

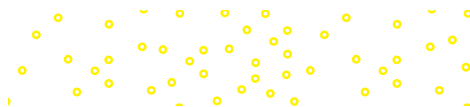
2024 RELEASE

Human Anatomy

Kenneth S. Saladin
Justin J. York



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HUMAN ANATOMY, 2024 RELEASE

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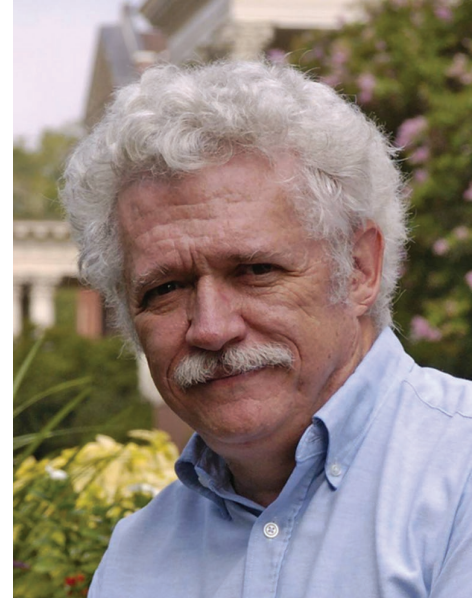
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Tim Vacula

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Justin York

Dedications

I dedicate this edition to my son, Emory who knows a thing or two about the unity of form and function.

—Ken

I dedicate this book to my wife and kids, Brittany, Lily, and Owen for locking arms with me on every step of this journey.

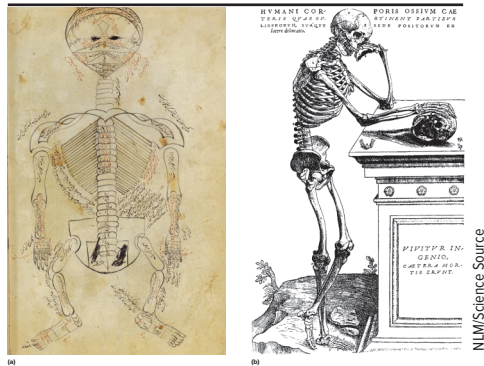
—Justin

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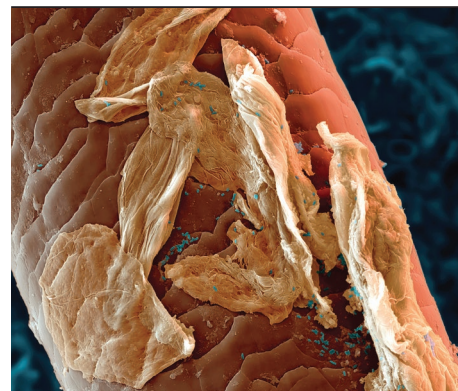
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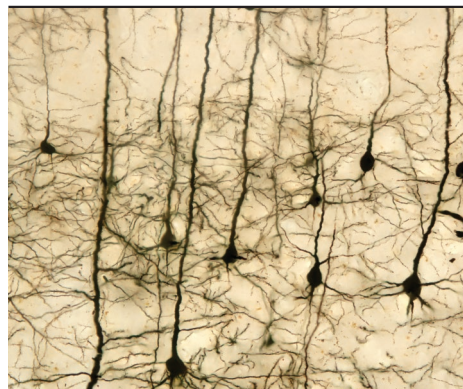
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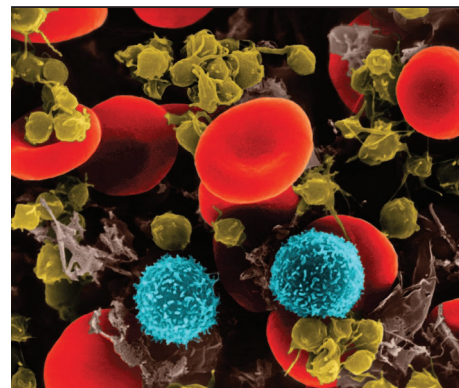
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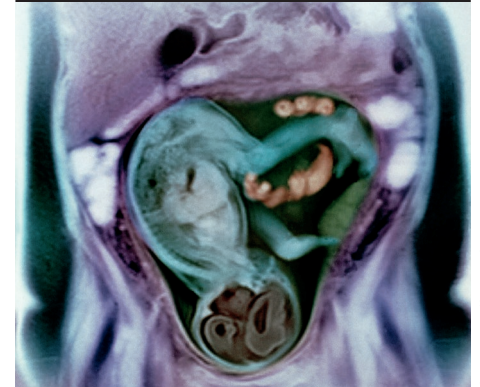
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PREFACE

Saladin's *Human Anatomy* goes beyond descriptions of body structure to read as a story that weaves together basic science, clinical applications, the history of medicine, and the evolutionary basis of human structure. Saladin and York combine this humanistic perspective with vibrant photos and art to convey the beauty and excitement of the subject to beginning students.

Changes to the 2024 Release

New Science

Scientific updates in this edition include new diagnostic uses of PET scans; anatomy of the mesentery; ciliary motility; cytoskeleton and lysosomes; mitochondrial ancestries; brown adipose tissue; infant thermogenesis; types of melanin; evolution of skin color; appearance of pathological skin colors in people of brown and black complexions; function of the “prune fingers” effect; melanoma; endocrine functions of bone and muscle; osteopenia; joint cartilage repair; muscle and microtrauma repair; unusual morphology of muscle mitochondria; the enteric nerve plexus; retrograde synaptic communication; the glymphatic system of the brain; several aspects of the sense of taste; Müller cells of the retina; pathways of visual information processing; the widening scope of the endocrine system; diabetes mellitus; erythrocyte, neutrophil, and platelet functions; pulmonary platelet production; coronary artery disease and atheroma pathogenesis; alveolar number and structure; e-cigarettes and vaping; the gut microbiome; colon cancer; obesity; nonbinary gender and intersexuality; spermatogenesis; clitoral function; gamete migration; and the site and mechanism of fertilization.

