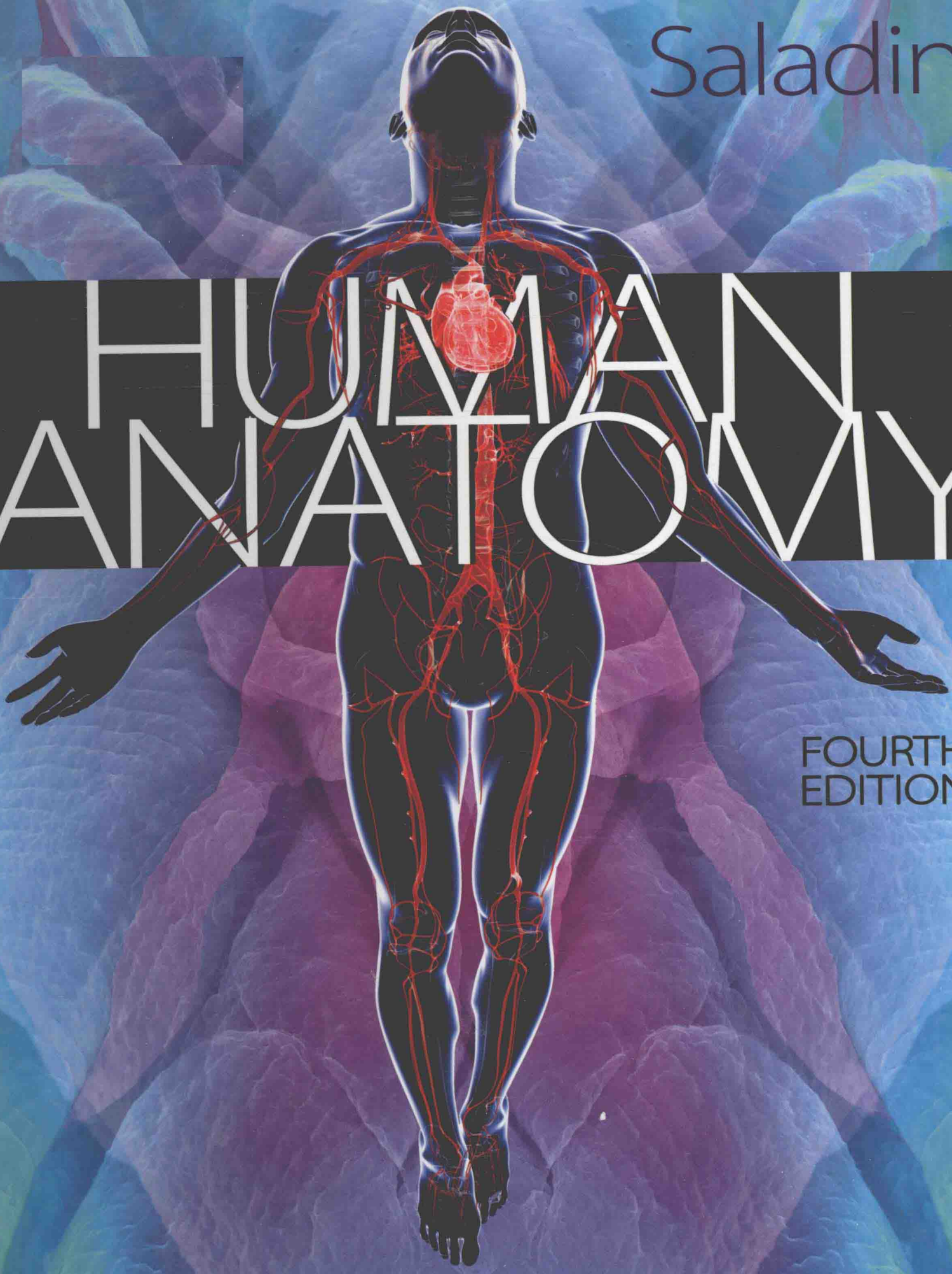
Saladin

HUMAN ANATOMY



FOURTH EDITION

Kenneth S. Saladin
Georgia College and State University

HUMAN ANATOMY

FOURTH EDITION

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HUMAN ANATOMY, FOURTH EDITION

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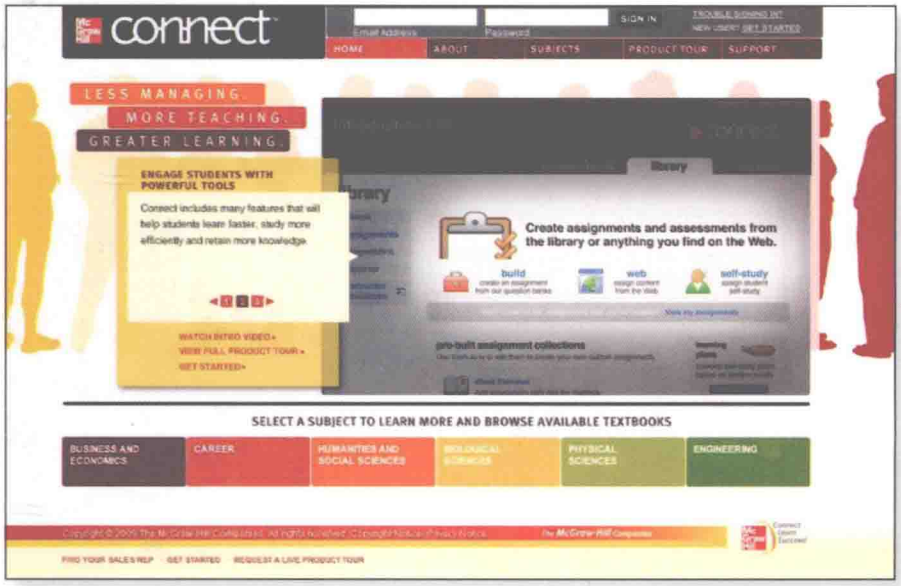

