Bontrager's

TEXTBOOK of

RADIOGRAPHIC POSITIONING and RELATED ANATOMY

NINTH EDITION

John P. Lampignano
Leslie E. Kendrick






EVOLVE STUDY RESOURCES
FREE WITH TEXTBOOK PURCHASE
EVOLVE.ELSEVIER.COM

ELSEVIER

Bontrager's

TEXTBOOK of RADIOGRAPHIC POSITIONING and RELATED ANATOMY

This page intentionally left blank

Bontrager's TEXTBOOK of RADIOGRAPHIC POSITIONING and RELATED ANATOMY

NINTH EDITION

John P. Lampignano, MEd, RT(R)(CT)
Leslie E. Kendrick, MS, RT(R)(CT)(MR)

ELSEVIER

ELSEVIER

3251 Riverport Lane
St. Louis, Missouri 63043

BONTRAGER'S TEXTBOOK OF RADIOGRAPHIC POSITIONING AND RELATED ANATOMY, NINTH EDITION ISBN: 978-0-323-39966-1

International Standard Book Number: 978-0-323-39966-1

Executive Content Strategist: Sonya Seigafuse
Content Development Manager: Lisa P. Newton
Senior Content Development Specialist: Tina Kaemmerer
Publishing Services Manager: Julie Eddy
Senior Project Manager: Mary G. Stueck
Design Direction: Renée Duenow

Printed in the United States of America

Last digit is the print number: 9 8 7 6 5 4 3 2 1

Acknowledgments and Dedication

John P. Lampignano

First, I must acknowledge the contributions from students and imaging faculty throughout the United States and various aspects of the world. I hear frequently from them, as they provide feedback on the text and ancillaries. They have provided us with fresh ideas and perspectives for the text and how to improve it. A special thank you to Michele L. Gray-Murphy and her students from Allen College for their constant feedback on the text and ancillaries.

The Diagnostic Medical Imaging and Therapy faculty at GateWay are outstanding role models for their students and the profession. Mary J. Carrillo, Jeanne Dial, Nicolle M. Hightower, Julia Jacobs, Bradley D. Johnson, and Nancy Johnson were instrumental in contributing to this text, providing images, and serving as reviewers and consultants. Special recognition to Jerry Olson for teaching me radiography over 40 years ago. His wisdom and unique insights still ring true. Special recognition to Mark Barry for being a trusted friend and outstanding technologist. Also, thanks to Terry L. Gaberdiel, my close friend, whose passing left a void for his family and friends. *Semper fidelis.*

The contributing authors for the ninth edition did an outstanding job in researching and writing the content for numerous chapters. My heartfelt gratitude to each of them for making this edition truly reflective of the current practice in medical imaging. Special thanks to Andrew Woodward and Bradley D. Johnson. Andrew redesigned Chapters 1 and 18 in this edition, served as consultant for all of the digital imaging concepts, and provided numerous photographs and images. Brad redesigned Chapter 15 to make the content more current and relevant. Brad and his students helped us secure many of the new images for this edition. Christopher Wertz of Idaho State University was also instrumental in obtaining new images for this edition.

The ninth edition marks the first edition without Ken Bontrager's expertise and leadership. Ken passed away on January 17, 2014. In honor of his dedication to his life work and to the profession, this text will always be titled *Bontrager's Textbook of Radiographic Positioning and Related Anatomy.*

Ken Bontrager, with the help and support of his family, had been dedicated to this text and other instructional media in radiologic technology for over 48 years. They had given of themselves fully to this text and its ancillaries; it has always been more than just another project to them. His impact on the practice of diagnostic imaging has been profound, especially for our students. As lead author I will dedicate myself to maintaining the same standards as have been established by Mr. Bontrager—a true pioneer of the profession. I hope our profession never forgets Ken Bontrager and his contributions.

Leslie Kendrick formally became co-author for the ninth edition. Leslie is a driven, detailed, and outstanding writer. She took on this huge endeavor while maintaining her program responsibilities at Boise State University and taking care of her family. You can't measure the character of a writer until they are tested by long hours, pressing deadlines, and personal sacrifice. Leslie has the character and heart of a writer. I am privileged to work with her.

Over 250 photographs were taken for the ninth edition. This feat would not have been possible without the special talents of Keith Alstrin of Alstrin Photography. His photography, imagination, and creativity are imprinted throughout this edition.

Thanks to Ed Schultes, Jr. with BioMedia Communications. Ed made the arrangements for the photo shoot, models, and photo locations.

Thank you Gateway Community College and Mary J. Carrillo for providing us the radiography suites for the photo shoot. Special thanks to our commercial partners who provided many of the new photos and images.

Our gratitude to Angela Bosovski, Ariella Bosovski, Mary J. Carrillo, Karina Delgado, Allen Hentley, Bradley D. Johnson, Deborah Lampignano, Alberto Sanchez, and Amy Serna who served as models for this edition. They maintained a high degree of professionalism and tremendous patience throughout the long photo shoots.

We were honored to have Sonya Seigafuse as our Executive Content Strategist. Sonya was our leader through the ninth edition from its inception to completion. Sonya helped us navigate through difficult waters and always with a kind word and smile.

Our Senior Content Development Specialist, Tina Kaemmerer, was simply incredible. She is a perfectionist who challenged us to bring forth our best effort in a loving way. Her support was ongoing, professional, and always positive.

Mary Stueck is the Senior Project Manager who led us through the production phase. We couldn't have produced this edition without her expertise.

Most importantly, a thank you to Elsevier Publishing for allowing us to continue to be part of this wonderful reference for the past 44 years.

Finally, my thanks to my family for their ongoing support. My wife Deborah, son Daniel, daughter Molly, and granddaughter, Tatum. I'm especially proud that Daniel and Molly have entered the medical profession. They are both excellent professionals and they understand the importance of treating their patients with dignity and compassion. They have always been important to me even though I don't express it adequately. My true inspiration is my granddaughter, Tatum, who makes me smile daily. What a beautiful and kind person she has become. When things got difficult and overwhelming, I only needed to see her picture or spend a few minutes with her and my spirit was renewed. Tatum will always own my heart. Finally, to Buddy, the wonder dog, for sitting in the office (ok…sleeping) while I wrote. The Bishop, Daniel's dog, was a hero to those he found over the many years on search and rescue missions.

Deborah has been at my side for over 39 years. She has been the compassionate anchor that provides our family with the stability and encouragement to be successful in all of our professional and personal endeavors. My life changed in so many positive ways since I first met her. Meeting the demands of a new edition of the text would not have been possible if it wasn't for her enduring love and support. I dedicate this edition to my family.

JPL

Acknowledgments and Dedication

Leslie E. Kendrick

John Lampignano has eloquently acknowledged many outstanding individuals from the worlds of medical imaging and publishing. I sincerely echo his appreciation and recognition that this ninth edition has been made possible with the minds and hands of many. Being part of the realm of medical imaging with so many amazing professionals is an incredible honor. We not only have unfaltering dedication and compassion for our patients, but we also share tremendous respect and regard for each other as health care professionals and friends. I take this opportunity to give back to the profession as the co-author of this textbook and ancillaries with utmost gratitude for the trust placed in my abilities.