New Art and Photography

Numerous figures have improved labels, leaders, colors, and other details to aid readers with variations in visual acuity and color vision, and for better visibility of details in classroom projection. The art in this edition now represents a greater diversity in skin color, ethnicity, and cultural geography.

New and significantly modified drawings include brown adipose tissue, gamete transport and the locus of fertilization, the fertilization process, implantation, the geographic distribution of skin color, cranial versus facial bone groups, sarcomere cross sections, dystrophin, muscle atrophy, divisions of the nervous system, visual processing streams in the brain, nerve signal pathways in relation to sectional anatomy of the spinal cord, the glymphatic system of the brain, and spermatogenesis.

New photographs include comminuted bone fractures and repair; cadaver photos of the muscles, brain, heart, blood vessels, and reproductive systems; atherosclerotic plaques; lung, kidney, intestine, and ovarian histology; and colon cancer.

Diversity, Equity, and Inclusiveness

Previous editions consciously aimed for ethnic balance in art and language, but this edition has received even closer attention to ethnic and cultural diversity, color, and the gender spectrum. It addresses the inadequately diverse representation seen in many textbooks in hopes that all readers will feel a sense of inclusion and familiarity. In the language of ethnicity, “race,” and color, this edition follows the recent guidelines of the American Medical Association and the American Psychological Association. Gender-specific pronouns and nouns have been minimized, balanced where some remain, and deleted where they were adding nothing to the meaning of the writing. Discussions in anatomical variation (chapter 1) and reproductive anatomy (chapter 26) now describe several biological reasons why people cannot be simply classified as male or female anatomically, physiologically, or behaviorally.

Major Changes by Chapter

The book before you has over 1,000 changes from the previous edition—updates in scientific content, changes in the art and photography, and changes in writing style and organization for ever-better flow and accessibility to the student reader. They cannot all be listed here, but these are a sampling of the stand-out changes in each chapter.

Chapter 1, The Study of Human Anatomy, presents scientific updates for MRI, PET, and sonography, including the coupling of PET with CT or MRI for improved resolution. It adds nonbinary sexual anatomy as an example of anatomical variation, includes a new Clinical Application on peritonitis, and offers a new perspective on mesenteric anatomy.

Chapter 2, The Cellular Level of Organization, has thorough rewrites of the cell theory and characteristics of life; includes a description and figure on mechanisms of ciliary beating; adds updated science on the cytoskeleton, endomembrane system, and lysosomes; and adds a description of the cytosol. It has several new and updated images of microvilli, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, ribosomes, mitochondria, centrioles, and embryonic stem cells.

Chapter 3, The Tissue Level of Organization, adds new coverage of the interstitium; expands upon white adipose tissue appearance and its function in hormone secretion; further describes brown adipose tissue structure and function, including two new figures; and updates Marfan syndrome life expectancy.

Chapter 4, Human Embryology, is extensively rewritten to include updated science on gamete migration, sperm capacitation, fertilization, and migration of the conceptus. Numerous changes were made to implantation and gastrulation, both text and art, for improved accuracy. It has a new Clinical Application on cleft lip and palate.

Chapter 5, The Integumentary System, includes scientific updates on forms of melanin and skin color. Skin color evolution is extensively rewritten, and now includes a map of skin color variation by geographical location. It gives a better account of black and brown complexions in the recognition of cyanosis, pallor, and other pathological colors. It updates the physiological and functional perspectives on skin wrinkling in the “prune fingers” effect, inheritance of hair color, the mutational history and evolution of apocrine glands, and several aspects of melanoma. Epidermal dendritic cells are now more accurately depicted in size and number in figure 5.3 and Black hair is now included in the figure of hair histology.

Chapter 6, Bone Tissue, includes the endocrine role of bone, new research on intramembranous ossification, a new discussion of osteopenia, and new X-rays of bone fractures and repair.

Chapters 7 and 8, Axial and Appendicular Skeleton, have extensively reorganized the labeling and visibility of skeletal anatomy, especially of the skull, and deleted the use of color keys to identify the bones. They add a new figure distinguishing the facial and cranial bone groups, new Clinical Application essays on rib fractures and spinal stenosis, and new axial skeleton disorders in Table 7.5. Pelvic girdle anatomy was also extensively revised for style and organization and updated science.

Chapter 9, Joints, clarifies the classification of joints and adds a new table 9.1 to clarify overlapping and otherwise confusing joint terminology. It improves the description of the joint capsule and synovial membrane histology, and refines the descriptions and illustrations of joint movements. New information is added on joint cartilage repair and Lyme disease.

Chapter 10, Muscle Cells, adds the endocrine role of muscles; notes the astounding number of nuclei per muscle fiber; describes their action, and that of satellite cells, in repairing muscle microtrauma; describes the unusual arrangement of deep muscle mitochondria; adds a figure on dystrophin in support of updated text discussion of muscular dystrophy; updates the description of sarcomeres and now illustrates thin and thick myofilament arrangements in sarcomere cross sections; has new details on motor units; illustrates muscle atrophy; and includes new Clinical Applications on crush syndrome and rhabdomyosarcoma.

Chapters 11 and 12, Axial and Appendicular Muscles, improve the presentation of muscle anatomy by restricting tabular content to muscle attachments, actions, and innervation; all narrative prose is now in the main body of text. They add numerous new cadaver dissection photos, labeled and paired with corresponding art.