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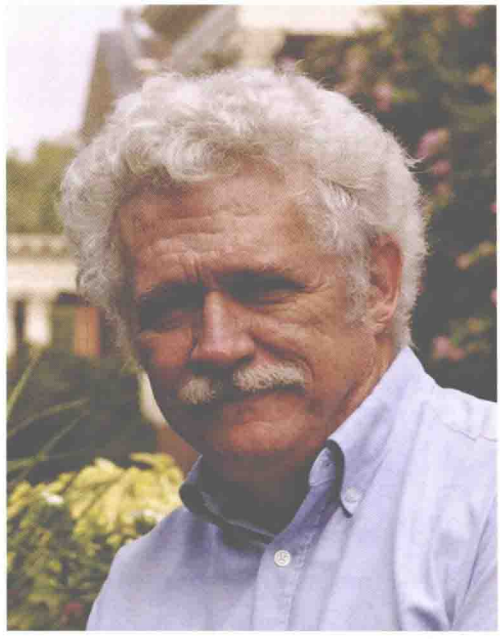
ABOUT THE AUTHOR

KENNETH S. SALADIN is Professor of Biology at Georgia College & State University in Milledgeville, Georgia, where he has taught since 1977. Ken teaches human anatomy and physiology, introductory medical physiology, histology, animal behavior, and natural history of the Galápagos Islands. He has also previously taught introductory biology, general zoology, sociobiology, parasitology, and biomedical etymology. Ken is a member of the Human Anatomy and Physiology Society, American Association of Anatomists, American Physiological Society, Society for Integrative and Comparative Biology, and American Association for the Advancement of Science. He is the author of the best-selling textbook *Anatomy & Physiology: The Unity of Form and Function,* and the newest in the Saladin brand, *Essentials of Anatomy & Physiology,* which he coauthored with Robin McFarland. Ken and his wife Diane have two adult children.



• • • • •

Dedicated to my students, who are to my spirits what ATP is to my cells; and to Diane for her parasympathetic effects on my physiology.

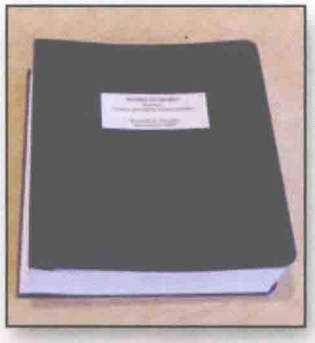
—K.S.S.

• • • • •

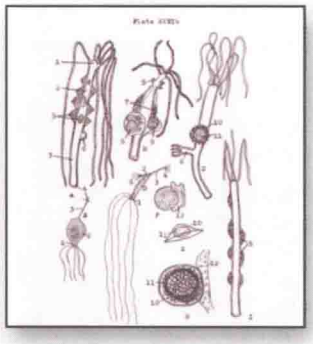
EVOLUTION
of a Storyteller

Ken Saladin's penchant for writing began early. For his 10th-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.

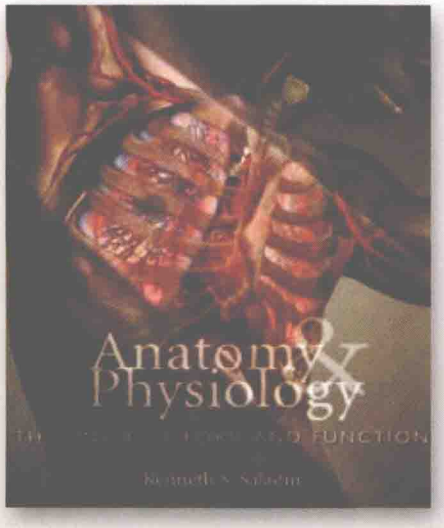
Ken in 1964



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

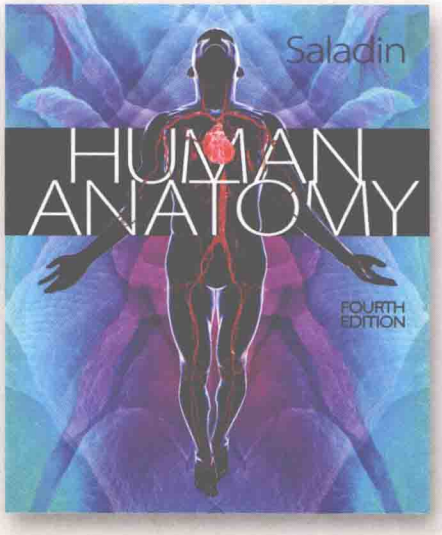


Some of Ken's first pen-and-ink artwork (1965)

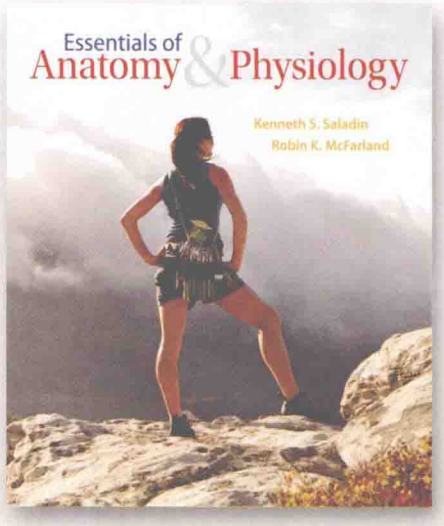


Ken's first textbook published in 1997

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 *Human Anatomy,* fourth edition.



The story continues in 2013



Essentials book published in 2013

Instructive Artwork for Visual Learners

Saladin'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.

