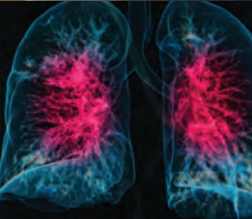
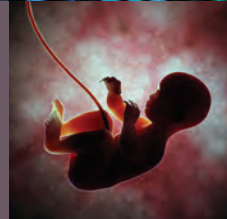
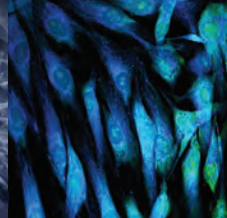
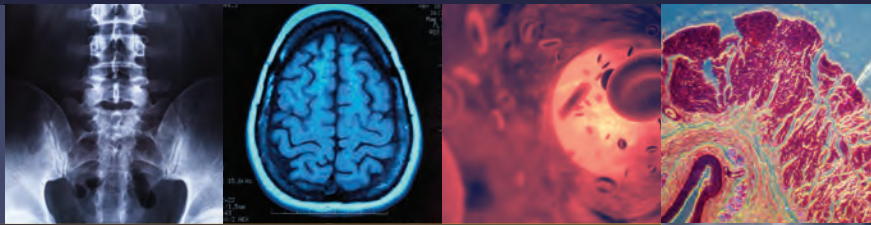


SECOND EDITION

ANATOMY AND PHYSIOLOGY

FOR HEALTH PROFESSIONALS



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Cover Design: Kristin E. Parker
Cover Images: From left to right: © IxMaster/Shutterstock,
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Printing and Binding: Courier Companies
Cover Printing: Courier Companies

Library of Congress Cataloging-in-Publication Data

Moini, Jahangir, 1942- , author.
[Anatomy and physiology for health professionals]
Anatomy & physiology for health professionals / Jahangir Moini. — Second edition.
p. ; cm.
Preceded by Anatomy and physiology for health professionals / Jahangir Moini. c2012.
Includes index.
ISBN 978-1-284-03694-7
I. Title.
[DNLM: 1. Anatomy. 2. Allied Health Personnel. 3. Physiological Phenomena. QS 4]
QP34.5
612—dc23

2014028797

6048

Printed in the United States of America
19 18 17 16 15 10 9 8 7 6 5 4 3 2 1

DEDICATION

This book is dedicated to my wonderful and amazing wife, Hengameh, and two beautiful daughters, Mahkameh and Morvarid.

It is also dedicated to my granddaughters, Laila Jade and Anabelle Jasmine Mabry.

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PREFACE

In 24 years of teaching anatomy and physiology, I have utilized numerous books related to the subject. Some were very high-level while others were very low-level, and I couldn't find a "middle ground" book that really taught the subject to allied health students—surprising, given that this is a time when the field is growing exponentially. Therefore, I undertook the writing of this book for all allied health professionals. Anatomy and physiology are two of the major core subjects for almost all allied health professionals; they must understand the structures and normal functions of the body in the simplest possible terms. This book strives to make that possible.

Organization of This Text

This text is based on levels of organization within the body and becomes more multifaceted as the student incorporates the understanding of basic, then intermediate, and finally more complex subjects.

In total, the text consists of six units. Unit I, "Levels of Organization," begins by providing a general introduction to human anatomy and physiology, along with the organization levels through which the body is understood. The unit then delves into the atomic, molecular, and chemical interactions on which life is based before moving on to discussions of the cells and tissues that comprise the body.

As the title implies, Unit II, "Support and Movement," focuses on the body systems that support the body and allow for a range of motion. The unit first considers the integumentary system, composed of the skin and its accessory structures: These are the body's first line of defense against the environment. The text then approaches the bones and joints that comprise the skeletal system before discussing the muscular system.

Unit III, "Control and Coordination," tackles the critical components of the body that control all body functions. The text considers the all-important nervous system across four chapters on neural tissue, the central nervous system, the peripheral nervous system, and the senses. The unit then ends with a chapter on the endocrine system, which works along with the nervous system to regulate the functions of the human body to maintain homeostasis.

Unit IV, "Transport," focuses on the cardiovascular and lymphatic systems, which keep the body running. The first three chapters discuss the major components of the cardiovascular system: the heart, blood, and blood vessels. The last chapter in this unit focuses on the lymphatic system. Like the cardiovascular system, it transports fluids through a network of vessels; without the lymphatic system, fluid would accumulate in tissue spaces.