I am especially grateful to Darlene Travis, O. Scott Staley, Duane McCrorie (rest in peace), and Lorrie Kelley for the high-quality education I received at Boise State University. You each freely shared your vast knowledge and expertise in the field of radiologic sciences. Thank you for fostering in me the passion and drive for life-long learning. To Joie Burns, a special thanks for your continued support as an invaluable resource of knowledge, a colleague, and a mentor. You each stand as a pillar of greatness in the field. It is truly an honor to have been your student and now a colleague.

I also thank my loving family for their unfailing patience. My three youngest children, Atticus, Aubrie, and Livia, have endured many hours of mommy reading and writing to complete this ninth edition. Thank you for being so kind and understanding. I also thank my incredible husband, Travis, for recognizing the honor of my participation in this project and supporting my insatiable desire to get it right. Words cannot express the pride I feel when I reflect on my family: seven beautiful children—each talented, kind, and a blessing to those around them: CJ, Ren, Robyn, Kade, Atticus, Aubrie, and Livia; four lovely grandchildren—each filled with wonder and delight: Fox, Killian, Kellen, and Charlotte; one amazing husband who loves me unconditionally and makes my life complete. There aren't enough words to express even a drop of the joy you each bring to me. Thank you for sharing so much of yourselves.

Lastly, thank you to John Lampignano for entrusting this co-authorship to me. The honor to be part of this project is something I never imagined, but I accept it with humility and respect. The first time I met John, I was impressed by his professionalism and poise. To now be his colleague is an incredible privilege. I will work hard to uphold the standards set by Kenneth Bontrager and now John for this textbook and ancillaries. I will continue to recognize the value of collaboration with professionals across the United States and world to ensure quality and accuracy. I encourage communication from all readers of these materials on how to improve and better meet the needs of the users. It is our goal to be an invaluable resource for educators, students, and imaging professionals.

LEK

This page intentionally left blank

Contributors

Joie Burns, MS, RT(R)(S), RDMS, RVT
Chapter 20
Diagnostic Medical Sonography Program Director
Radiologic Sciences
Boise State University
Boise, Idaho

Mary J. Carrillo, MBA/HCM, RT(R)(M), CDT
Chapter 20
Medical Radiography Program Director
Health Sciences
GateWay Community College
Phoenix, Arizona;
Mammographer
SimonMed Imaging
Mesa, Arizona

Jeanne Dial, MEd, CNMT, RSO
Chapter 20
Nuclear Medicine Technology Program Director
Health Sciences
GateWay Community College
Phoenix, Arizona

Cheryl DuBose, EdD, RT(R)(MR)(CT)(QM)
Chapter 20
CT/MRI Program Director
Arkansas State University
Jonesboro, Arkansas

Frank Goerner, PhD, DABR
Chapter 1
Medical Physicist
Medical Physics
The Queens Medical Center
Honolulu, Hawaii

Michele L. Gray-Murphy, BSRS, RT(R)(M)(ARRT)
Chapter 11
Associate of Science in Radiography Program Faculty
Allen College–UnityPoint Health
Waterloo, Iowa

Kelli Welch Haynes, MSRS, RT(R)
Chapter 3
Program Director and Associate Professor
Allied Health
Northwestern State University
Shreveport, Louisiana

Chad Hensley, MEd, RT(R)(MR)
Chapter 16
Clinical Coordinator
Radiography
University of Nevada–Las Vegas
Las Vegas, Nevada

Nicolle M. Hightower, MEd, RT(R)(VI)
Chapter 17
Diagnostic Medical Imaging Faculty and Clinical Coordinator
Health Sciences
GateWay Community College
Phoenix, Arizona

Julia Jacobs, MBA, RT(R)(T)
Chapter 20
Program Director
Radiation Therapy
GateWay Community College
Phoenix, Arizona

Bradley D. Johnson, MEd, RT(R)(ARRT)
Chapters 15 and 19
Faculty
Medical Radiography
GateWay Community College
Phoenix, Arizona

Nancy Johnson, MEd, RT(R)(CV)(CT)(QM)(ARRT), FASRT
Chapters 2 and 4
Dean of Professional and Technical Education
GateWay Community College
Phoenix, Arizona

Derek Lee, BS, CNMT, PET
Chapter 20
Lead Nuclear Medicine Technologist
Nuclear Medicine & PET/CT
Phoenix VA Medical Center
Phoenix, Arizona;
Adjunct Faculty
Nuclear Medicine Technology Program
GateWay Community College
Phoenix, Arizona

Beth L. Vealé, BSRS, MEd, PhD, RT(R)(QM)
Chapter 7
Professor
Radiologic Sciences
Midwestern State University
Wichita Falls, Texas

Patti Ward, PhD, RT(R)
Chapters 8 and 9
Professor
Program Director, Radiologic Technology
Colorado Mesa University
Grand Junction, Colorado

Christopher I. Wertz, MSRS, RT(R)
Chapter 6
Program Director, Assistant Professor
Radiographic Science
Idaho State University
Pocatello, Idaho

Andrew Woodward, MA, RT(R)(CT)(QM)
Chapters 1 and 18
Assistant Professor
Radiologic Sciences
University of North Carolina at Chapel Hill
Chapel Hill, North Carolina

Contributors to Past Editions

Barry T. Anthony, RT(R)
Englewood, Colorado

Patrick Apfel, MEd, RT(R)
Las Vegas, Nevada

April Apple, RT(R)
Durham, North Carolina

Alex Backus, MS, RT(R)
Phoenix, Arizona

Daniel J. Bandy, MS, CNMT
Phoenix, Arizona

Kristi Blackhurst, BS, RT(R)(MR)
Gilbert, Arizona

Karen Brown, RT(R)
Phoenix, Arizona

Claudia Calandrino, MPA, RT(R)
Los Angeles, California

Timothy C. Chapman, RT(R)(CT)
Phoenix, Arizona

Donna Davis, MEd, RT(R)(CV)
Little Rock, Arkansas

Nancy L. Dickerson, RT(R)(M)
Rochester, Minnesota

Eugene D. Frank, MA, RT(R), FASRT, FAERS
Rochester, Minnesota

Richard Geise, PhD, FACR, FAAPM
Minneapolis, Minnesota

Cecilie Godderidge, BS, RT(R)
Boston, Massachusetts

Jeannean Hall-Rollins, MRC, BS, RT(R)(CV)
Jonesboro, Arkansas

Jessie R. Harris, RT(R)
Los Angeles, California

W.R. Hedrick, PhD, FACR
Canton, Ohio

Dan L. Hobbs, MSRS, RT(R)(CT)(MR)
Pocatello, Idaho

Brenda K. Hoopingarner, MS, RT(R)(CT)
Hays, Kansas

Jenny A. Kellstrom, MEd, RT(R)
Klamath Falls, Oregon

Leslie E. Kendrick, MS, RT(R)(CT)(MR)
Boise, Idaho

Molly E. Lampignano, CNMT, PET
Phoenix, Arizona

Linda S. Lingar, MEd, RT(R)(M)
Little Rock, Arkansas

James D. Lipcamon, RT(R)
Torrance, California

Kathy M. Martensen, BS, RT(R)
Iowa City, Iowa

Cindy Murphy, BHSc, RT(R), ACR
Halifax, Nova Scotia, Canada

Kathleen Murphy, MBA, RDMS, RT(R)
Apache Junction, Arizona

Manjusha Namjoshi, BS, RDMS, RT(R)
Phoenix, Arizona

Sandra J. Nauman, RT(R)(M)
Austin, Minnesota

Joseph Popovitch, RT(R), ACR, DHSA
Halifax, Nova Scotia, Canada

E. Russel Ritenour, PhD
Minneapolis, Minnesota

Bette Schans, PhD, RT(R)
Grand Junction, Colorado

Mindy S. Shapiro, RT(R)(CT)
Tucson, Arizona

Katrina Lynn Steinsultz, BS, RT(R)(M)
Phoenix, Arizona

Marianne Tortorici, EdD, RT(R)
San Diego, California

Renee F. Tossell, PhD, RT(R)(M)(CV)
Phoenix, Arizona

Beth L. Vealé, BSRS, MEd, PhD, RT(R)(QM)
Wichita Falls, Texas

Patti Ward, PhD, RT(R)
Grand Junction, Colorado

Charles R. Wilson, PhD, FAAPM, FACR
Milwaukee, Wisconsin

Donna L. Wright, EdD, RT(R)
Wichita Falls, Texas

Linda Wright, MHSA, RT(R)
Denver, Colorado

Reviewers

Alberto Bello, MEd, RT(R)(CV)
Director of Medical Imaging
Danville Area Community College
Danville, Illinois