The visual appeal of nature is immensely important in motivating one to study it. We certainly see this at work in human anatomy—in the countless students who describe themselves as visual learners; in the millions of laypeople who flock to museums and popular exhibitions such as Body Worlds; *and in all those who find anatomy atlases so intriguing. I have illustrated* Human Anatomy *not only to visually explain concepts, but also to appeal to this sense of the esthetics of the human body.*

—Ken Saladin

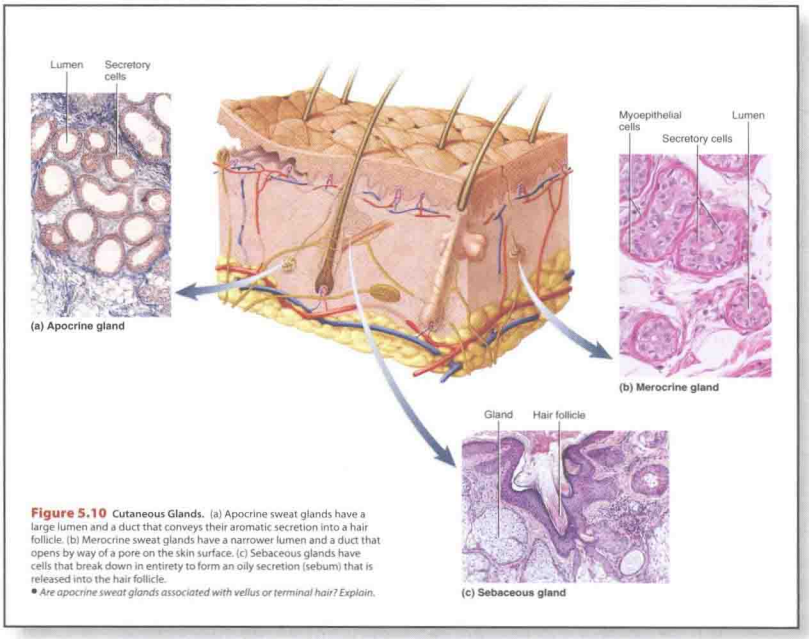


Figure 5.10 Cutaneous Glands. (a) Apocrine sweat glands have a large lumen and a duct that conveys their aromatic secretion into a hair follicle. (b) Merocrine sweat glands have a narrower lumen and a duct that opens by way of a pore on the skin surface. (c) Sebaceous glands have cells that break down in entirety to form an oily secretion (sebum) that is released into the hair follicle.

• *Are apocrine sweat glands associated with vellus or terminal hair? Explain.*

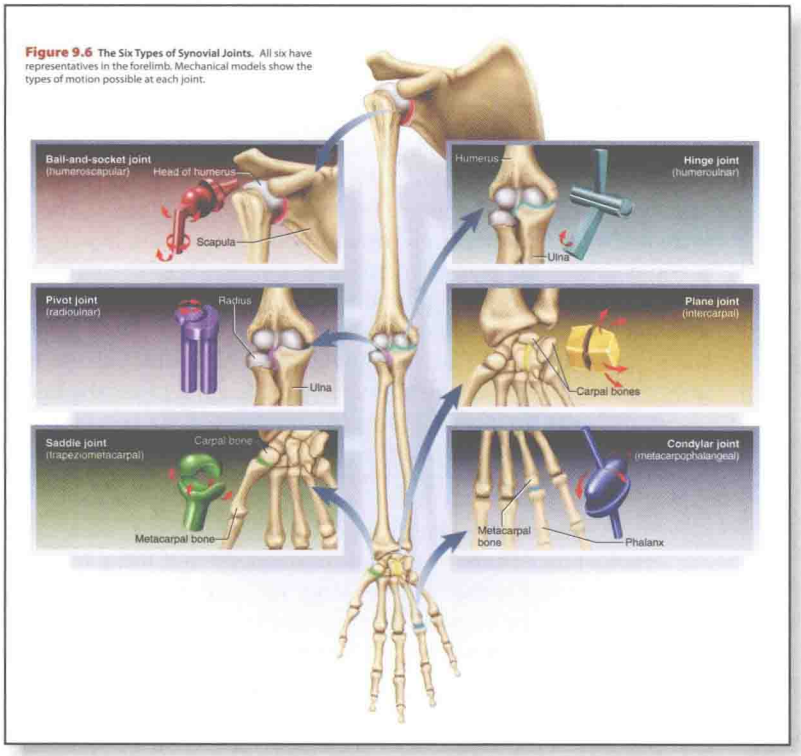


Figure 9.6 The Six Types of Synovial Joints. All six have representatives in the forelimb. Mechanical models show the types of motion possible at each joint.

Illustrations are relevant and help visual learners see what is described in paragraph form in the text.

—Gary Lechner, Butte Community College

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 combines this humanistic perspective with vibrant photos and art to convey the beauty and excitement of the subject to beginning students.

New to the Fourth Edition

This fourth edition has numerous textual updates, as well as enhancements to the illustration program. Among the most important changes are

- Scientific and clinical updates on proteasomes (chapter 2), stem-cell technology (chapter 2), fingertip friction ridges and "prune fingers" (chapter 5), congenital hip dislocation (chapter 9), elastic myofilaments and sarcomere structure (chapter 10), microglia and astrocyte functions (chapter 13), folic acid and spina bifida (chapter 13), shingles (chapter 14), accessory nerve anatomy (chapter 15), primary motor cortex (chapter 15), and more.
- Improved columnar format for muscle tables (chapters 11–12).
- New illustrative concepts for mesenteries (figure 1.16), endocrine versus exocrine gland architecture (figure 3.29), modes of exocrine secretion (figure 3.31), cranial nerve pathways (figure 15.24), and others.