Unit V, "Environmental Exchange," considers the systems and processes that balance what the body intakes with what it expels. The unit first examines the respiratory system, which intakes oxygen and removes carbon dioxide from the body, before shifting focus to the urinary system, which eliminates wastes and maintains homeostatic regulation of the volume and solute concentration of blood plasma. The text then surveys fluid, electrolyte, and acid-base balance before moving on to the digestive system, which in simplest terms supplies nutrients for body cells.

Finally, in Unit VI, "Continuity of Life," the focus shifts to the male and female reproductive systems, which, while not essential to the survival of an individual, are needed to ensure the continued existence of the human species. The final chapter then discusses pregnancy before delving into a brief discussion of genetics.

In addition to the recurring features that guide the student through each chapter (of which an overview is given in the "How to Use This Book" section), the body systems chapters contained in this text address the effects of aging on each specific system, information that is especially critical at a time when the number of older adults is on the rise.

New to This Edition

This second edition has been updated to take into account both advancements in medical knowledge in the last several years as well as feedback from valued users of the *First Edition*.

For the *Second Edition*, the text was expanded from 20 to 24 chapters. Changes include the following:

- Chapter 8, "Articulations," is new to this edition and provides an overview of the classifications of joints, types of joint movements, intervertebral joints and ligaments, and joint injuries.
- The content in the "Nervous System" chapter has been expanded and divided into three chapters: Chapter 10, "Neural Tissue"; Chapter 11, "The Central Nervous System"; and Chapter 12, "The Peripheral Nervous System."
- The content in the "Cardiovascular System" chapter has also been expanded and divided into two chapters: Chapter 16, "The Heart," and Chapter 17, "The Vascular System."
- *Focus on Pathology* boxes have been added throughout the chapters, incorporating explanation of abnormal conditions relating to the body systems.
- *Essay Questions* have been added to the end of each chapter, while the *Critical Thinking Questions* have been expanded.

New tables and figures have been added as appropriate, particularly ones that focus on diagnostic imaging.

Instructor Resources

Qualified instructors can receive a full suite of extensive Instructor Resources, including:

- Slides in PowerPoint format, featuring more than 2,000 slides
- Test Bank, containing more than 800 questions
- Instructor's Manual, including teaching strategies, lecture outlines, discussion topics, and answers to end-of-chapter questions

- Image Bank, supplying key figures from the text
- Sample Syllabus, showing how a course can be structured around this text
- Transition Guide, providing guidance in switching from the previous edition

To gain access to these valuable teaching materials, contact your Health Professions Account Specialist at go.jblearning.com/findarep.

Jahangir Moini, MD, MPH

HOW TO USE THIS BOOK

Anatomy and Physiology for Health Professionals, Second Edition incorporates a number of engaging pedagogical features to aid in the student's understanding and retention of the material. A colorful and engaging layout enables easy reading and supports the retention of important concepts. More than 450 full-color photographs and medically accurate illustrations provide valuable insight into human anatomy and physiology.

Chapter Objectives and Outline

Each chapter begins with a framework for learning the most important topics by presenting *Objectives* that list the chapter's desired outcomes and an *Outline* indicating the material to be discussed.



CHAPTER
7

Bone Tissues and the Skeletal System

OBJECTIVES

After studying this chapter, readers should be able to:

1. Discuss the major functions of bones.
2. Discuss bone classifications and give examples of each.
3. Distinguish between the axial and appendicular skeletons.
4. Identify the major features of the bones that compose the thoracic cage and the upper limbs.
5. Distinguish the major parts of a long bone.
6. List the substances normally stored in bone tissue.
7. Name each of the bones of the cranium.
8. Explain how the structures of cervical, thoracic, and lumbar vertebrae differ.
9. Name each of the bones of the lower limbs.
10. List the bones of the ankle and identify the largest of these.

OUTLINE

- Overview
- Classifications of Bones
- Structures of Bones
 - Gross Anatomy
 - Microscopic Anatomy (Bone Cells)
 - Chemical Composition of Bone
- Growth and Development of Bones
- Functions of Bones
- Bone Homeostasis
 - Bone Remodeling
 - Bone Fracture
 - Bone Repair
 - Bone Deposition
 - Bone Resorption
 - Control of Bone Remodeling
- Bone Homeostatic Imbalance
 - Rickets
 - Osteomalacia
 - Osteoporosis
- Skeletal Organization
 - Axial Skeleton
 - Appendicular Skeleton
- Effects of Aging on the Skeletal System
- Summary
- Key Terms
- Learning Goals
- Critical Thinking Questions
- Review Questions
- Essay Questions