Britni Hardy, MHA, RSO, RT(R)
Radiologic Technology Program Director
Lake Superior College
Duluth, Minnesota

Joel Hicks, EdD, RT(R)
Associate Professor
Northwestern State University
School of Allied Health
Shreveport, Louisiana

Veronica C. Manning, EdS, RT(R)(M)
Assistant Professor / Clinical Coordinator
Medical Imaging & Radiation Sciences
Arkansas State University
Jonesboro, Arkansas

Quentin T. Moore, MPH, RT(R)(T)(QM)
Program Director
Bachelor of Science in Medical Imaging and Associate of Science in Radiologic Technology
Mercy College of Ohio
Toledo, Ohio

This page intentionally left blank

Preface

Purpose and Goal of the Ninth Edition

The ninth edition of Bontrager's Textbook of Radiographic Positioning and Related Anatomy is a one-volume reference that provides the essential knowledge for the student in radiographic positioning. Positioning remains as one of the critical variables in medical radiography that is solely in the hands of the technologist. Proper positioning displays anatomy and pathology correctly to enable the radiologist and other physicians to make an accurate diagnosis. In many respects, the patient's health and well-being is in the hands of the technologist. The authors and contributors had this goal in mind as we made the revisions for the ninth edition. Each position and procedure were carefully evaluated to provide the most accurate information for the student and practicing technologist. Our goals were to be accurate, use language that was easy to follow, and observe current practices for reducing dose to the patient and technologist. Our aim was to continue this format in the Workbook, Handbook, and web-based resources.

We hope we have met these goals. We continue to be open to your feedback and suggestions to make this text and its ancillaries more accurate and valuable resources.

Methodology

We apply the principle of presenting information from simple to complex, from known to unknown, and we provide diagrams and images to illustrate these concepts. The chapters are arranged to first describe the more basic radiographic procedures and proceed to the more complex ones in later chapters. This method is continued in the format of the Workbook and Handbook as well.

New to This Latest Edition

- Chapter 1, *Terminology, Positioning, and Imaging Principles* contains examples of terminology, basic principles, both analog and digital system imaging, grids, radiographic quality factors, and radiation protection that provide a central resource for these principles and concepts. Information on analog and digital radiographic concepts has been updated and reflects current practices. The chapter on radiation protection was edited to stress national initiatives such as ImageGently® and ImageWisely®. One distinct change is the use of portrait and landscape (rather than lengthwise and crosswise) to describe image receptor alignment. The terms lengthwise and crosswise have been eliminated from this edition.
- Chapter 15, *Trauma, Mobile, and Surgical Radiography* was revised extensively to focus on key concepts of mobile, trauma and surgical radiography. In doing so, we retained key concepts while eliminating procedures no longer performed.
- Chapter 16, *Pediatric Radiography* has been updated to reflect best practices in reducing dose to young patients. ImageGently® principles are stressed in this chapter and Chapter 1.
- Chapter 17, *Angiography and Interventional Procedures* has new art and photographs added to illustrate current procedures and angiographic devices currently seen in clinical practice.
- Chapter 18, *Computed Tomography* was revised to reflect the newest technology available. New procedures and current CT technology was added in this chapter.
- The ninth edition follows closely the procedures and positioning concepts required by the American Registry of Radiologic Technologists (ARRT) Content Specifications for the Radiography Examination.
- Over 250 positioning photographs have been replaced in the ninth edition. A different perspective was used with these photos. They demonstrate close-ups of the positioning model so students and technologists can better view positioning landmarks, CR centering points, and collimation. We hope this makes the art of positioning easier for the students first learning these positions.
- New images have been added throughout the ninth edition. We replaced many analog film-based images with digital versions. Several of the commercial medical imaging companies graciously allowed us to use their images for this edition.
- Digital imaging continues to be emphasized in the ninth edition. Terminology, technical factors, part centering, and kV ranges are described with a primary focus on digital systems.
- kV ranges have been reviewed by experts in the field to ensure they are consistent with current practice and will provide the most diagnostic images while reducing patient dose.
- Consistent positioning terminology is used throughout the Textbook, Workbook, and Handbook. Projection names are used that are formally recognized in the profession. All projections match those stated in the ARRT Content Specifications in Radiography.
- Twenty chapters. The number of chapters for the ninth edition remains 20 chapters. To keep the size and page count of the text to a reasonable size, we kept this edition to the relative size of the previous edition. The body of knowledge in medical imaging continues to grow exponentially. This edition provides the most essential concepts in radiographic anatomy and positioning while keeping the size and weight of this text consistent with past editions.
- The authors and contributors believe the changes and improvements in this latest edition will enhance learning and reflect current clinical practice.

Ancillaries

WORKBOOK

This edition contains new learning-exercise and self-test questions, including more situation-based questions and new questions on digital imaging. All questions have been reviewed by a team of educators and students to ensure the accuracy of the content and answers.

EVOLVE INSTRUCTOR RESOURCES

A computerized test bank is available on Evolve to instructors who use this textbook in their classrooms. The test bank features over 1200 questions. They include registry-type questions, which can be used as final evaluation exams for each chapter, or they can be put into custom exams that educators create. These tests can be administered as either computer- or print-based assessments, and are available in ExamView format.

Also available on Evolve is an electronic image collection featuring over 2700 images that are fully coordinated with the ninth edition Textbook and Workbook. Instructors can create their own customized classroom presentations using these electronic images, which closely follow the Textbook and Workbook, chapter by chapter. Faculty can download these images into web-based and PowerPoint applications.

The Evolve Instructor Resources also provide a complete PowerPoint presentation that correlates with the Textbook.

HANDBOOK

The new ninth edition revised pocket Handbook, also authored by John Lampignano and Leslie Kendrick, is now available from Elsevier as one of the ancillary components along with student workbooks and an electronic image collection for a complete current student resource on radiographic positioning.

MOSBY'S RADIOGRAPHY ONLINE

Mosby's Radiography Online: Anatomy and Positioning for Bontrager's Textbook of Radiographic Positioning and Related Anatomy is a unique online courseware program that promotes problem-based learning with the goal of developing critical thinking skills that will be needed in the clinical setting. Developed to be used in conjunction with the Lampignano/Kendrick Textbook and Workbook, the online course enhances learning with animations and interactive exercises and offers application opportunities that can accommodate multiple learning styles and circumstances.