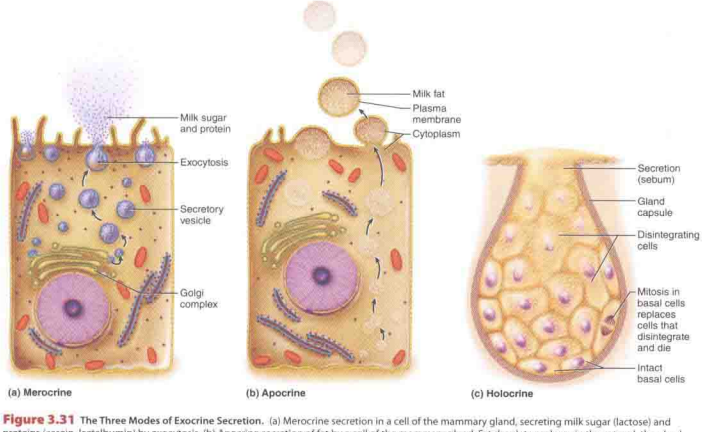


Figure 3.31 **The Three Modes of Exocrine Secretion.** (a) Merocrine secretion in a cell of the mammary gland, secreting milk sugar (lactose) and proteins (casein, lactalbumin) by exocytosis. (b) Apocrine secretion of fat by a cell of the mammary gland. Fat droplets coalesce in the cytosol, then bud from the cell surface with a thin coating of cytoplasm and plasma membrane. (c) Holocrine secretion by a sebaceous (oil) gland of the scalp. In this method, entire gland cells break down and become the secretion (sebum).
• *Which of these three glands would require the highest rate of mitosis? Why?*

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 choose Saladin hands down, finding Saladin clearly written, easy to understand, and a stimulating, interesting read.

Saladin's Human Anatomy *is one of the most readable anatomy texts on the market. This readability in conjunction with the wonderful graphics truly enhances the students' abilities to comprehend the subject matter.*
—Gavin C. O'Connor, Ozarks Technical Community College

Dr. Saladin's writing style is extremely effective in my opinion. It is concise without superfluous information. Many undergraduate anatomy courses use Dr. Saladin's books here at Long Island University. The students enjoy his writing and choice of artwork.
—Michael Masaracchio, Long Island University, Brooklyn Campus

Fresh Analogies

Saladin's analogy-rich writing enables students to easily visualize abstract concepts in terms of everyday experience.

The cytoskeleton is composed of *microfilaments, intermediate filaments,* and *microtubules.* **Microfilaments (thin filaments)** are about 6 nm thick and are made of the protein actin. They form a fibrous **terminal web (membrane skeleton)** on the cytoplasmic side of the plasma membrane. The lipids of the plasma membrane are spread out over the terminal web like butter on a slice of bread. The web, like the bread, provides physical support, whereas the lipids, like butter, provide a permeability barrier. It is thought that, without this support by the terminal web, the lipids would break up into little droplets and the plasma membrane would not be able to hold together. As described earlier, actin mi-

Neurosomas range from 5 to 135 μm in diameter, whereas axons range from 1 to 20 μm in diameter and from a few millimeters to more than a meter long. Such dimensions are more impressive when we scale them up to the size of familiar objects. If the soma of a spinal motor neuron were 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" soma and deliver them through its "mile-long garden hose" to the end of the axon. In a process called *axonal transport,* neurons employ *motor proteins* that can carry organelles and macromolecules as they crawl along the cytoskeleton of the nerve fiber to distant destinations in the cell.

The Psychology of Learning

Having taught human anatomy for 35 years, Saladin knows what works in the classroom and incorporates those approaches into the pedagogy of *Human Anatomy.*

> *Saladin's* Human Anatomy *is an excellent college level anatomy text containing pedagogical features that are designed for student success.*
> —Fran Miles, Lake Michigan College

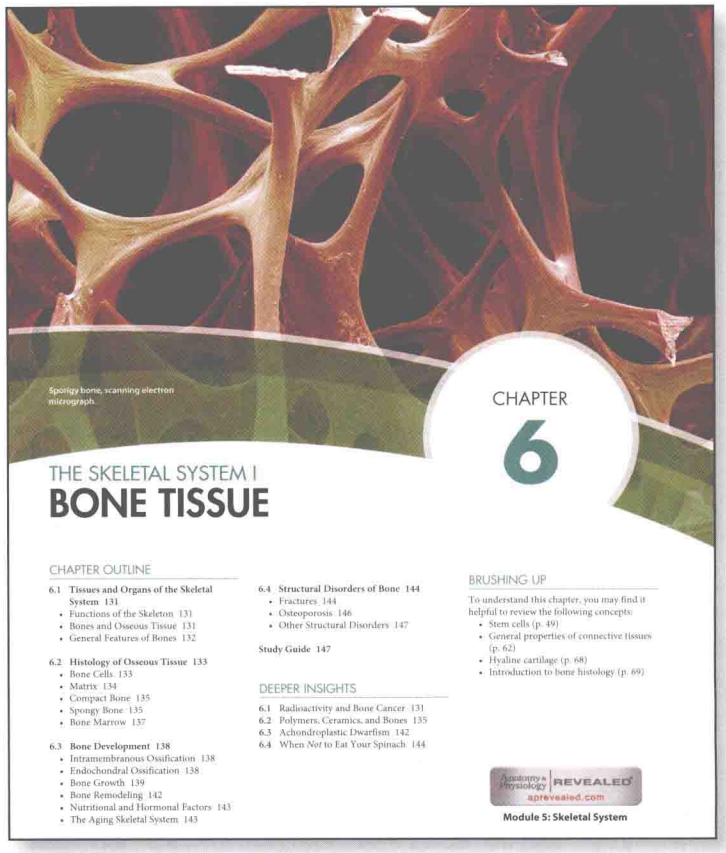
Chapters Organized for Preview and Review