Chapter 13, Nervous Tissue, now interprets the enteric plexus as a third branch of the autonomic nervous system in its own right. New information is added on lipofuscin, the neuron-to-neuroglia ratio, and the functions of Schwann cells. Synapse structure is explained more fully, including the cell-adhesion molecules holding the pre- and postsynaptic neurons together, and a new TEM photograph of a synapse is added. Glioma is illustrated by a new photo.

Chapter 14, Spinal Cord and Spinal Nerves, has brief factual additions on spinal taps, perineurium composition, and spinal cord injury statistics; details the concept of proprioception in relation to the gracile fasciculus; and updates the anatomy of mixed nerves.

Spinal cord tracts are treated more concisely. Color changes in figure 14.1 and figures of the spinal nerve plexuses enhance nerve visibility and aid readers with color vision variation. A new figure relates nerve signal pathways to spinal cord cross-sectional anatomy.

Chapter 15, Brain and Cranial Nerves, defines CNS *nuclei* more explicitly and introduces new facts on meningitis, the number of brain neurons, the functions of CSF, the insula and amygdala, the vagus nerve, and Alzheimer disease. Per recent literature, it provides an updated discussion on the motor and sensory homunculi and removes the term *somatotopy*. It adds new figures of the brain, cerebral histology, Bell palsy, and Parkinson disease. Reversing a decision in previous editions, cranial nerve classification has reverted to the traditional designations identifying motor nerves as such, and not mixed, notwithstanding their inclusion of proprioceptive fibers. Also reversing an earlier treatment, it now interprets the brainstem as medulla through midbrain only, and doesn't include the diencephalon.

Chapter 16, Autonomic Nervous System, now better describes the enteric plexus and treats it as a third division of the ANS rather than part of the parasympathetic division; and includes an extensively rewritten and illustrated section on nervous system embryology, better located here than in chapter 13, as in past editions, so it can include the ANS. It includes a new table that more clearly correlates embryonic brain vesicles with their adult derivatives.

Chapter 17, Sense Organs, has updates on filiform papillae, taste bud structure, human olfactory sensitivity, the communication role of eyebrows, and the explanation of eye color. It corrects common textbook and public misconceptions about humans having a poor sense of smell; on the blood supply to the retina; and on the numbers of rod and cone cells. It introduces Müller cells, better explains how the retina is held firmly against the choroid, and improves on the functions of the superior and inferior oblique muscles. It provides a fantastic new SEM image of the cochlea, and has new figures of the auditory ossicles, cataracts, and the dorsal and ventral streams of visual information processing.

Chapter 18, The Endocrine System, updates the meaning and widening scope of the endocrine system and the varied roles of melatonin, and adds additional endocrine functions of adipose, bone, and skeletal muscle tissue.

Chapter 19, The Blood, adds the role of RBCs in immune clearance and detection of infections; provides new analogies for the shape and metabolism of RBCs; expands upon mechanisms of RBC senescence; and extensively updates bone marrow and cord blood transplants. It updates neutrophil and platelet functions. Platelet production in the bone marrow and lungs is better described.

Chapter 20, The Heart, is extensively reorganized and rewritten for clarity and logical flow, and includes several new photos of cadaver hearts to correspond to the art. The Clinical Application on coronary artery disease contains significant updates and new photos.

Chapter 21, The Blood Vessels, includes major format changes to the tabular arrangement in prior editions. It updates tunica intima structure and function and the distribution of venous valves. Four new cadaver photos are paired with the art; figures showing blood

flow are modified to accommodate color blindness; and there are new figures illustrating varicose veins, air embolism, and ascites, and an improved photo of superficial veins important in phlebotomy.

Chapter 22, The Lymphoid System and Immunity, updates the name of the system and its organs and tissues to *lymphoid*, using *lymphatic* only for the vessels. It has a new section on a surprising new finding, the brain's glymphatic system, linking brain CSF and tissue fluid to the lymphoid and immune systems. Descriptions of lymphoid cells and immunity were extensively revised and updated.

Chapter 23, The Respiratory System, has further information on the nasal cycle of breathing and its contribution to olfaction; brush cells of the nasal epithelium; the role of the lungs in platelet production; vaping and lung disease; and pulmonary blood circulation. It updates the number and structure of pulmonary alveoli and has new LM and SEM photos of lung histology.

Chapter 24, The Digestive System, includes new perspectives on mesenteric anatomy, the role of saliva in repair and maintenance of the oral mucosa, the importance of dental proprioception and degenerative effects of its absence, the role of GI mucus in promoting tolerance of food antigens and beneficial bacteria. It adds a new section on the gut microbiome, a Clinical Application on colorectal cancer, and new SEM photos of the intestinal mucosa.

Chapter 25, The Urinary System, contains a better understanding of mesangial cell functions, and extensively rewrites urinary tract anatomy. It adds several improvements in the art for the urinary bladder, urethra, and urinary sphincters. It also adds new photos of

kidney stones and of peritubular capillaries, showing how densely packed they are among the renal tubules.

Chapter 26, The Reproductive System, is extensively reorganized for improved presentation and flow; and updates spermatogenesis, prostate cancer, testicular cancer, and functions of the clitoris and peg cells. It adds cadaver photos of the male and female reproductive systems, and a new figure on chromosomal sex determination. A new Clinical Application addresses the biological bases of gender diversity and intersex.