How to Use the Positioning Pages

1 PROJECTION TITLE BARS describe the specific position/projection to be radiographed, including the proper name of the position, if such applies.

2 CLINICAL INDICATIONS section summarizes conditions or pathologies that may be demonstrated by the examination and/or projection. This brief review helps the technologist understand the purpose of the examination and which structures or tissues should be most clearly demonstrated.

3 PROJECTION SUMMARY BOXES list all the specific routine or special projections most commonly performed for that body part.

4 TECHNICAL FACTORS section includes the image receptor (IR) size recommended for the average adult; whether the IR should be placed portrait or landscape in relation to the patient; a grid, if one is needed; and the kV range for analog and digital systems. The minimum SID (source-to-image receptor distance) is listed.

5 IMAGE RECEPTOR ICONS give a visual display of the IR relative size (cm) and orientation (portrait or landscape), relative collimated field size, location of R and L markers, and the recommended AEC cell location (if AEC is used).

6 SHIELDING section describes shielding that should be used for the projection.

7 PATIENT POSITION section indicates the general body position required for the projection.

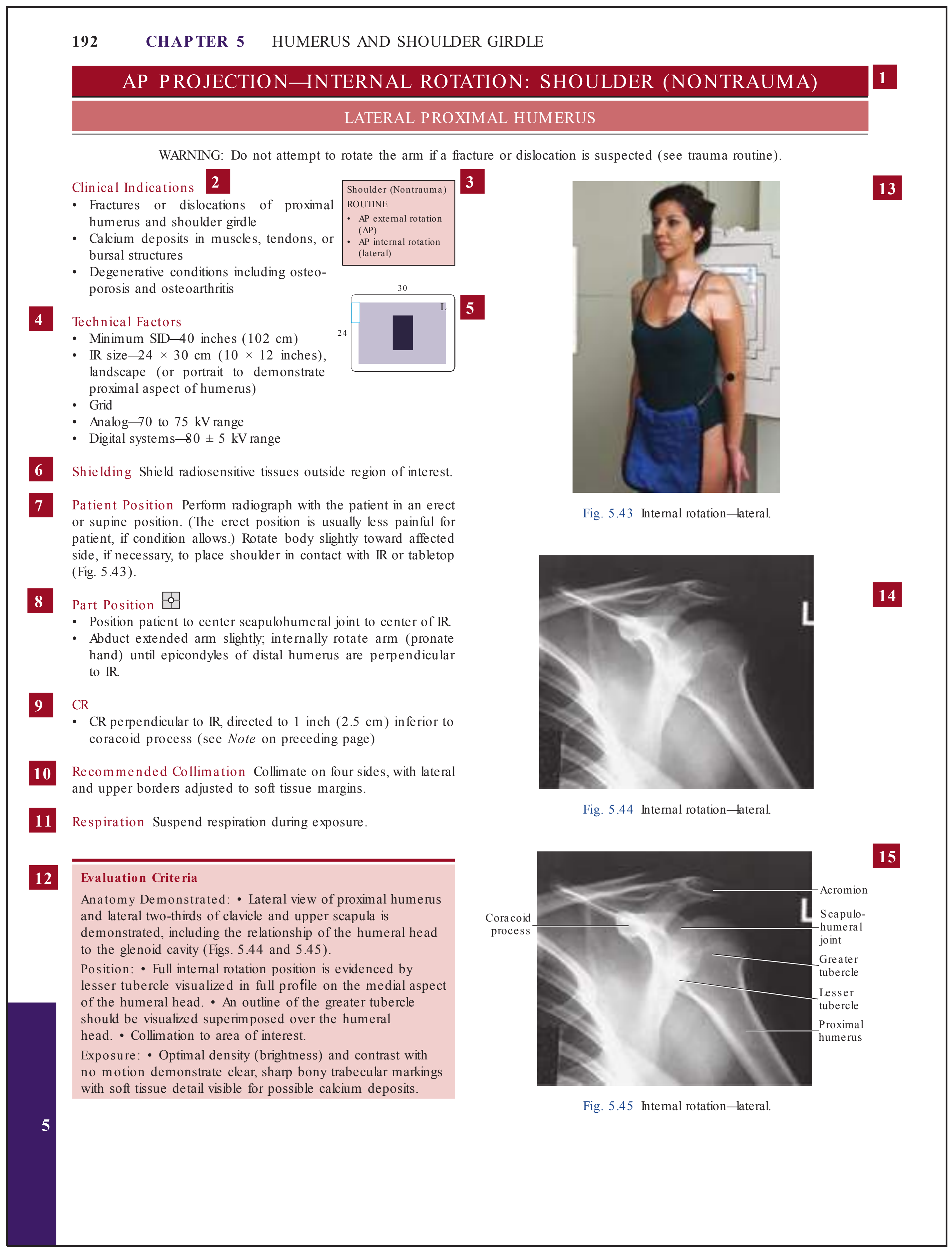
8 PART POSITION section gives a clear, step-by-step description of how the body part should be positioned in relation to the IR and/or tabletop. The CR icon is included for all those projections in which the CR is of primary importance to remind the technologist to pay special attention to the CR during the positioning process for that projection.

9 CENTRAL RAY (CR) section describes the precise location of the CR in relation to both the IR and the body part.

10 RECOMMENDED COLLIMATION section describes the collimation of the x-ray field recommended for that projection.

11 RESPIRATION section lists the breathing requirements for that projection.

12 EVALUATION CRITERIA boxes describe evaluation/critique process that should be completed for each processed radiographic image. This process is divided into the following three broad categories: (1) anatomy demonstrated, (2) position, (3) exposure.


192 CHAPTER 5 HUMERUS AND SHOULDER GIRDLE

AP PROJECTION—INTERNAL ROTATION: SHOULDER (NONTRAUMA) 1

LATERAL PROXIMAL HUMERUS

WARNING: Do not attempt to rotate the arm if a fracture or dislocation is suspected (see trauma routine).

Clinical Indications 2
- Fractures or dislocations of proximal humerus and shoulder girdle
- Calcium deposits in muscles, tendons, or bursal structures
- Degenerative conditions including osteoporosis and osteoarthritis

3 Shoulder (Nontrauma) ROUTINE
- AP external rotation (AP)
- AP internal rotation (lateral)

5 (30, 24, L)

4 Technical Factors
- Minimum SID—40 inches (102 cm)
- IR size—24 × 30 cm (10 × 12 inches), landscape (or portrait to demonstrate proximal aspect of humerus)
- Grid
- Analog—70 to 75 kV range
- Digital systems—80 ± 5 kV range

6 Shielding Shield radiosensitive tissues outside region of interest.

7 Patient Position Perform radiograph with the patient in an erect or supine position. (The erect position is usually less painful for patient, if condition allows.) Rotate body slightly toward affected side, if necessary, to place shoulder in contact with IR or tabletop (Fig. 5.43).

8 Part Position
- Position patient to center scapulohumeral joint to center of IR.
- Abduct extended arm slightly; internally rotate arm (pronate hand) until epicondyles of distal humerus are perpendicular to IR.

9 CR
- CR perpendicular to IR, directed to 1 inch (2.5 cm) inferior to coracoid process (see *Note* on preceding page)

10 Recommended Collimation Collimate on four sides, with lateral and upper borders adjusted to soft tissue margins.

11 Respiration Suspend respiration during exposure.

12 Evaluation Criteria

Anatomy Demonstrated: • Lateral view of proximal humerus and lateral two-thirds of clavicle and upper scapula is demonstrated, including the relationship of the humeral head to the glenoid cavity (Figs. 5.44 and 5.45).