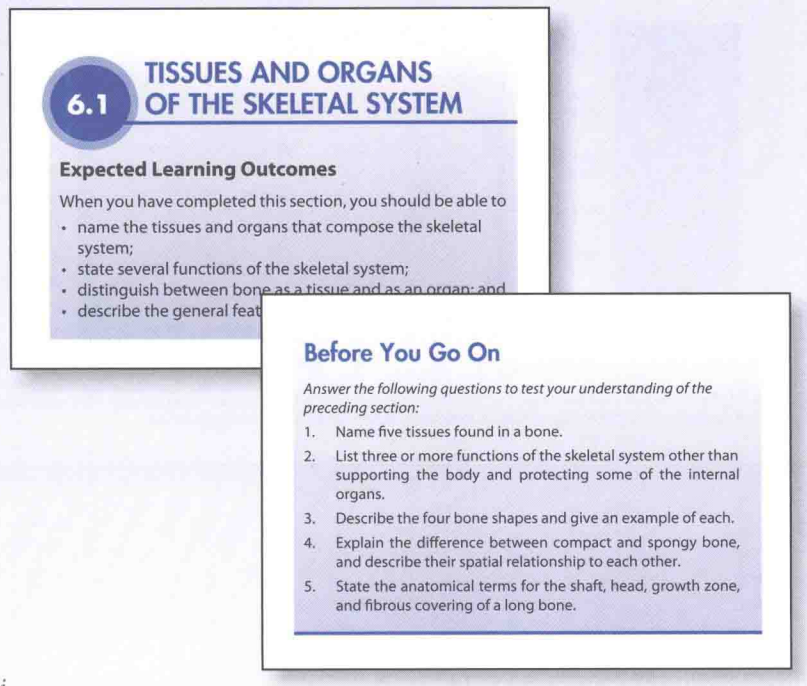
Chapter Outline provides a content preview and facilitates review and study.

Deeper Insights 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.





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.

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

Before You Go On prompts the student to pause and spot-check his or her mastery of the previous few pages before progressing to new material.

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

1. The **sinoatrial (SA) node,** a patch of modified cardiocytes in the right atrium, just under the epicardium near the superior vena cava. This is the **pacemaker** that initiates each heartbeat and determines the heart rate.
2. Signals from the SA node spread throughout the atria, as shown by
3. The **atri** of the int acts as a signals t node bec prevents other rou
4. The **atrioventricular (AV) bundle (bundle of His**[15]**),** a cord of modified cardiocytes by which signals leave the AV node. The bundle soon forks into **right** and **left bundle branches,** which enter the interventricular septum and descend toward the apex of the heart.
5. **Purkinje**[16] (pur-KIN-jee) **fibers,** nervelike processes that arise from the lower end of the bundle branches and turn upward to spread throughout the ventricular myocardium. Purkinje fibers distribute the electrical excitation to the cardiocytes of the ventricles. They form a more elaborate network in the left ventricle than in the right.

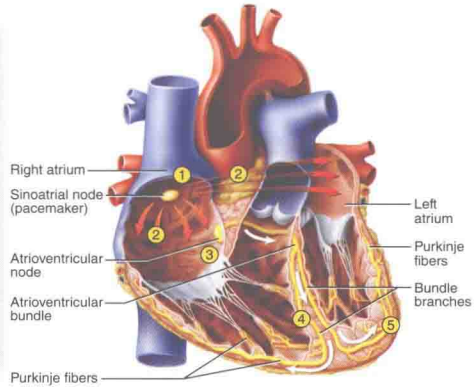
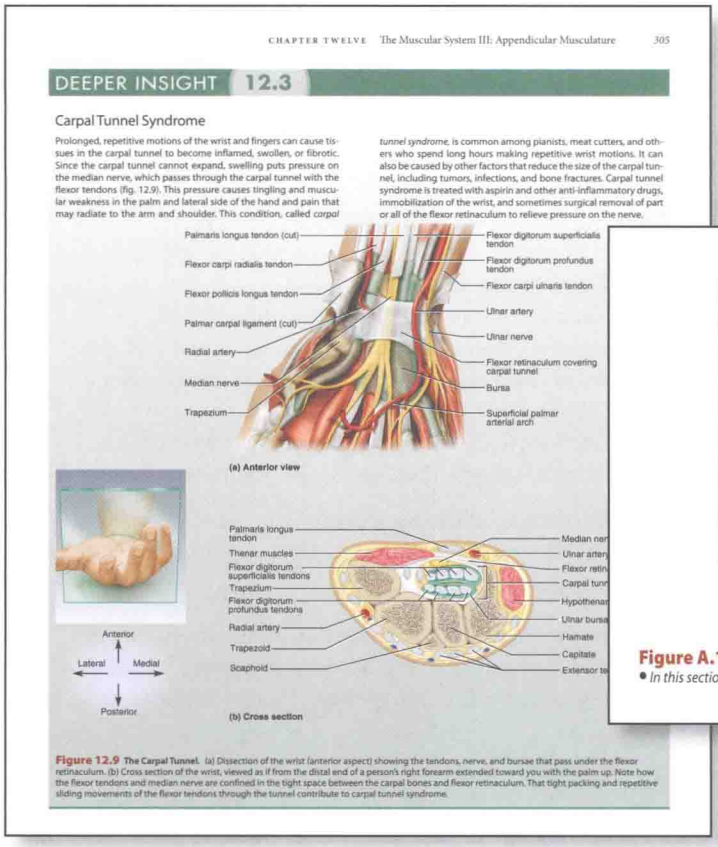


Figure 20.13 **The Cardiac Conduction System.** Electrical signals travel along the pathways indicated by the arrows.
• *Which atrium is the first to receive the signal that induces atrial contraction?*

Orientation Tools, like a compass on the anatomical art, clarify the perspective from which a structure is viewed.