A Storytelling Writing Style

Students and instructors alike cite Saladin's prose style as the number one attraction of this book. Students doing blind comparisons of Ken Saladin's chapters and those of other anatomy books routinely find Saladin clearly written, easy to understand, and a stimulating, interesting read. Saladin's analogy-rich writing enables students to easily visualize abstract concepts in terms of everyday experience. Consider, for example, from chapter 13:

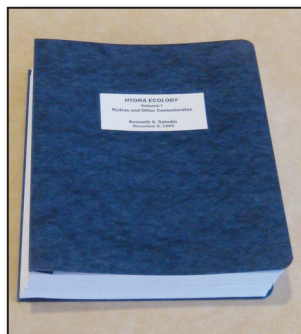
The dimensions of human neurons are more impressive when we scale them up to the size of familiar objects. If the cell body of a spinal motor neuron was the size of a tennis ball, its dendrites would form a huge bushy mass that could fill a 30-seat classroom from floor to ceiling. Its axon would be up to a mile long but a little narrower than a garden hose. This is quite a point to ponder. The neuron must assemble molecules and organelles in its "tennis ball" cell body and deliver them through its "mile-long garden hose" to the end of the axon.

EVOLUTION OF A STORYTELLER

Ken Saladin's penchant for writing began early. For his tenth-grade biology class, he wrote a 318-page monograph on hydras with 53 original India ink drawings and 10 original photomicrographs. We at McGraw Hill think of this as Ken's "first book." At a young age, Ken already was developing his technical writing style, research habits, and illustration skills.

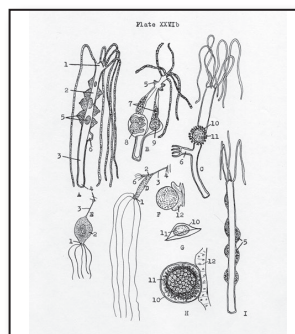


Courtesy of Ken Saladin



Courtesy of Ken Saladin

Ken Saladin's "first book,"
Hydra Ecology (1965)



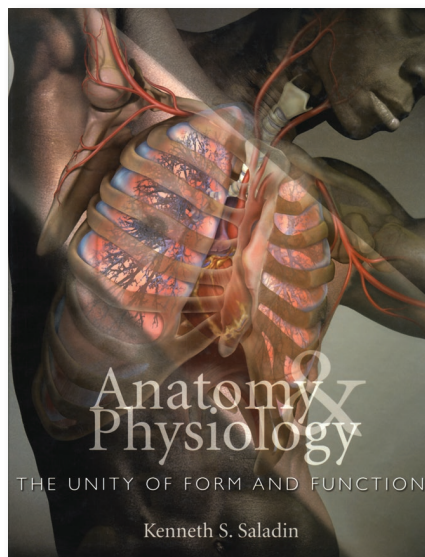
Courtesy of Ken Saladin

Some of Ken's first
pen-and-ink artwork (1965)



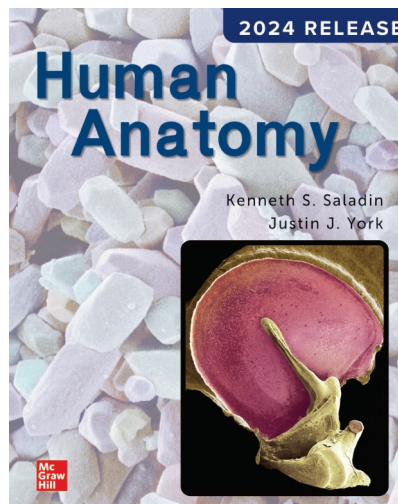
Courtesy of Ken Saladin

Ken in 1964

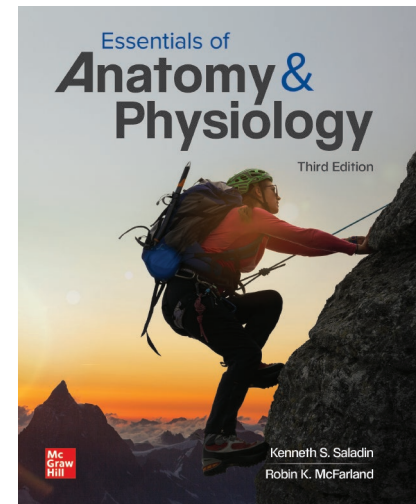


Ken's first textbook published in 1997
Ysbrand Cosijn/Shutterstock

Ken served as an A&P textbook reviewer and testbank writer for several years and then embarked on his first book for McGraw Hill in 1993. He published the first edition of *Anatomy & Physiology: The Unity of Form and Function* in 1997 and his first edition of *Human Anatomy* in 2004. The story continues with the 2024 release of *Human Anatomy*.



The story continues in 2024
Steve Gschmeissner/Science Source



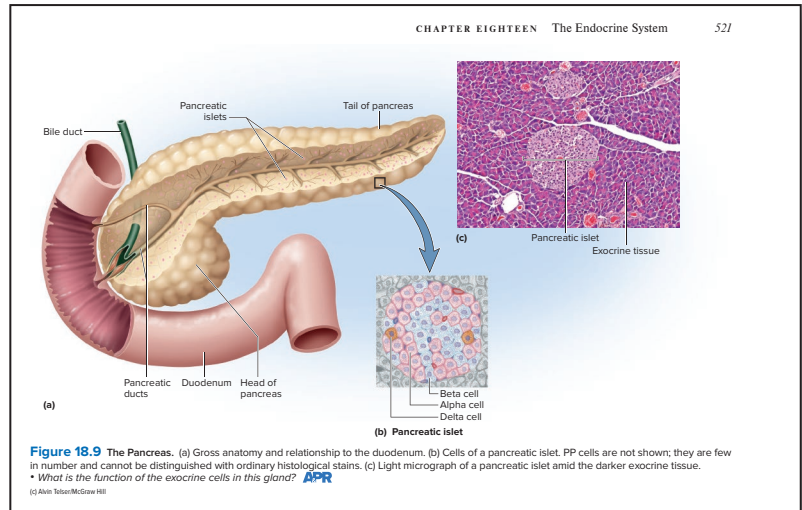
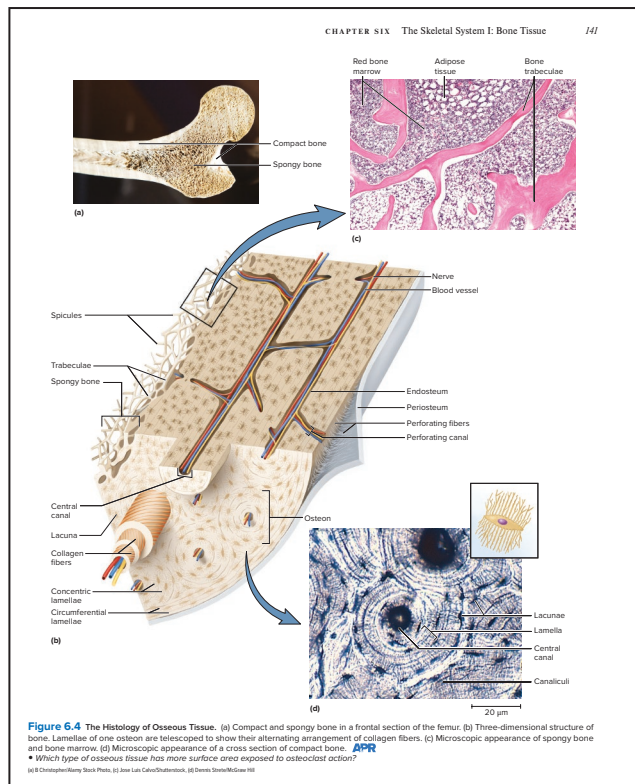
Essentials book published in 2013
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GUIDED TOUR