Position: • Full internal rotation position is evidenced by lesser tubercle visualized in full profile on the medial aspect of the humeral head. • An outline of the greater tubercle should be visualized superimposed over the humeral head. • Collimation to area of interest.

Exposure: • Optimal density (brightness) and contrast with no motion demonstrate clear, sharp bony trabecular markings with soft tissue detail visible for possible calcium deposits.

13

Fig. 5.43 Internal rotation—lateral.

14

Fig. 5.44 Internal rotation—lateral.

15

Fig. 5.45 Internal rotation—lateral.

5

13 POSITIONING PHOTOGRAPHS shows a correctly positioned patient and part in relation to the CR and IR.

14 RADIOGRAPHIC IMAGES provide an example of a correctly positioned and correctly exposed radiographic image of the featured projection.

15 ANATOMY LABELED IMAGES identify specific anatomy that should be demonstrated on the radiographic image shown. The labeled image, in most cases, matches the radiographic image example on the same page.

This page intentionally left blank

Contents

This page intentionally left blank

CHAPTER 1

Terminology, Positioning, and Imaging Principles

CONTRIBUTIONS BY Andrew Woodward, MA, RT(R)(CT)(QM)

RADIATION PROTECTION CONTRIBUTOR Frank Goerner, PhD, DABR

CONTRIBUTORS TO PAST EDITIONS W. R. Hedrick, PhD, FACR, Cindy Murphy, BHSc, RT(R), ACR, Joseph Popovitch, RT(R), ACR, DHSA, Kathy M. Martensen, BS, RT(R), Barry T. Anthony, RT(R), Katrina Lynn Steinsultz, BS, RT(R)(M)

RADIATION PROTECTION PAST CONTRIBUTORS Richard Geise, PhD, FACR, FAAPM, E. Russel Ritenour, PhD

CONTENTS

1

PART THREE: RADIATION PROTECTION

PART ONE ▪ TERMINOLOGY and POSITIONING

GENERAL, SYSTEMIC, AND SKELETAL ANATOMY AND ARTHROLOGY

General Anatomy

Anatomy is the study, classification, and description of the structure and organs of the human body, whereas physiology deals with the processes and functions of the body, or how the body parts work. In the living subject, it is almost impossible to study anatomy without also studying some physiology. However, radiographic study of the human body is primarily a study of the anatomy of the various systems, with less emphasis on the physiology. Consequently, anatomy of the human system is emphasized in this radiographic anatomy and positioning textbook.

NOTE: Phonetic respelling[1] of anatomic and positioning terms is included throughout this text to facilitate correct pronunciation of the terms commonly used in medical radiography.

STRUCTURAL ORGANIZATION

Several levels of structural organization make up the human body. The lowest level of organization is the **chemical** level. All chemicals necessary for maintaining life are composed of **atoms**, which are joined in various ways to form **molecules**. Various chemicals in the form of molecules are organized to form **cells**.

Cells

The cell is the basic structural and functional unit of all living tissue. Every single part of the body, whether muscle, bone, cartilage, fat, nerve, skin, or blood, is composed of cells.

Tissues

Tissues are cohesive groups of similar cells that, together with their intercellular material, perform a specific function. The four basic types of tissue are as follows:

1. *Epithelial* (ep″-i-the′le-al): Tissues that cover internal and external surfaces of the body, including the lining of vessels and organs, such as the stomach and the intestines
2. *Connective:* Supportive tissues that bind together and support various structures
3. *Muscular:* Tissues that make up the substance of a muscle
4. *Nervous:* Tissues that make up the substance of nerves and nerve centers

Organs

When complex assemblies of tissues are joined to perform a specific function, the result is an organ. Organs usually have a specific shape. Examples of organs of the human body are the kidneys, heart, liver, lungs, stomach, and brain.

System

A system consists of a group or an association of organs that have a similar or common function. The urinary system, consisting of the kidneys, ureters, bladder, and urethra, is an example of a body system. The total body comprises 10 **individual** body systems.

Organism

The 10 systems of the body when functioning together make up the total organism—one living being (Fig. 1.1).

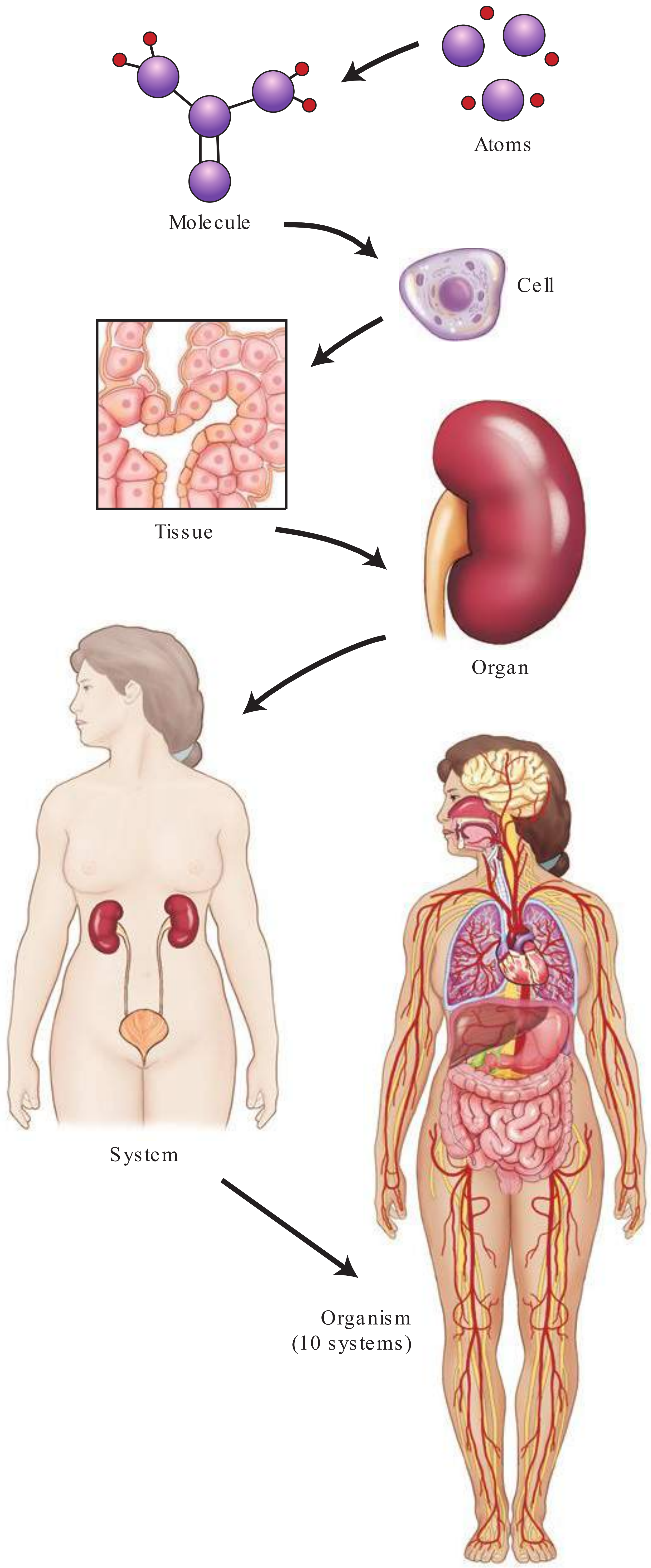


Fig. 1.1 Levels of human structural organization.