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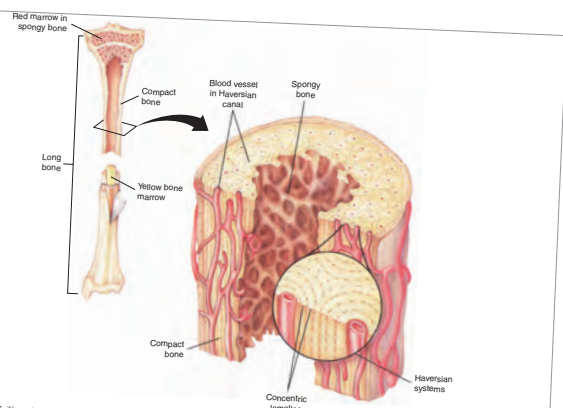


FIGURE 7-5 The microscopic structure of a long bone

extensions contains gap junctions. As the matrix hardens, a system of canaliculi is formed, containing tissue fluid and the osteocytes' extensions. A mature osteon is then bound together, and both nutrients and wastes can move from one osteocyte to the next. The bone matrix therefore allows bone cells to receive nourishment while it still remains hard and impermeable. However, some lamellae in compact bone are not part of complete osteons. Between osteons are incomplete *interstitial lamellae* that either fill gaps or are leftover structures of previous osteons that experienced bone remodeling. Deep to the periosteum, just superficial to the endosteum, are *circumferential lamellae*, which extend completely around the diaphysis, helping the long bone to resist twisting.

- **Spongy bone:** This type of bone is similarly composed to compact bone, but its cells do not aggregate around the central canals. The cells in spongy bone lie inside the *trabeculae* (supporting structures of dense tissue) and take their nutrients from diffused substances that enter the canaliculi. The trabeculae are only a few cells thick. They have irregular lamellae and osteocytes, interconnected

by canaliculi, and no osteons are present. Nutrients reach spongy bone osteocytes via diffusion through the canaliculi from capillaries in the endosteum that surround the trabeculae.

TEST YOUR UNDERSTANDING

1. Compare the structure of compact bone with spongy bone.
2. List various types of bone cells and their functions.

Chemical Composition of Bone

Organic components of bones include osteogenic cells, osteoblasts, bone lining cells, osteocytes, osteoclasts, and *osteoid*. Nearly one-third of the matrix is made up of the osteoid. The osteoid includes proteoglycans and glycoproteins making up its ground substance) and collagen fibers, both the ground substance and the collagen fibers are made and secreted by osteoblasts. Collagen is the greater contributor to the structure of bones and to their flexibility and tensile strength. *Sacrificial bonds* inside or between collagen

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Test Your Understanding

Each chapter contains *Test Your Understanding* boxes scattered throughout, which present open-ended questions that reinforce key content covered in preceding sections.

Focus on Pathology

Focus on Pathology boxes connect the book's coverage of anatomy and physiology to important topics in pathology, or the study of disease.

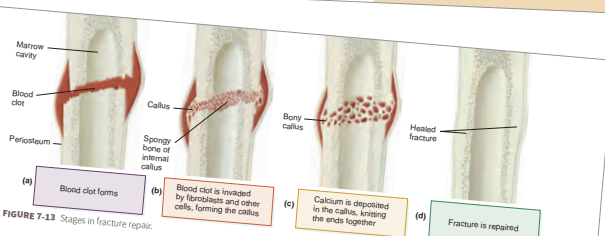


FIGURE 7-13 Stages in fracture repair.

to 12 μm in width. Between osteoid seams and older bone, an abrupt transition point exists, known as the *calcification front*. The osteoid seems mature for about 1 week before calcification occurs. Mechanical signals are involved in this calcification. In the endosteal cavity, nearby concentrations of calcium and phosphate ions are needed for calcification to occur. When this calcium-phosphate product is sufficient, tiny crystals of hydroxyapatite are formed. They catalyze continued crystallization of calcium salts. Additional factors include matrix proteins (which bind and concentrate calcium) and alkaline phosphatase, an enzyme that is lost in mineralization. Eventually, calcium salts are deposited at one time throughout the matured matrix in an ordered manner.