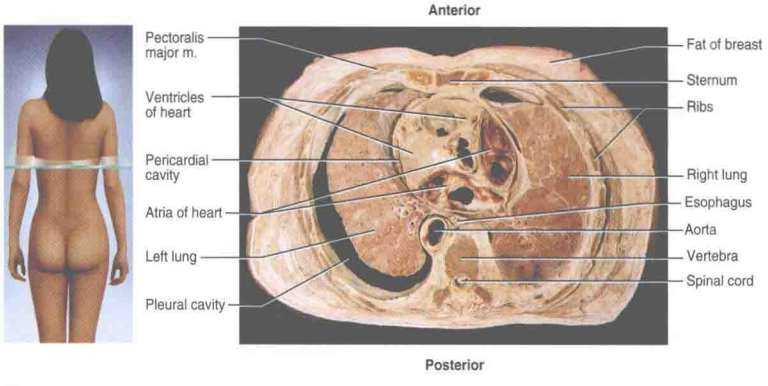


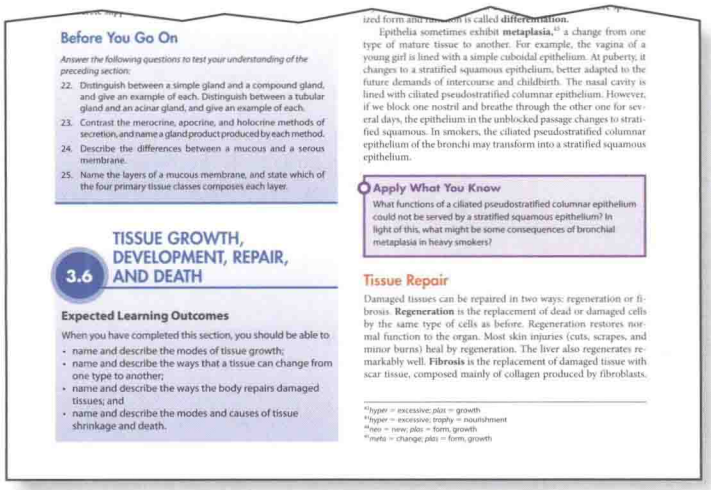
Figure A.11 **Transverse Section of the Thorax.** Section taken at the level shown by the inset and oriented the same as the reader's body.
• *In this section, which term best describes the position of the aorta relative to the heart:* posterior, lateral, *or* proximal?

Self-Assessment Tools

Saladin provides 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 a student's ability to think of the deeper implications or clinical applications of a point he or she just read.



Before You Go On

Answer the following questions to test your understanding of the preceding section:

22. Distinguish between a simple gland and a compound gland, and give an example of each. Distinguish between a tubular gland and an acinar gland, and give an example of each.
23. Contrast the merocrine, apocrine, and holocrine methods of secretion, and name a gland product produced by each method.
24. Describe the differences between a mucous and a serous membrane.
25. Name the layers of a mucous membrane, and state which of the four primary tissue classes composes each layer.

3.6 TISSUE GROWTH, DEVELOPMENT, REPAIR, AND DEATH

Expected Learning Outcomes

When you have completed this section, you should be able to
- name and describe the modes of tissue growth;
- name and describe the ways that a tissue can change from one type to another;
- name and describe the ways the body repairs damaged tissues; and
- name and describe the modes and causes of tissue shrinkage and death.

ized form and function is called **differentiation**.

Epithelia sometimes exhibit **metaplasia**,[d] a change from one type of mature tissue to another. For example, the vagina of a young girl is lined with a simple cuboidal epithelium. At puberty, it changes to a stratified squamous epithelium, better adapted to the future demands of intercourse and childbirth. The nasal cavity is lined with ciliated pseudostratified columnar epithelium. However, if we block one nostril and breathe through the other one for several days, the epithelium in the unblocked passage changes to stratified squamous. In smokers, the ciliated pseudostratified columnar epithelium of the bronchi may transform into a stratified squamous epithelium.

Apply What You Know

What functions of a ciliated pseudostratified columnar epithelium could not be served by a stratified squamous epithelium? In light of this, what might be some consequences of bronchial metaplasia in heavy smokers?

Tissue Repair

Damaged tissues can be repaired in two ways: regeneration or fibrosis. **Regeneration** is the replacement of dead or damaged cells by the same type of cells as before. Regeneration restores normal function to the organ. Most skin injuries (cuts, scrapes, and minor burns) heal by regeneration. The liver also regenerates remarkably well. **Fibrosis** is the replacement of damaged tissue with scar tissue, composed mainly of collagen produced by fibroblasts.

[c] *hyper* = excessive; *plas* = growth
[d] *hyper* = excessive; *trophy* = nourishment
[e] *neo* = new; *plas* = form, growth
[f] *meta* = change; *plas* = form, growth

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

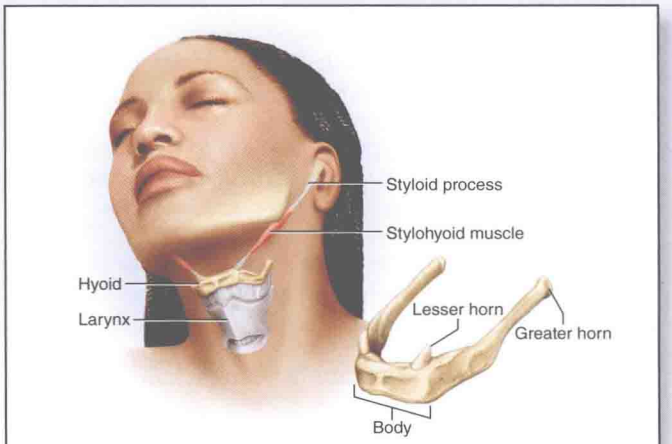
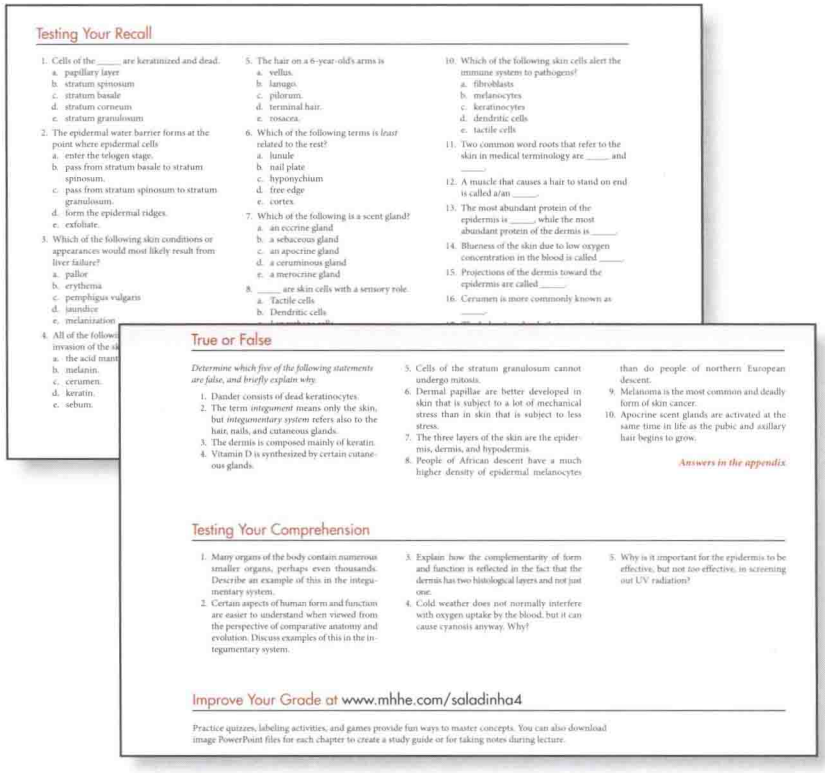


