Embryology

- Sixteen illustrations either are new or have been significantly revised.
- Four new Tips & Tools boxes were added to this chapter.

4 The Integumentary System

- Nine illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

5 The Skeletal System: Osseous Tissue and Bone Structure

- Nine illustrations either are new or have been significantly revised.
- The sections dealing with blood and nerve supply to bones and factors regulating growth were reorganized and revised to better facilitate student learning.

6 The Skeletal System: Axial Division

- Twenty-nine illustrations either are new or have been significantly revised.
- Two new Tips & Tools boxes were added to this chapter.

7 The Skeletal System: Appendicular Division

- Twenty-four illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

8 The Skeletal System: Joints

- The chapter title has been changed from Articulations to Joints.
- Twenty-one illustrations either are new or have been significantly revised.
- The sections dealing with darthroses (freely movable synovial joints) and the elbow and radio-ulnar joints were reorganized and revised.

9 The Muscular System: Skeletal Muscle Tissue and Muscle Organization

- Thirteen illustrations either are new or have been significantly revised.
- All sections dealing with the microanatomy and the physiology of skeletal muscle contraction were extensively revised.
- One new Tips & Tools box was added to this chapter.

10 The Muscular System: Axial Musculature

- Fourteen illustrations either are new or have been significantly revised.
- The organization of the sections dealing with muscles of the vertebral column and muscles of the perineum and the pelvic diaphragm was changed to better facilitate student learning.
- One new Tips & Tools box was added to this chapter.

11 The Muscular System: Appendicular Musculature

- Thirty illustrations either are new or have been significantly revised.
- Five new Tips & Tools boxes were added to this chapter.

12 Surface Anatomy and Cross-Sectional Anatomy

- Eighteen illustrations either are new or have been significantly revised.
- Four Clinical Note illustrations have been added to this chapter.

13 The Nervous System: Nervous Tissue

- The chapter title has been changed from Neural Tissue to Nervous Tissue.
- Sixteen illustrations either are new or have been significantly revised.
- The section dealing with synaptic transmission was reorganized and revised to better facilitate student learning.

14 The Nervous System: The Spinal Cord and Spinal Nerves

- Seventeen illustrations either are new or have been significantly revised.
- The sections dealing with the spinal meninges and the peripheral distribution of spinal nerves were reorganized and revised to better facilitate student learning.

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

- Seven illustrations either are new or have been significantly revised.
- The entire chapter was significantly revised to better facilitate student learning.

16 The Nervous System: The Brain and Cranial Nerves

- Thirty-four illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

17 The Nervous System: Autonomic Nervous System

- Eleven illustrations either are new or have been significantly revised.
- All material describing the anatomy of the sympathetic nervous system was revised to better facilitate student learning
- A new Spotlight Figure on the sympathetic nervous system has been added.
- New material was added to clarify the anatomy of the sympathetic ganglia

18 The Nervous System: General and Special Senses

- Twenty-eight illustrations either are new or have been significantly revised.
- All sections dealing with the physiology of the general and special senses were extensively revised.

19 The Endocrine System

- Eleven illustrations either are new or have been significantly revised.
- All sections dealing with the physiology of the endocrine glands were extensively revised.
- All material describing the anatomy of the pituitary gland was reorganized and revised to better facilitate student learning.

20 The Cardiovascular System: Blood

- Eight illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

21 The Cardiovascular System: The Heart

- Twelve illustrations either are new or have been significantly revised.
- All material describing the anatomy of the pericardium and the surface anatomy of the heart were revised to better facilitate student learning.

22 The Cardiovascular System: Vessels and Circulation

- Twenty-six illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

23 The Lymphatic System

- Seventeen illustrations either are new or have been significantly revised.
- All sections dealing with the development and immunological functions of the lymphatic cells, lymphatic vessels, and lymph nodes were extensively revised.

24 The Respiratory System

- Eighteen illustrations either are new or have been significantly revised.
- The organization of several sections was changed to better facilitate student learning.