Bone Resorption

Bone resorption occurs because of osteoclast activities, including the creation of grooves or depressions as bone matrix is broken down. Osteoclast borders use their irregular shape to stick to the bone and seal off areas of bone destruction. They secrete lysosomal enzymes, digesting proteins and the organic matrix. In the resorption bays, the high acidocytes and demineralized matrix may be phagocytized by the osteoclasts. Endocytosis occurs to the digested matrix, which is then removed, via transcytosis, across the osteoclasts to be released at the opposite end. Osteoclasts to be released at the opposite end. Osteoclasts undergo apoptosis after a certain bone area has been resorbed. Both parathyroid hormone (PTH) and protein from the immune system's T cells play a role.

Control of Bone Remodeling

Bone remodeling is controlled by genetic factors, a negative feedback hormonal loop, and in response to gravitational and mechanical forces. The negative feedback hormonal loop maintains calcium ion homeostasis in the blood. Ionic calcium is essential for nerve impulse transmission, blood coagulation, muscle contraction, cell division, and secretion

by glands as well as nerve cells. More than 99% of the body's 1,200 to 1,400 g of calcium is present in the bones. The remainder is primarily in the cells, and a small amount is in the blood. Hormonal controls keep blood calcium ions in a range between 9 and 11 mg/dL. 1,000 mL of blood. Vitamin D Children under age 10 need 400 to 800 mg of calcium in their daily diet, whereas people between ages 11 and 24 require 1,200 to 1,500 mg.

PTH, released by the parathyroid glands, is the primary hormonal controller of bone remodeling, although calcitonin is also involved to a lesser degree. The parathyroid glands are embedded in the thyroid gland in the neck. PTH is released when blood levels of ionic calcium decline, stimulating osteoclasts to resorb bone and releasing calcium into the blood. Osteoclasts break down old as well as new bone reversing its effects and lowering blood calcium. Blood calcium homeostasis is therefore maintained. However, if blood calcium levels are low for a long time, the bones lose minerals and develop large, irregular holes.

FOCUS ON PATHOLOGY

Calcium ion levels must be strictly controlled by the body and usually only change within 10% of their normal amounts. If they decrease by 35%, convulsions may occur. If they increase by 30%, muscle cells and neurons become unresponsive. If they reduce to 50%, death usually occurs. Hypercalcemia is the condition of sustained high blood levels of calcium. This can lead to dangerous calcium salt deposition in the blood vessels and soft organs such as the kidneys, which results in kidney stones. This deposition can harm their function in many different ways.

SUMMARY

Joints can be classified according to their degree of movement and by the type of tissue that binds together the bones that surround them. Joints are divided into fibrous, cartilaginous, and synovial types. Fibrous joints are tightly joined by a layer of dense connective tissue. They include sutures, syndesmoses, and gomphoses. Fibrous joints may be amphiarthrotic (having little movement, such as cartilaginous joints) or synarthrotic (immovable). Cartilaginous joints include synchondroses and symphyses. Synovial joints are covered with hyaline cartilage and are held together by a fibrous joint capsule. Synovial joints that allow free movement (diarthrotic) include ball-and-socket, hinge, condyloid, gliding, saddle, and pivot types. Synovial joints include characteristics such as articular cartilage, articular cavities, articular capsules, synovial fluid, reinforcing

ligaments, nerves, and blood vessels. Both bursae and tendon sheaths are closely related to synovial joints. Joint movements include flexion, extension, dorsiflexion, plantar flexion, hyperextension, supination, eversion, inversion, rotation, circumduction, pronation, supination, abduction, adduction, retraction, protraction, depression, and elevation. Joints must be stabilized to avoid becoming dislocated during stretching and compression. Muscle tendons crossing joints are often the most important factors concerning stability. As we age, joints may develop conditions such as arthritis or rheumatism. Many people over age 60 have osteoarthritis, which is also known as degenerative joint disease. Rheumatoid arthritis is an autoimmune disease that affects the joints. Gouty arthritis involves uric acid crystals forming in the synovial joint fluid.

KEY TERMS

Abduction	Fibrous joints	Protraction
Acetabular labrum	Flexion	Pubofemoral ligament
Adduction	Glenohumeral ligaments	Radial collateral ligament
Amphiarthrotic	Gomphoses	Retraction
Anterior cruciate ligament	Gouty arthritis	Rheumatoid arthritis
Annular ligament	Hip joints	Rotation
Arcuate popliteal ligament	Hyperextension	Rotator cuff
Arthritis	Iliofemoral ligament	Sprain
Arthroscopic surgery	Intervertebral joints	Supination
Bursae	Inversion	Sutures
Bursitis	Isohumeral ligament	Symphyses
Cartilaginous joints	Joint capsule	Synarthrotic
Circumduction	Joints	Synchondroses
Collateral ligament	Lyme disease	Syndesmoses
Coracohumeral ligament	Menisci	Synostoses
Depression	Nucleus pulposus	Synovial fluid
Diarthrotic	Oblique popliteal ligament	Synovial joints
Dislocation	Opposition	Synovial membrane
Dorsiflexion	Osteoarthritis	Tibial collateral ligament
Elevation	Plantar flexion	Tibiofemoral joints
Eversion	Posterior cruciate ligament	Ulnar collateral ligament
Extension	Pronation	

Summary

A number of features appear at the end of each chapter. The *Summary* recaps the most important points in the chapter and connects it to the student's overall journey.