Systemic Anatomy

BODY SYSTEMS

The human body is a structural and functional unit made up of 10 lesser units called systems. These 10 systems include (1) skeletal, (2) circulatory, (3) digestive, (4) respiratory, (5) urinary, (6) reproductive, (7) nervous, (8) muscular, (9) endocrine, and (10) integumentary (in-teg″-u-men′-tar-e).

Skeletal System

The skeletal system (Fig. 1.2) is important for the technologist to learn. The skeletal system includes the 206 separate bones of the body and their associated cartilages and joints. The study of bones is termed osteology, whereas the study of joints is called arthrology.

The four functions of the skeletal system are as follows:

1. Support and protect many soft tissues of the body
2. Allow movement through interaction with the muscles to form a system of levers
3. Produce blood cells
4. Store calcium

Fig. 1.2 Skeletal system.

Circulatory System

The circulatory system (Fig. 1.3) is composed of the following:

- The cardiovascular organs—heart, blood, and blood vessels
- The lymphatic system—lymph nodes, lymph vessels, lymph glands, and spleen

The six functions of the circulatory system are as follows:

1. Distribute oxygen and nutrients to the cells of the body
2. Transport cell waste and carbon dioxide from the cells
3. Transport water, electrolytes, hormones, and enzymes
4. Protect against disease
5. Prevent hemorrhage by forming blood clots
6. Assist in regulating body temperature

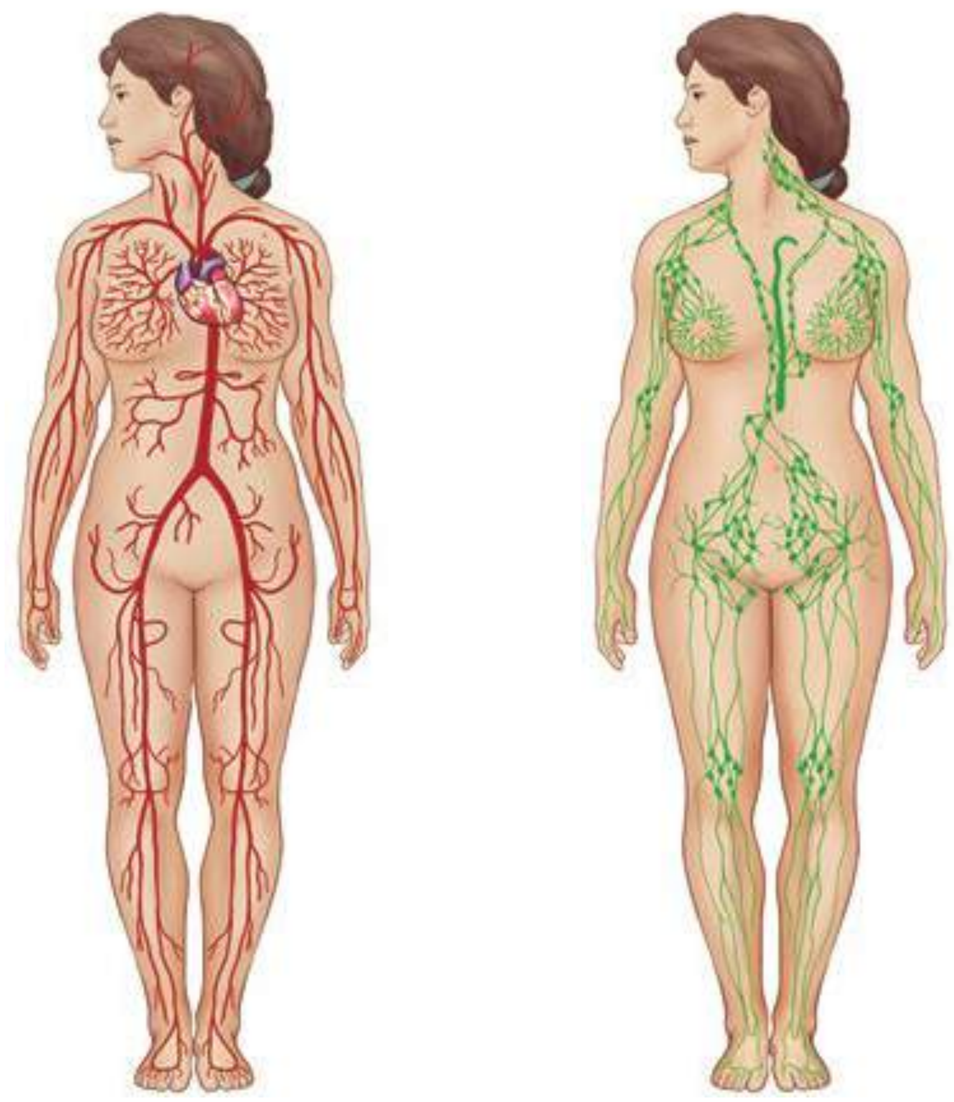


Fig. 1.3 Circulatory system.

Digestive System

The digestive system includes the alimentary canal and certain accessory organs (Fig. 1.4). The alimentary canal is made up of the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus. Accessory organs of digestion include the salivary glands, liver, gallbladder, and pancreas.

The twofold function of the digestive system is as follows:

1. Prepare food for absorption by the cells through numerous physical and chemical breakdown processes
2. Eliminate solid wastes from the body

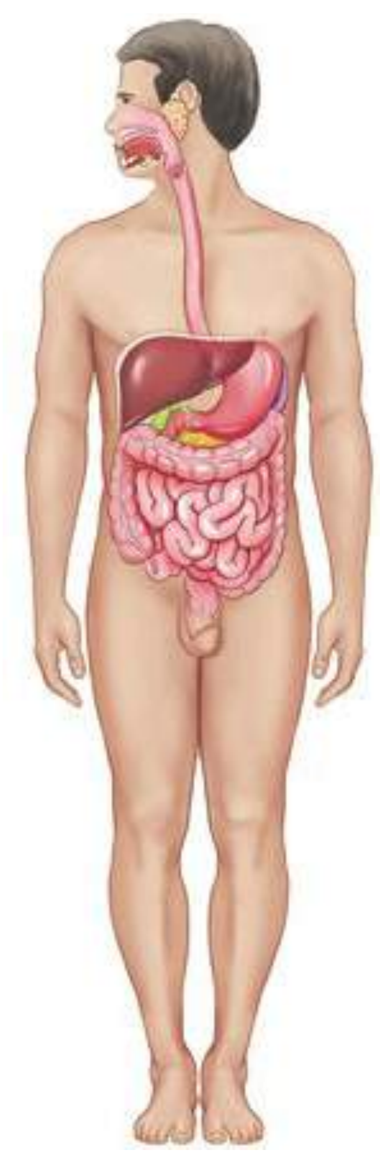


Fig. 1.4 Digestive system.

Respiratory System

The respiratory system is composed of two lungs and a series of passages that connect the lungs to the outside atmosphere (Fig. 1.5). The structures that make up the passageway from the exterior to the alveoli of the lung interior include the nose, mouth, pharynx, larynx, trachea, and bronchial tree.

The three primary functions of the respiratory system are as follows:

1. Supply oxygen to the blood and eventually to the cells
2. Eliminate carbon dioxide from the blood
3. Assist in regulating the acid-base balance of the blood

Fig. 1.5 Respiratory system.