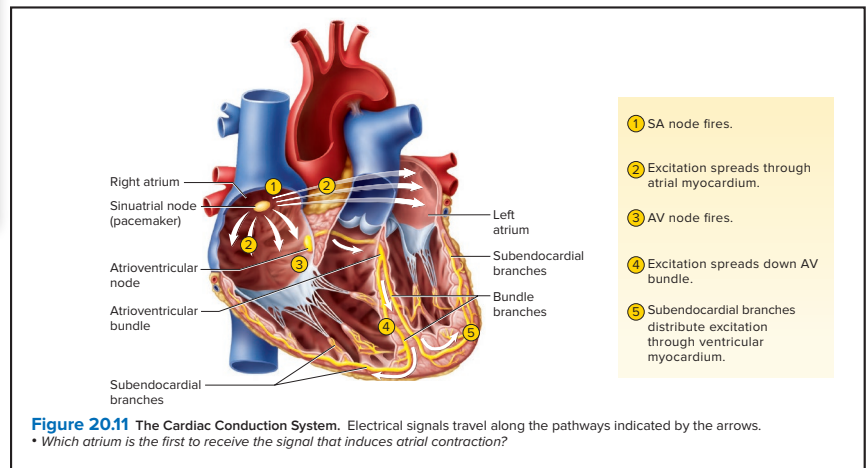
Instructive Artwork for Visual Learners

Saladin and York's stunning illustrations and photos entice students who regard themselves as "visual learners."

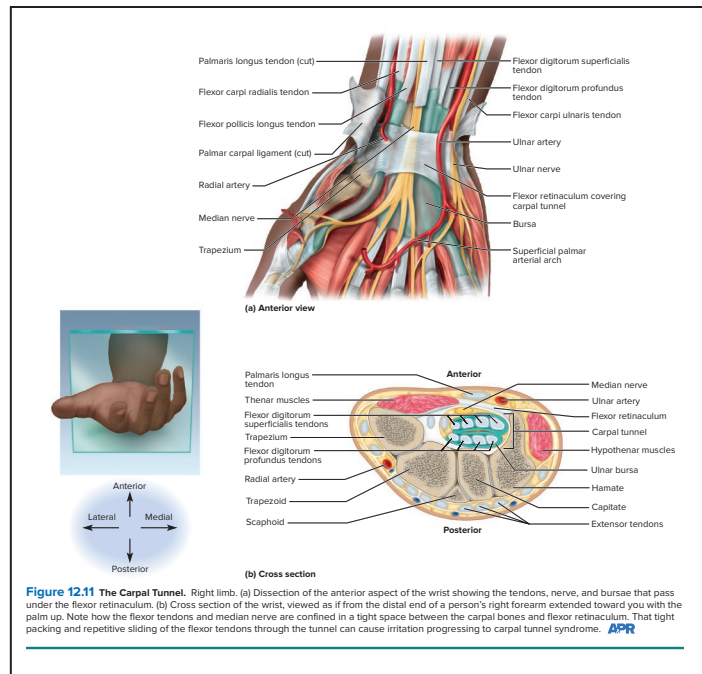
Vivid Illustrations with rich textures and shading and bold, bright colors bring anatomy to life.



Process Figures relate numbered steps in the art with corresponding numbered text descriptions.



Orientation Tools, such as dissection planes and a compass on the anatomical art, clarify the perspective from which a structure is viewed.



The Psychology of Learning

Having taught human anatomy and histology for 40 years, Saladin knows what works in the classroom and incorporates those approaches into the pedagogy of *Human Anatomy*.

Chapters Organized for Preview and Review

Chapter Outlines provides content preview and facilitate review and study.

Clinical Applications pique the interest of health-science students by showing the clinical relevance of the core science.

Brushing Up reminds students of the relevance of earlier chapters to the one on which they are currently embarking.

Anatomy & Physiology REVEALED® icons indicate which area of this interactive cadaver dissection program corresponds to the chapter topic.