Key Terms

Key Terms list the most important new terms covered in the chapter; correlating definitions can be found in the end-of-text glossary.

Learning Goals

Learning Goals encapsulate how each *Objective* has been addressed over the course of the chapter.

LEARNING GOALS

The following learning goals correspond to the objectives at the beginning of this chapter:

1. Joints (articulations) are the junctions between bones.
2. Joints are structurally classified as fibrous, cartilaginous, and synovial joints. Joints are functionally classified as immovable (synarthrotic), slightly movable (amphiarthrotic), or freely movable (diarthrotic).
3. The structures of synovial joints include an outer layer of ligaments (joint capsules) and inner linings of synovial membrane that secrete synovial fluid. Some synovial joints have shock-absorbing fibrocartilage pads called menisci. They may also have fluid-filled sacs (bursae) commonly found between tendons and underlying bony prominences such as in the knee or elbow.
4. The six types of synovial joints are ball-and-socket, condyloid or condyloid (ellipsoidal), plane (gliding), hinge, pivot, and saddle joints.
5. Common bodily movements include angular, gliding, and rotation movements. Angular movements include flexion, extension, abduction, adduction, supination, eversion, inversion, protraction, retraction, depression, and opposition.
6. The most common joint injuries include sprains, dislocations, and cartilage tears. In a sprain, there is stretching or tearing of the ligaments that reinforce a joint. A dislocation is also known as a luxation and occurs when bones are forced out of alignment. They are usually involved with a sprain. Tearing of cartilage causes it to break or pop because of being overstressed. This usually occurs in the knee menisci.
7. The common types of arthritis include osteoarthritis, which is degeneration of joints, via enzymatic activity, because of aging; rheumatoid arthritis, which is a chronic inflammatory disorder that usually appears between the ages of 30 and 50 and usually in women; and gouty arthritis, which is based on excessive, abnormal levels of uric acid deposited as needle-like urate crystals in soft tissues of joints, which triggers an inflammatory response, causing extreme pain.
8. Accompanying the knee joint, there are three broad ligaments running from the patella to the tibia below: the *patellar, medial, and lateral patellar retinacular ligaments*. When the knee is extended, the *extracapsular fibular and tibial collateral ligaments* are crucial to prevent lateral or medial rotation. The posterior oblique popliteal ligament. The posterior aspect of the knee joint is partially stabilized by the *fovea posterior* by the *arcuate popliteal ligament*, which has a superior arc, from the head of the fibula over the popliteus muscle. The *intracapsular ligaments (cruciate ligaments)* cross each other to form an "X". The anterior cruciate ligament is attached to the tibia's anterior intercondylar area and passes upward, laterally, and posteriorly to attach to the femur. The posterior cruciate ligament has more strength and is attached to the tibia's posterior intercondylar area.
9. Gliding movements occur when a flat or nearly flat bond surface slips over or glides over another in a side-to-side or back-and-forth motion. There is no major rotation or angulation. Examples include the movement of the intertarsal and intercarpal joints and movements of the flat articular vertebral processes. Angular movements decrease or increase the angle between two bones. This can occur in any body plane and includes extension, flexion, hyperextension, abduction, adduction, and circumduction.
10. The causes of Lyme disease are bites from ticks that infest deer or mice and carry a specific spirochete bacterium. Lyme disease complications include joint pain, arthritis, skin rash, flu-like symptoms, and impaired cognition. If untreated, Lyme disease results in neurological and cardiovascular problems.

CRITICAL THINKING QUESTIONS

A 26-year-old professional football player injured his right knee during a game. After the team trainer examined him, he was taken off the field and directly to the emergency department. After a computed tomography, he was diagnosed with a fracture of the patella.

1. What are the three ligaments that connect the patella to the tibia?
2. If at the moment the injury occurred his knee was hyperextended and twisted, which ligament would have been damaged as well?