25 The Digestive System

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

26 The Urinary System

- Thirteen illustrations either are new or have been significantly revised.
- All sections dealing with the anatomy of the nephron were revised to better facilitate student learning
- All sections dealing with the physiology of the urinary system were extensively revised.

27 The Reproductive System

- Twenty-two illustrations either are new or have been significantly revised.
- All sections dealing with the physiology of the male and female reproductive systems were extensively revised

28 The Reproductive System: Embryology and Human Development

- All of the Embryology Summaries have been revised.

Acknowledgments

Once again, the creative talents and patience brought to this project by our artist team, William Ober, M.D., Claire E. Ober, 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. Thanks also to Dr. Ruth Anne O'Keefe for her excellent work on the clinical material, and to Colonel (ret) Michael Yard of Indiana University – Purdue University Indianapolis, for his additional feedback on clinical cases and notes. We are grateful to Elise Lansdon of Elise Lansdon Design for her excellent work on the design of the ninth edition of *Human Anatomy*.

Special thanks also goes to our new Portfolio Manager, Cheryl Cechvala, who came in the midst of revisions and supported us to the end. Content Producer, Caroline Ayres, guided us through all the stages from development to pages. This text wouldn't be what it is today without their valuable expertise and help.

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.

Reviewers

Jeffrey Blodig, *Johnson County Community College*
Lisa Brinn, *Florida International University*
Diep Burbridge, *Long Beach City College*
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Deborah Shelley, *Fresno City College*
Michael Yard, *Indiana University – Purdue University Indianapolis*

We are also indebted to the Pearson staff, whose efforts were vital to the creation of this edition. A special note of thanks and appreciation goes to the editorial staff at Pearson. Thanks also to Barbara Yien, Courseware Director, Courseware Analysts Alice Fugate and Molly Ward, and Kimberly Twardochleb, Editorial Coordinator. We express thanks to Patrice Fabel and Lauren Chen for their work on the media programs that support *Human Anatomy,* especially MasteringA&P and Practice Anatomy Lab™ (PAL™). Thanks also to Norine Strang for her role in the production of the text.

We are very grateful to Adam Jaworski, Vice President, and Serina Beauparlant, Editor in Chief, for their continued enthusiasm and support of this project. We appreciate the contributions of Derek Perrigo, Senior Anatomy and Physiology Specialist, and Allison Rona, Executive Marketing Manager, who keep their fingers on the pulse of the market and help us meet the needs of our customers. Thanks also to the remarkable and tireless Pearson Science sales reps.

We are also grateful that the contributions of all 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.

Finally, we would like to thank our families for their love, patience, and support during the revision process. We could not have accomplished this without the help of our spouses—Kitty, Mary, and Mike.