Colorized X-ray of the flexed cervical spine of a 20-year-old female
Source: Photo Library: iStock/Getty Images

CHAPTER

7

THE SKELETAL SYSTEM II

AXIAL SKELETON

CHAPTER OUTLINE

7.1 Overview of the Skeleton

7.1a Bones of the Skeletal System

7.1b Anatomical Features of Bones

7.2 The Skull

7.2a Cranial Bones

7.2b Facial Bones

7.2c Bones Associated with the Skull

7.2d Adaptations of the Skull for Bipedalism

7.3 The Vertebral Column and Thoracic Cage

7.3a General Features of the Vertebral Column

7.3b General Structure of a Vertebra

7.3c Intervertebral Discs

7.3d Regional Characteristics of Vertebrae

7.3e The Thoracic Cage

7.4 Developmental and Clinical Perspectives

7.4a Development of the Axial Skeleton

7.4b Pathology of the Axial Skeleton

Study Guide

CLINICAL APPLICATIONS

7.1 Injury to the Ethmoid Bone

7.2 Abnormal Spinal Curvatures

7.3 Spinal Stenosis

7.4 Rib Fractures

BRUSHING UP

To understand this chapter, you may find it helpful to review the following concepts:

- Directional terms (table 1.1)
- The axial and appendicular body regions (section 1.2d)
- The neural tube, somites, and pharyngeal arches of the embryo (section 4.2b)
- General features of bones (section 6.1c)
- Intramembranous and endochondral ossification (sections 6.3a, b)

Anatomy & Physiology REVEALED®

Module 5: Skeletal System

9.1 Joints and Their Classification

Expected Learning Outcomes

When you have completed this section, you should be able to

- explain what joints are and how they are classified with respect to structure and mobility;
- name and define the three principal classes of joints;
- name, define, and give examples of the two major types of fibrous joints;
- distinguish between the three types of skull sutures;
- name, define, and give examples of the two types of cartilaginous joints; and
- explain how synovial joints differ from the preceding types.

Before You Go On

Answer or complete the following to test your understanding of the preceding section:

- What is the difference between arthrology and kinesiology?
- What kind of tissue holds the adjacent bones together in a fibrous, cartilaginous, and synovial joint? How does that differ between a synchondrosis and a symphysis?
- How do the fibers and joint mobility differ between a suture and a syndesmosis?
- What three anatomical features distinguish synovial joints from all the others?
- Some amphiarthroses are synovial joints, yet most synovial joints are not amphiarthroses. Explain. With respect to freedom of movement, what term includes the majority of synovial joints?

Reinforced Learning

Each section is a conceptually unified topic, framed between a pair of learning “bookends”—a set of learning objectives at the beginning and a set of review and self-testing questions at the end. Each section is numbered for easy reference in lecture, assignments, and ancillary materials. These “bookends” provide the student an optimistic impression of short, easily digestible sections manageable in short bits of reading time.

Expected Learning Outcomes give the student a preview of key points to be learned within the next few pages.

Before You Go On prompts students to pause and spot-check their mastery of the previous few pages before progressing to new material.

Vocabulary Building

Several features help build a student’s level of comfort with medical vocabulary.

Pronunciation Guides Knowing proper pronunciation is key to remembering and spelling terms. Saladin and York give simple, intuitive “pro-NUN-see-AY-shun” guides to help students over this hurdle and widen the student’s comfort zone for medical vocabulary.

Word Origins Accurate spelling and insight into medical terms are greatly enhanced by a familiarity with commonly used word roots, prefixes, and suffixes.

Footnotes throughout the chapters help build the student’s working lexicon of word elements. An end-of-book Glossary provides clear definitions of the most important or frequently used terms.

Building Your Medical Vocabulary An exercise at the end of each chapter helps students creatively use their knowledge of new medical word elements.

Any point where two bones meet is called a **joint (articulation)**, whether or not the bones are movable at that interface. The science of joint structure, function, and dysfunction is called **arthrology**.¹ The study of musculoskeletal movement is **kinesiology**² (kih-NEE-see-OL-oh-jee). This is a branch of **biomechanics**, which deals with a broad variety of movements and mechanical processes in the body, including the physics of blood circulation, respiration, and hearing.

The name of a specific joint is typically derived from the names of the bones involved. For example, the *atlanto-occipital joint* is

¹*arthro* = joint; *logy* = study of

²*kinesio* = movement; *logy* = study of

Building Your Medical Vocabulary

State a meaning of each word element and give a medical term from this chapter that uses it or a slight variation of it.

- haplo-
- gameto-

- zygo-
- tropho-
- cephalo-
- gyneco-
- genesis

- syn-
- meso-
- terato-

Answers in appendix A

Self-Assessment Tools

Saladin and York provide students with abundant opportunities to evaluate their comprehension of concepts. A wide variety of questions from simple recall to analytical evaluation cover all six cognitive levels of Bloom's Taxonomy of Educational Objectives.

Before You Go On questions test simple recall and lower-level interpretation of information read in the previous few pages.

Apply What You Know tests the students' ability to think of the deeper implications or clinical applications of points they have just read.

Apply What You Know

Martha is showing a sonogram of her unborn baby to her coworkers. Her friend Betty tells her she shouldn't have sonograms made because X-rays can cause birth defects. Is Betty's concern well founded? Explain.

Before You Go On

Answer or complete the following to test your understanding of the preceding section:

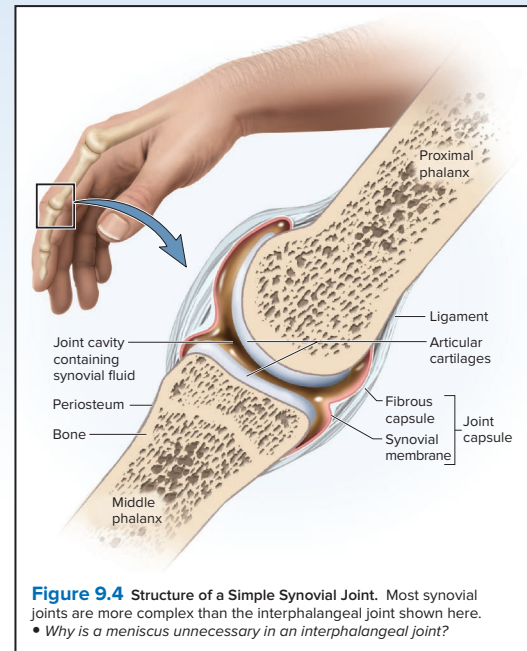
12. In what sense can spontaneous abortion be considered a protective mechanism?
13. Mutation and nondisjunction both produce chromosomal abnormalities. What is the difference between them?
14. Why is a baby more likely to be born with anatomical defects stemming from teratogen exposure at 30 days than from exposure at 10 days?