Figure 7.16 The Hyoid Bone.
• *Why would a fractured hyoid bone be a common finding in strangulation cases?*

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

True or False statements require students not only to evaluate their truth, but also to concisely explain why the false statements are untrue, or rephrase them in a way that makes them true.

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.



Testing Your Recall

1. Cells of the _____ are keratinized and dead.
   a. papillary layer
   b. stratum spinosum
   c. stratum basale
   d. stratum corneum
   e. stratum granulosum
2. The epidermal water barrier forms at the point where epidermal cells
   a. enter the telogen stage.
   b. pass from stratum basale to stratum spinosum.
   c. pass from stratum spinosum to stratum granulosum.
   d. form the epidermal ridges.
   e. exfoliate.
3. Which of the following skin conditions or appearances would most likely result from liver failure?
   a. pallor
   b. erythema
   c. pemphigus vulgaris
   d. jaundice
   e. melanization
4. All of the follow… invasion of the sk…
   a. the acid mant…
   b. melanin.
   c. cerumen.
   d. keratin.
   e. sebum.
5. The hair on a 6-year-old's arms is
   a. vellus.
   b. lanugo.
   c. pilorum.
   d. terminal hair.
   e. rosacea.
6. Which of the following terms is *least* related to the rest?
   a. lunule
   b. nail plate
   c. hyponychium
   d. free edge
   e. cortex
7. Which of the following is a scent gland?
   a. an eccrine gland
   b. a sebaceous gland
   c. an apocrine gland
   d. a ceruminous gland
   e. a merocrine gland
8. _____ are skin cells with a sensory role.
   a. Tactile cells
   b. Dendritic cells
10. Which of the following skin cells alert the immune system to pathogens?
    a. fibroblasts
    b. melanocytes
    c. keratinocytes
    d. dendritic cells
    e. tactile cells
11. Two common word roots that refer to the skin in medical terminology are _____ and _____.
12. A muscle that causes a hair to stand on end is called a/an _____.
13. The most abundant protein of the epidermis is _____, while the most abundant protein of the dermis is _____.
14. Blueness of the skin due to low oxygen concentration in the blood is called _____.
15. Projections of the dermis toward the epidermis are called _____.
16. Cerumen is more commonly known as _____.

True or False

Determine which five of the following statements are false, and briefly explain why.

1. Dander consists of dead keratinocytes.
2. The term *integument* means only the skin, but *integumentary system* refers also to the hair, nails, and cutaneous glands.
3. The dermis is composed mainly of keratin.
4. Vitamin D is synthesized by certain cutaneous glands.
5. Cells of the stratum granulosum cannot undergo mitosis.
6. Dermal papillae are better developed in skin that is subject to a lot of mechanical stress than in skin that is subject to less stress.
7. The three layers of the skin are the epidermis, dermis, and hypodermis.
8. People of African descent have a much higher density of epidermal melanocytes than do people of northern European descent.
9. Melanoma is the most common and deadly form of skin cancer.
10. Apocrine scent glands are activated at the same time in life as the pubic and axillary hair begins to grow.

Answers in the appendix

Testing Your Comprehension

1. Many organs of the body contain numerous smaller organs, perhaps even thousands. Describe an example of this in the integumentary system.
2. Certain aspects of human form and function are easier to understand when viewed from the perspective of comparative anatomy and evolution. Discuss examples of this in the integumentary system.
3. Explain how the complementarity of form and function is reflected in the fact that the dermis has two histological layers and not just one.
4. Cold weather does not normally interfere with oxygen uptake by the blood, but it can cause cyanosis anyway. Why?
5. Why is it important for the epidermis to be effective, but not *too* effective, in screening out UV radiation?

Improve Your Grade at www.mhhe.com/saladinha4

Practice quizzes, labeling activities, and games provide fun ways to master concepts. You can also download image PowerPoint files for each chapter to create a study guide or for taking notes during lecture.

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 gives 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.

Lateral to the sella turcica, the sphenoid is perforated by several foramina (see fig. 7.5). The **foramen rotundum** and **foramen ovale** (oh-VAY-lee) are passages for two branches of the trigeminal nerve. The **foramen spinosum,** about the diameter of a pencil lead, provides passage for an artery of the meninges. An irregular gash called the **foramen lacerum**[18] (LASS-eh-rum) occurs at the junction of the sphenoid, temporal, and occipital bones. It is filled with cartilage in life and transmits no major vessels or nerves.

In an inferior view of the skull, the sphenoid can be seen just anterior to the basilar part of the occipital bone (see fig. 7.5a). The internal openings of the nasal cavity seen here are called the **posterior nasal apertures,** or **choanae**[19] (co-AH-nee). Lateral to each aperture, the sphenoid bone exhibits a pair of parallel plates—the **medial** and **lateral pterygoid**[20] (TERR-ih-goyd) **plates.** Each plate has a narrow inferior extension called the *pterygoid process* (see fig. 7.5a). The plates provide attachment for some of the chewing muscles.