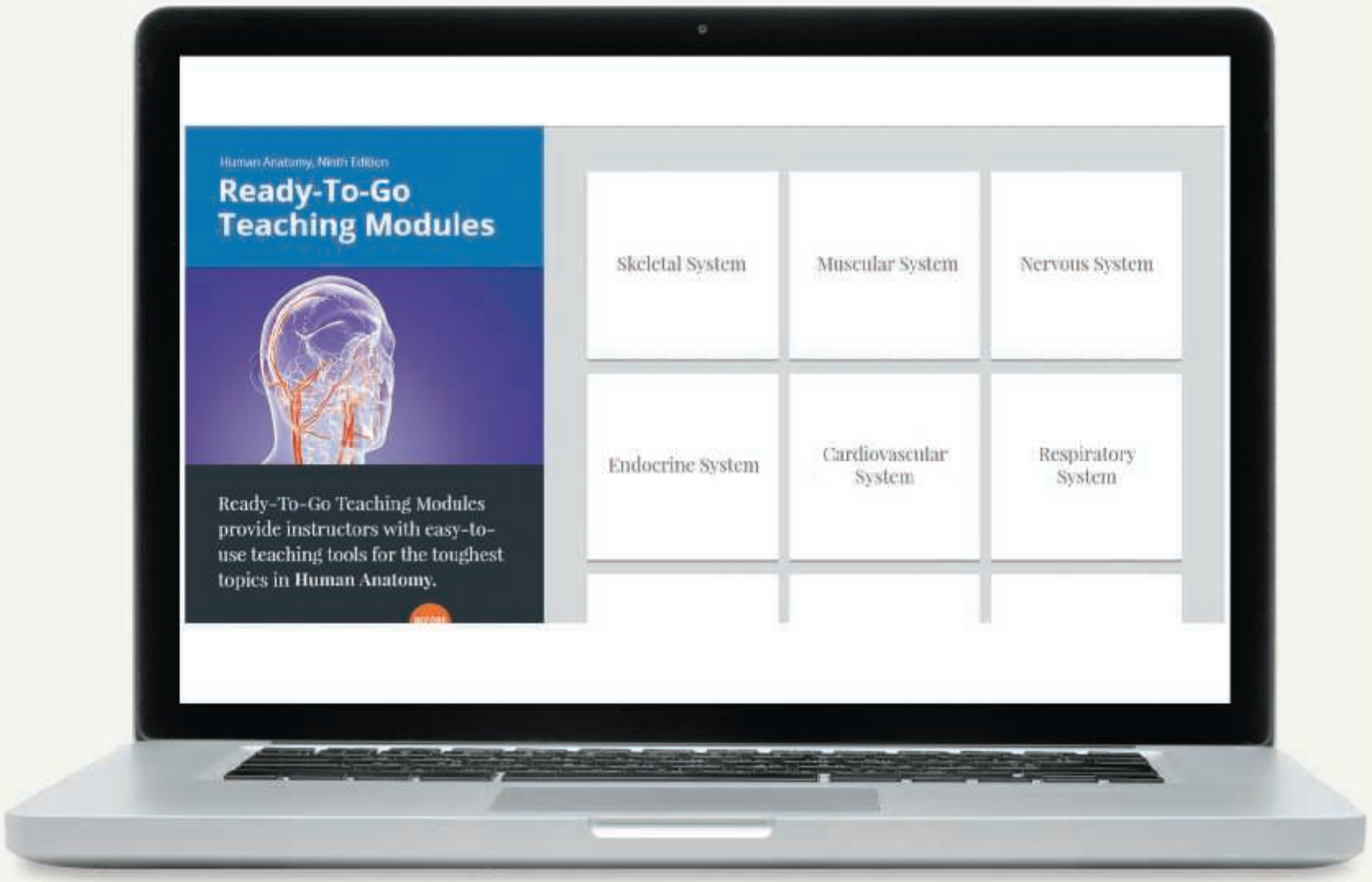
In an effort to improve future editions, we ask that readers with pertinent information, suggestions, or comments concerning the organization or content of this textbook send their remarks to Robert Tallitsch directly, by the email address below, or care of Publisher, Applied Sciences, Pearson Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.

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Robert B. Tallitsch
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Judi L. Nath

Human Anatomy Experience

Celebrated author Judi Nath (*Fundamentals of Anatomy & Physiology* and *Visual Anatomy & Physiology*) brings a fresh voice and a clear, engaging writing style to the **Ninth Edition** of **Human Anatomy**. The Ninth Edition continues the Martini legacy of a visually stunning presentation with exceptionally clear photographs, detailed illustrations, and captivating clinical content.

NEW! Ready-to-Go Teaching Modules help instructors find the best assets to use before, during, and after class to teach the toughest topics in Human Anatomy. Created by teachers for teachers, these curated sets of teaching tools save you time by highlighting the most effective and engaging animations, videos, quizzing, coaching and active learning activities from MasteringA&P.



Prepare for the Classroom

New Study Tools

throughout each chapter help students understand and navigate the content.