Testing Your Recall sections at the end of each chapter offer 20 simple recall questions to test retention of terminology and basic ideas.

What's Wrong with These Statements? requires students to concisely explain why the false statements are untrue.

Testing Your Comprehension questions are clinical application and other interpretive essay questions that require the student to apply the chapter's basic science to clinical or other scenarios.

Figure Legend Questions posed in many of the figure legends prompt the student to interpret the art and apply it to the reading.



Testing Your Recall

1. Below L2, the vertebral canal is occupied by a bundle of spinal nerve roots called
a. the terminal filum.
b. the descending tracts.
c. the gracile fasciculus.
d. the medullary cone.
e. the cauda equina.
2. The brachial plexus gives rise to all of the following nerves *except*
a. the axillary nerve.
b. the radial nerve.
c. the obturator nerve.
d. the median nerve.
e. the ulnar nerve.
3. Between the dura mater and vertebral bone, one is most likely to find
a. arachnoid mater.
b. denticulate ligaments.
c. cartilage.
d. adipose tissue.
e. spongy bone.
4. Which of these tracts carries motor signals destined for the postural muscles?
a. the gracile fasciculus
b. the cuneate fasciculus
c. the spinothalamic tract
d. the vestibulospinal tract
e. the tectospinal tract
5. A patient has a gunshot wound that caused a bone fragment to nick the spinal cord. The patient now feels no pain or temperature sensations from that level of the body down. Most likely, the _____ was damaged.
a. gracile fasciculus
b. posterior spinocerebellar tract
c. tectospinal tract
d. lateral corticospinal tract
e. spinothalamic tract
6. Which of these is *not* a region of the spinal cord?
a. cervical
b. thoracic

What's Wrong with These Statements?

Briefly explain why each of the following statements is false, or reword it to make it true.

1. More people get rheumatoid arthritis than osteoarthritis.
2. A doctor who treats arthritis is called a kinesiologist.
3. Most synovial joints are classified functionally as synarthroses.
4. The lateral and medial menisci are shock-absorbing cartilages in the elbow joint.

5. Reaching behind you to take something out of your hip pocket involves flexion of the shoulder.
6. The lateral and medial malleoli are protrusions of the two sides of the tibia in the tarsal region.
7. To stand on tiptoes to reach something on a high shelf, you would use dorsiflexion of the ankle.
8. At a cartilaginous joint, the facing surfaces of the two bones are covered with layers of

- cartilage and there is a narrow space with lubricating fluid between them.
9. Synovial fluid is secreted by the articular cartilages of the joint.
10. Several sutures can be found in the long bones of the upper and lower limbs.

Answers in appendix A

Testing Your Comprehension

1. Why are there menisci in the knee joint but not in the elbow, the corresponding joint of the upper limb? Why is there an articular disc in the temporomandibular joint?
2. What ligaments would most likely be torn if you slipped and your foot was suddenly forced into an excessively inverted position: (a) the posterior talofibular and calcaneofibular ligaments, or (b) the medial ligament? Explain. What would the resulting condition of the ankle be called?
3. In order of occurrence, list the joint actions (flexion, pronation, etc.) and the joints where they would occur as you (a) sit down at a table, (b) reach out and pick up an apple, (c) take a bite, and (d) chew it. Assume that you start in anatomical position.
4. What structure in the elbow joint serves the same purpose as the anterior cruciate ligament (ACL) of the knee?
5. List the six types of synovial joints and for each one, if possible, identify a joint in the upper limb and a joint in the lower limb that fall into each category. Which of these six joints have no examples in the lower limb?

Making It Relevant

Clinical Application essays cover the clinical relevance of basic science.

CLINICAL APPLICATION

14.2

Poliomyelitis and Amyotrophic Lateral Sclerosis

*Poliomyelitis*¹³ and *amyotrophic lateral sclerosis*¹⁴ (ALS) are two diseases that result from the destruction of motor neurons. In both diseases, the skeletal muscles atrophy from lack of innervation.

Poliomyelitis (polio) is caused by the poliovirus, which destroys motor neurons in the brainstem and anterior horn of the spinal cord. Signs of polio include muscle pain, weakness, and loss of some reflexes, followed by paralysis, muscular atrophy, and sometimes respiratory arrest. The virus spreads through water contaminated by feces. Historically, polio afflicted many children who contracted the virus from contaminated public swimming pools. For a time, the polio vaccine nearly eliminated new cases, but the disease has lately begun to reemerge among children in some countries because of antivaccination politics.

ALS is also known as Lou Gehrig¹⁵ disease after the baseball player who succumbed to it. It is marked not only by the degeneration of motor neurons and atrophy of the muscles, but also sclerosis (scarring) of the lateral regions of the spinal cord—hence its name. Most cases occur when astrocytes fail to reabsorb the neurotransmitter glutamate from the tissue fluid, allowing it to accumulate to a neurotoxic level. The early signs of ALS include muscular weakness and difficulty in speaking, swallowing, and using the hands. Sensory and intellectual functions remain unaffected, as evidenced by the accomplishments of astrophysicist and best-selling author Stephen Hawking (fig. 14.10), who was stricken with ALS while he was in college. Despite near-total paralysis, he had a slowly progressive form of the disease, remained intellectually undiminished, and communicated with the aid of a speech synthesizer and computer. Tragically, many people are quick to assume that those who have lost most of their ability to communicate their ideas and feelings have no ideas and feelings to communicate. To a victim, this may be more unbearable than the loss of motor function itself.