Urinary System

The urinary system includes the organs that produce, collect, and eliminate urine. The organs of the urinary system consist of the kidneys, ureters, bladder, and urethra (Fig. 1.6).

The four functions of the urinary system are as follows:

1. Regulate the chemical composition of the blood
2. Eliminate many waste products
3. Regulate fluid and electrolyte balance and volume
4. Maintain the acid-base balance of the body

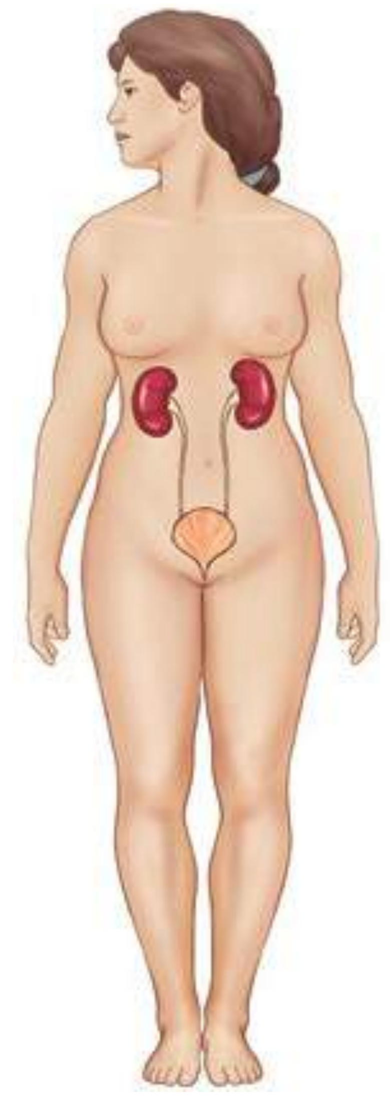


Fig. 1.6 Urinary system.

Reproductive System

The reproductive system is made up of organs that produce, transport, and store the germ cells (Fig. 1.7). The testes in the male and the ovaries in the female produce mature germ cells. Transport and storage organs of the male include the vas deferens, prostate gland, and penis. The organs of reproduction in the female are the ovaries, uterine (fallopian) tubes, uterus, and vagina (see Fig. 1.7).

The function of the reproductive system is to reproduce the organism.

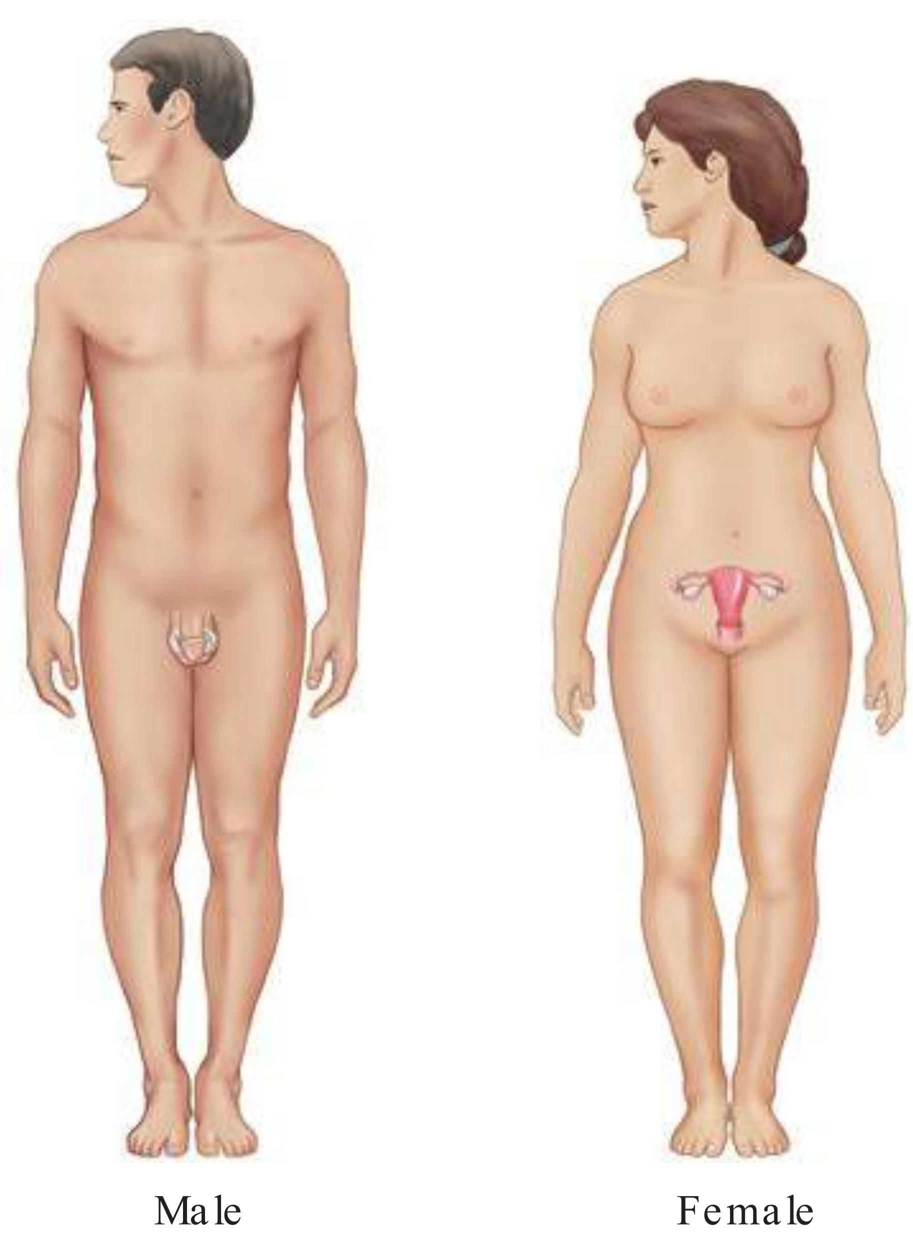


Fig. 1.7 Reproductive system.

Nervous System

The nervous system is composed of the brain, spinal cord, nerves, ganglia, and special sense organs such as the eyes and ears (Fig. 1.8).

The function of the nervous system is to coordinate voluntary and involuntary body activities and transmit electrical impulses to various parts of the body and the brain.

Fig. 1.8 Nervous system.

Muscular System

The muscular system (Fig. 1.9), which includes all muscle tissues of the body, is subdivided into three types of muscles: (1) skeletal, (2) smooth, and (3) cardiac.

Most of the muscle mass of the body is skeletal muscle, which is striated and under voluntary control. The voluntary muscles act in conjunction with the skeleton to allow body movement. About 43% of the weight of the human body is accounted for by voluntary or striated skeletal muscle.

Smooth muscle, which is involuntary, is located in the walls of hollow internal organs such as blood vessels, the stomach, and intestines. These muscles are called involuntary because their contraction usually is not under voluntary or conscious control.

Cardiac muscle is found only in the walls of the heart and is involuntary but striated.

The three functions of muscle tissue are as follows:

1. Allow movement, such as locomotion of the body or movement of substances through the alimentary canal
2. Maintain posture
3. Produce body heat

Fig. 1.9 Muscular system.