NEW! Summary Boxes
at the beginning of each section outline the key points from that reading.

▶ **KEY POINT** Dermal ridges form friction ridges, ensuring a secure grip on objects. Dermal ridges also form fingerprints, a unique genetic identifier of an individual.

▶ **KEY POINT** The position of the wrist affects the functioning of the hand. Many muscles of the forearm, therefore, affect the actions of the wrist because (1) all of the muscles that flex or extend the wrist originate on the humerus, radius, and/or ulna and (2) many muscles that flex or extend the fingers originate on the radius and/or ulna.

TIPS & TOOLS

Remembering the names of the epidermal layers of thick skin

A mnemonic to help you remember the names of the epidermal layers of thick skin, from deep to superficial, is "Brent Spiner gained Lieutenant Commander" (basale, spinosum, granulosum, lucidum, corneum).

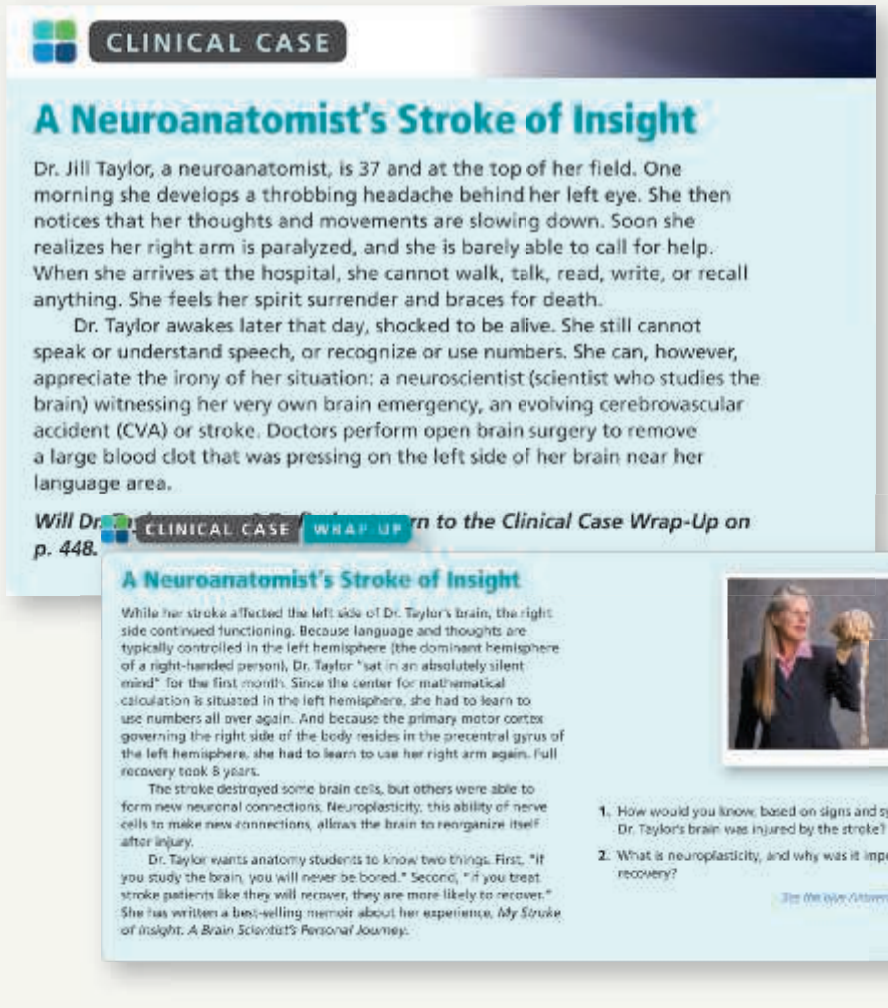
NEW! Tips & Tools
offer advice on how to approach some of the toughest topics.