Figure 14.10 Stephen Hawking (1942–2018). “When I was first diagnosed with ALS, I was given two years to live. Now 45 years later, I am doing pretty well” (Source: CNN Interview, 2010).

Geoff Robinson Photography/REX/Shutterstock

ACKNOWLEDGMENTS

Peer review is a critical part of the scientific process, and very important to ensure the content in this book continues to meet the needs of the instructors and students who use it. We are grateful for the people who agree to participate in this process and we thank them for their time, talents, and feedback. The reviewers of this text, listed here, contributed significant comments that helped us refine and update the print and digital components of this program.

We also owe a great deal to spontaneous emails from colleagues and students worldwide telling us what they've liked about the book and what could be improved, and alerting us to needed corrections; and to many fruitful discussions on the HAPS-L listserve of the Human Anatomy and Physiology Society. Ken also thanks anatomists, physiologists, physicians, and other experts on Quora who have provided so many helpful ideas and supportive literature citations to new developments in A&P.

We also extend our deep appreciation to the Life Sciences Team at McGraw Hill who worked with us on this project: Matthew Garcia, Executive Portfolio Manager; Monica Lewis, Marketing Manager; Melisa Seegmiller, Senior Product Developer; Vicki Krug, Senior Content Project Manager; Brent dela Cruz, Lead Assessment Project Manager; Lori Hancock, Senior Content Licensing Specialist; David Hash, Technology Specialist, Authoring; and Mike McGee, freelance copy editor.

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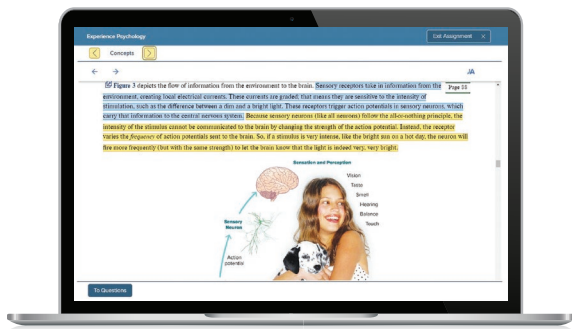
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LETTERS TO STUDENTS

Dear Students,

When I was a boy, I became interested in what I then called “nature study” for two reasons. One was the sheer beauty of nature. I reveled in children’s books with abundant, colorful drawings and photographs of animals, plants, minerals, and gems, supplementing my many “nature walks” around the woods, streams, and ponds near my home. It was this esthetic appreciation of nature that made me want to learn more about it and made me happily surprised to discover I could make a career of it. In my teens, I was drawn still deeper into biology by writers who had a way with words—who could captivate my imagination and curiosity with their elegant prose. I built my own little library of zoology and anatomy books that mesmerized me with their gracefulness of writing and fascinating art and photography. I began early on to write prolifically, emulate scientific authors I admired, evolve my own writing style, and learn techniques of illustration.

These interests and pleasures led to my college and graduate degrees in biology, my 40-year teaching career, and writing my own books. As a textbook writer, I now find myself endeavoring to pass similar interests and pleasures to you, my worldwide students beyond the classroom. I’m trusting that you’re like I was—that you appreciate a book that does more than simply give you the information you need, but also a writer who makes it enjoyable for you through scientific, storytelling prose and his concept of the way things should be illustrated to spark interest and facilitate understanding.

A&P is a complex, challenging subject, and it may seem a formidable task to acquire even a basic knowledge of the human body. I’ve always designed my chapters to make them easier for you to study and check whether you’ve understood what you read before your instructor tests you. The preceding pages of this book highlight the many learning aids we’ve built into *Human Anatomy*, and we encourage you to take a look at those for a preview of how to use the whole *Human Anatomy* package—much more than the book alone—for your best advantage.

After 23 years of writing *Human Anatomy* as a solo author, I am delighted to be joined by my colleague, Dr. Justin York, to “team-teach” the subject to you starting with this 2024 release. Carefully selected from a pool of hopeful author candidates, Justin shares my key values as an educator and author. His deep subject knowledge, keen attention to detail, and student-oriented work ethic have added tremendously to the quality of this book.

I hope you enjoy your study of this book, but I know there are always ways to make it even better. Suggestions from many past students have added to the quality of this book, and we hope you will feel free to contact us with your own impressions and suggestions, or even if we can help clarify a concept for you. Best wishes for success in your academic endeavor and career.

Ken Saladin
ksaladin2@windstream.net

Much like Ken, I, too, became entranced by the natural world at a young age. In fact, I was a biologist before I knew what biology was—always out observing, experimenting, and learning about the rich body of life surrounding me. It was this ever-curious mind that carried me through years of schooling to where I am today. My studies will always continue, but now I have the even greater pleasure of sharing it with students who, like you, are on their own academic journeys.

Recently I’ve had the great honor of joining Ken in authorship. As we collaborated on the pages ahead, you the student were top of mind, driving our writing, art, and content decisions. I encourage you to seek the logic and patterns we present that make learning easier and more meaningful than solely memorizing parts. Keeping an inquisitive mind and an appreciative eye will also add richness to the material. A final, and perhaps most important, note is that your academic journey need not be in isolation. I encourage you to surround yourself with resources—instructors, peers, and the numerous digital and text resources described in the preceding pages. They can help you stay on track when the material gets challenging or overwhelming.

Please reach out as I welcome your questions, comments, and feedback.

Justin York
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