Ethmoid Bone

The **ethmoid**[21] (ETH-moyd) bone is an anterior cranial bone located between the eyes (fig. 7.12). It contributes to the medial wall

[18] *lacerum* = torn, lacerated
[19] *choana* = funnel
[20] *pterygo* = wing
[21] *ethmo* = sieve, strainer; *oid* = resembling

Building Your Medical Vocabulary

State a medical meaning of each of the following word elements, and give an example of a term in which it is used.

1. osteo-
2. diplo-
3. lac-
4. -clast
5. -osis
6. dia-
7. -logy
8. artic-
9. -icul
10. -oid

Answers in the appendix

The Jaw Joint

The **temporomandibular joint (TMJ)** is the articulation of the condyle of the mandible with the mandibular fossa of the temporal bone (fig. 9.18). You can feel its action by pressing your fingertips against the jaw immediately anterior to the ear while opening and closing your mouth. This joint combines elements of condylar, hinge, and plane joints. It functions in a hingelike fashion when the mandible is elevated and depressed, it glides from side to side to grind food between the molars, and it glides slightly forward when the jaw is protracted to take a bite or when the mouth is opened widely. If you palpate the joint just anterior to your earlobe while opening the mouth, you can feel this forward glide of the condylar process. You can get a sense of the necessity of this movement if you press on your chin with the heel of your hand to prevent the mandible from gliding anteriorly; you will find it difficult to open the mouth very far.

Desktop Experiments

Many chapters offer simple experiments and palpations a student can do at his or her desk, with no equipment, to help visualize chapter concepts.

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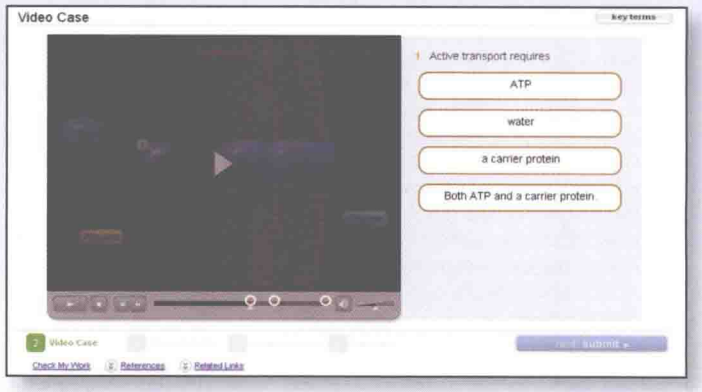

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DEEPER INSIGHT 8.2

Femoral Fractures

The femur is a very strong bone, well guarded by the thigh muscles, and it is not often fractured. Nevertheless, it can break in high-impact trauma suffered in automobile and equestrian accidents, figure skating falls, and so forth. If a person in an automobile collision has the feet braced against the floor or brake pedal with the knees locked, the force of impact is transmitted up the shaft and may fracture the shaft or neck of the femur (fig. 8.11). Comminuted and spiral fractures of the shaft can take up to a year to heal.

A "broken hip" is usually a fracture of the femoral neck, the weakest part of the femur. Elderly people often break the femoral neck when they stumble or are knocked down—especially women whose femurs are weakened by osteoporosis. Fractures of the femoral neck heal poorly because this is an anatomically unstable site and it has an especially thin periosteum with limited potential for ossification. In addition, fractures in this site often break blood vessels and cut off blood flow, resulting in degeneration of the head *(posttraumatic avascular necrosis)*.

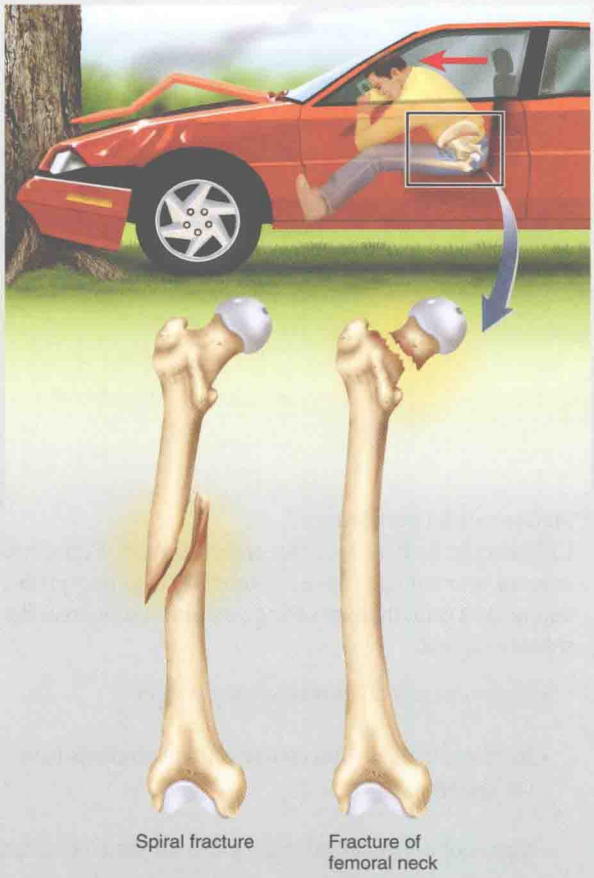

Figure 8.11 **Fractures of the Femur.** Violent trauma, as in automobile accidents, may cause spiral fractures of the femoral shaft. The femoral neck often fractures in elderly people as a result (or cause) of falls.

Making it Relevant

Deeper Insight essays cover the clinical application of basic science. Some Deeper Insight boxes highlight medical history and evolutionary interpretations of human structure and function.

Apply What You Know

An infant brought to a clinic shows abnormally yellow skin. What sign could you look for to help decide whether this was due to jaundice or to a large amount of carotene from strained vegetables in the diet?

Apply What You Know interjections prompt a student to apply what he or she has just read to a new thought-provoking problem or context, and they encourage new insights.

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