REVIEW QUESTIONS

1. A freely movable joint is a(n)
 - A. diarthrotic joint
 - B. synarthrotic joint
 - C. symphyseal joint
 - D. amphiarthrotic joint
2. Which of the following is an immovable joint?
 - A. diarthrotic joint
 - B. syndesmosis joint
 - C. synarthrotic joint
 - D. amphiarthrotic joint
3. The elbow joint is an example of a
 - A. hinge joint
 - B. pivot joint
 - C. saddle joint
 - D. gliding joint
4. Rotation of the forearm that causes the palm to face posteriorly is referred to as
 - A. supination
 - B. angulation
 - C. projection
 - D. pronation
5. The tibiofemoral joint functions as which of the following?
 - A. gliding joint
 - B. hinge joint
 - C. saddle joint
 - D. pivot joint
6. The amphiarthrotic articulation that limits movements between the two pubic bones is the
 - A. ischial ramus
 - B. pubic tubercle
 - C. pubic symphysis
 - D. ischial tuberosity
7. The type of synarthrosis that binds each tooth to the surrounding bony socket is a
 - A. gomphosis
 - B. suture
 - C. symphysis
 - D. synostosis
8. Extension is defined as movement that
 - A. moves a limb from the midline of the body
 - B. increases the angle between articulating elements
 - C. moves a limb toward the midline of the body
 - D. decreases the angle between articulating elements
9. The parts of the vertebral column that do not contain intervertebral discs are the
 - A. first and second cervical vertebrae
 - B. first thoracic and seventh cervical vertebrae
 - C. first lumbar vertebrae
 - D. first and second lumbar vertebrae
10. Examples of monoaxial joints, which permit angular movements in a single plane, are the
 - A. intervertebral joints
 - B. elbow and knee joints
 - C. shoulder and hip joints
 - D. intercarpal and intertarsal joints
11. A movement away from the longitudinal axis of the body in the frontal plane is known as
 - A. circumduction
 - B. opposition
 - C. adduction
 - D. abduction
12. Which of the following increases the risk of fractures and is related to aging?
 - A. decreases of bone mass
 - B. increases of bone mass
 - C. excessive degree of calcium salt deposition
 - D. excessive degree of sodium and potassium in the plasma
13. Intertarsal joints are examples of
 - A. ball-and-socket joints
 - B. gliding joints
 - C. pivot joints
 - D. hinge joints
14. Which of the following are examples of saddle joints?
 - A. elbow joints
 - B. shoulder joints
 - C. wrist joints
 - D. carpometacarpal joints
15. Moving the ankle so the top of the foot comes closer to the tibial bone is called
 - A. hyperextension
 - B. plantar flexion
 - C. dorsiflexion
 - D. abduction

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Review Questions

Review Questions provide students with a chance to answer multiple choice questions.

Critical Thinking Questions

A range of questions are also included at the end of each chapter; the student can use these for self-study or submit their answers to the instructor. A case is presented at the end of each chapter, with *Critical Thinking Questions* that cause the student to reflect on the situation described.

REVIEW QUESTIONS (CONTINUED)

14. Which of the following are examples of saddle joints?
 - A. elbow joints
 - B. shoulder joints
 - C. wrist joints
 - D. carpometacarpal joints
15. Moving the ankle so the top of the foot comes closer to the tibial bone is called
 - A. hyperextension
 - B. plantar flexion
 - C. dorsiflexion
 - D. abduction

ESSAY QUESTIONS

1. Describe articulation.
2. Define the terms monoaxial, biaxial, and multiaxial.
3. Classify the various types of joints.
4. Discuss types of joint movements.
5. List the six characteristics of synovial joints.
6. Classify the various types of synovial joints.
7. Compare the elbow joints with the hip joints.
8. Define circumduction and pronation.
9. Describe the intervertebral ligaments.
10. Explain the effects of aging upon the joints.

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Essay Questions

Finally, *Essay Questions* ask students to delve deeply into the content.

ACKNOWLEDGMENTS

I would like to acknowledge the following individuals for their time and efforts in aiding with this book:

Morvarid Moini, Designer, Dental Student
Nova Southeastern University

Greg Vadimsky, Author's Assistant
Melbourne, Florida

I would like to thank the entire staff of Jones & Bartlett Learning, especially Rhonda Dearborn, Sean Fabery, Talia Adry, Amy Rathburn, Joanna Lundeen, Shannon Sheehan, and Grace Richards.

I would also like to thank the reviewers who gave their time and guidance in helping me complete this book.

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