TIPS & TOOLS

Here is a simple trick to remember the four anterior superficial forearm muscles originating from the medial epicondyle of the humerus. Hold both arms out, palms touching. Then slide your right hand proximally until your palm reaches your elbow with your fingers pointing toward your wrist. With each finger representing one of the four muscles, think PFPF: **P**ronator teres (index finger), **F**lexor carpi radialis (middle finger), **P**almaris longus (ring finger), and **F**lexor carpi ulnaris (little finger).

and Future Careers

NEW! Clinical Cases help motivate students for their future careers. Each chapter opens with a story-based Clinical Case related to the chapter content and ends with a Clinical Case Wrap-Up.



CLINICAL CASE

A Neuroanatomist's Stroke of Insight

Dr. Jill Taylor, a neuroanatomist, is 37 and at the top of her field. One morning she develops a throbbing headache behind her left eye. She then notices that her thoughts and movements are slowing down. Soon she realizes her right arm is paralyzed, and she is barely able to call for help. When she arrives at the hospital, she cannot walk, talk, read, write, or recall anything. She feels her spirit surrender and braces for death.

Dr. Taylor awakes later that day, shocked to be alive. She still cannot speak or understand speech, or recognize or use numbers. She can, however, appreciate the irony of her situation: a neuroscientist (scientist who studies the brain) witnessing her very own brain emergency, an evolving cerebrovascular accident (CVA) or stroke. Doctors perform open brain surgery to remove a large blood clot that was pressing on the left side of her brain near her language area.

Will Dr[illegible]rn to the Clinical Case Wrap-Up on p. 448.

CLINICAL CASE WRAP UP

A Neuroanatomist's Stroke of Insight

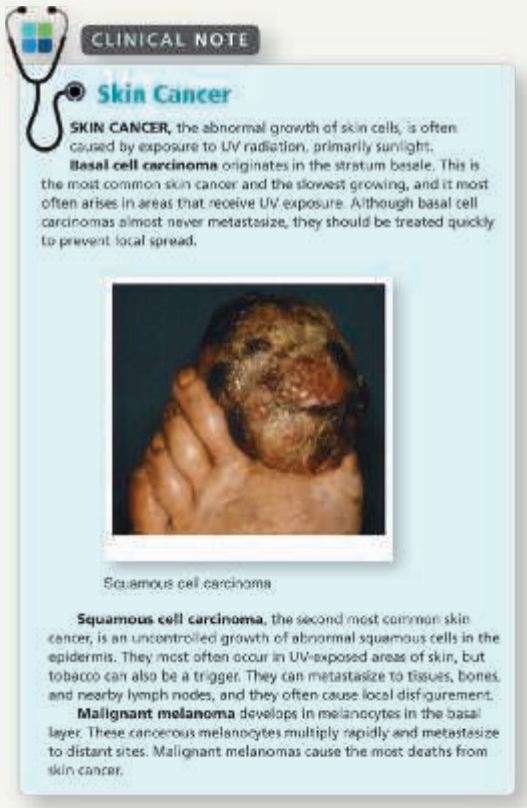
While her stroke affected the left side of Dr. Taylor's brain, the right side continued functioning. Because language and thoughts are typically controlled in the left hemisphere (the dominant hemisphere of a right-handed person), Dr. Taylor "sat in an absolutely silent mind" for the first month. Since the center for mathematical calculation is situated in the left hemisphere, she had to learn to use numbers all over again. And because the primary motor cortex governing the right side of the body resides in the precentral gyrus of the left hemisphere, she had to learn to use her right arm again. Full recovery took 8 years.

The stroke destroyed some brain cells, but others were able to form new neuronal connections. Neuroplasticity, this ability of nerve cells to make new connections, allows the brain to reorganize itself after injury.

Dr. Taylor wants anatomy students to know two things. First, "If you study the brain, you will never be bored." Second, "If you treat stroke patients like they will recover, they are more likely to recover." She has written a best-selling memoir about her experience, *My Stroke of Insight: A Brain Scientist's Personal Journey*.

1. How would you know, based on signs and symptoms, which side of Dr. Taylor's brain was injured by the stroke?
2. What is neuroplasticity, and why was it important in Dr. Taylor's recovery?

See the text Answers on the back of the page.



CLINICAL NOTE

Skin Cancer

SKIN CANCER, the abnormal growth of skin cells, is often caused by exposure to UV radiation, primarily sunlight.

Basal cell carcinoma originates in the stratum basale. This is the most common skin cancer and the slowest growing, and it most often arises in areas that receive UV exposure. Although basal cell carcinomas almost never metastasize, they should be treated quickly to prevent local spread.

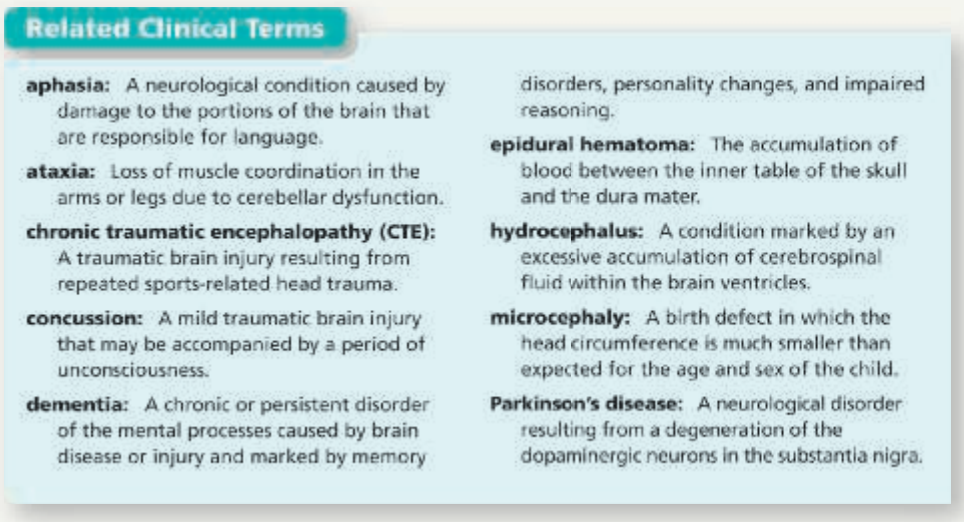
Squamous cell carcinoma

Squamous cell carcinoma, the second most common skin cancer, is an uncontrolled growth of abnormal squamous cells in the epidermis. They most often occur in UV-exposed areas of skin, but tobacco can also be a trigger. They can metastasize to tissues, bones, and nearby lymph nodes, and they often cause local disfigurement.

Malignant melanoma develops in melanocytes in the basal layer. These cancerous melanocytes multiply rapidly and metastasize to distant sites. Malignant melanomas cause the most deaths from skin cancer.

Clinical Notes appear within every chapter, expand upon topics just discussed, and present diseases and pathologies along with their relationship to normal function.

Clinical Terms end every chapter with a list of relevant clinical terms and definitions.



Related Clinical Terms

aphasia: A neurological condition caused by damage to the portions of the brain that are responsible for language.

ataxia: Loss of muscle coordination in the arms or legs due to cerebellar dysfunction.

chronic traumatic encephalopathy (CTE): A traumatic brain injury resulting from repeated sports-related head trauma.

concussion: A mild traumatic brain injury that may be accompanied by a period of unconsciousness.

dementia: A chronic or persistent disorder of the mental processes caused by brain disease or injury and marked by memory disorders, personality changes, and impaired reasoning.

epidural hematoma: The accumulation of blood between the inner table of the skull and the dura mater.

hydrocephalus: A condition marked by an excessive accumulation of cerebrospinal fluid within the brain ventricles.

microcephaly: A birth defect in which the head circumference is much smaller than expected for the age and sex of the child.

Parkinson's disease: A neurological disorder resulting from a degeneration of the dopaminergic neurons in the substantia nigra.