Endocrine System

The endocrine system includes all the ductless glands of the body (Fig. 1.10). These glands include the testes, ovaries, pancreas, adrenals, thymus, thyroid, parathyroid, pineal, and pituitary. The placenta acts as a temporary endocrine gland.

Hormones, which are the secretions of the endocrine glands, are released directly into the bloodstream.

The function of the endocrine system is to regulate bodily activities through the various hormones carried by the cardiovascular system.

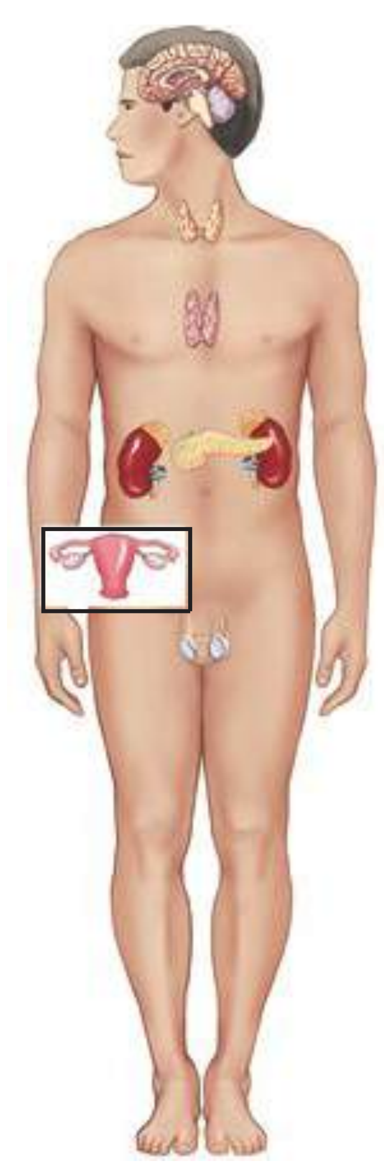


Fig. 1.10 Endocrine system.

1

Integumentary System

The tenth and final body system is the integumentary (in-teg″-u-men′-tar-e) system, which is composed of the skin and all structures derived from the skin (Fig. 1.11). These derived structures include hair, nails, and sweat and oil glands.

The skin is an organ that is essential to life. The skin is the largest organ of the body, covering a surface area of approximately 7620 cm^2 (3000 in^2) and constituting 8% of total body mass in the average adult.

The five functions of the integumentary system are as follows:

1. Regulate body temperature
2. Protect the body, within limits, against microbial invasion and mechanical, chemical, and ultraviolet (UV) radiation damage
3. Eliminate waste products through perspiration
4. Receive certain stimuli such as temperature, pressure, and pain
5. Synthesize certain vitamins and biochemicals such as vitamin D

Fig. 1.11 Integumentary system.

Skeletal Anatomy

Because a large part of general diagnostic radiography involves examination of the bones and joints, osteology (os″-te-ol′-o-je) (the study of bones) and arthrology (ar-throl′-o-je) (the study of joints) are important subjects for the technologist.

OSTEOLOGY

The adult skeletal system is composed of 206 separate bones, which form the framework of the entire body. Certain cartilages, such as those at the ends of long bones, are included in the skeletal system. These bones and cartilages are united by ligaments and provide surfaces to which the muscles attach. Because muscles and bones must combine to allow body movement, these two systems sometimes are collectively referred to as the locomotor system.

The adult human skeleton is divided into the axial skeleton and the appendicular skeleton.

Axial Skeleton

The axial (ak′-se-al) skeleton includes all bones that lie on or near the central axis of the body (Table 1.1). The adult axial skeleton consists of 80 bones and includes the skull, vertebral column, ribs, and sternum (the dark-shaded regions of the body skeleton in Fig. 1.12).

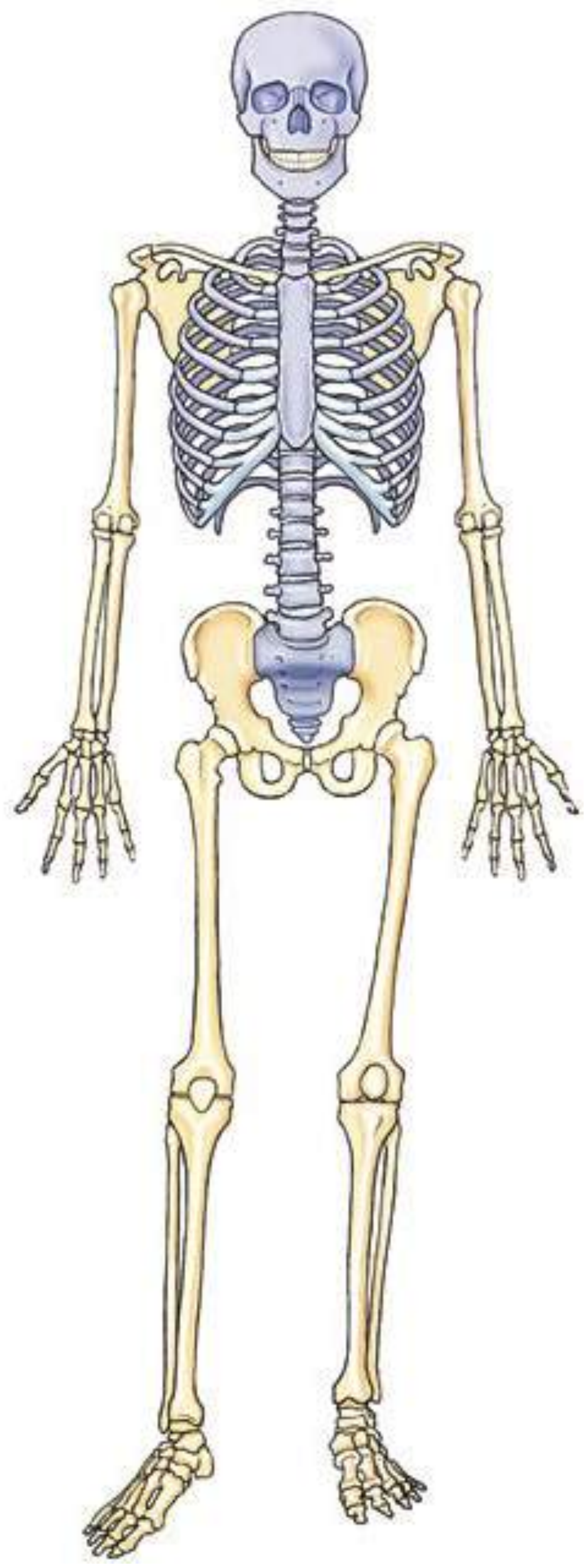


Fig. 1.12 Axial skeleton-80 bones.

TaBLE 1.1 ADULT AXIAL SKELETON

Skull	Cranium	8
	Facial bones	14
Hyoid		1
Auditory ossicles (3 small bones in each ear)		6
Vertebral column	Cervical	7
	Thoracic	12
	Lumbar	5
	Sacral	1
	Coccyx	1
Thorax	Sternum	1
	Ribs	24
Total bones in adult axial skeleton		80

Appendicular Skeleton

The second division of the skeleton is the **appendicular** (ap″-en-dik′-u-lar) portion. This division consists of all bones of the upper and lower limbs (extremities) and the shoulder and pelvic girdles (the dark-shaded regions in Fig. 1.13). The appendicular skeleton attaches to the axial skeleton. The adult appendicular skeleton comprises 126 **separate** bones (Table 1.2).

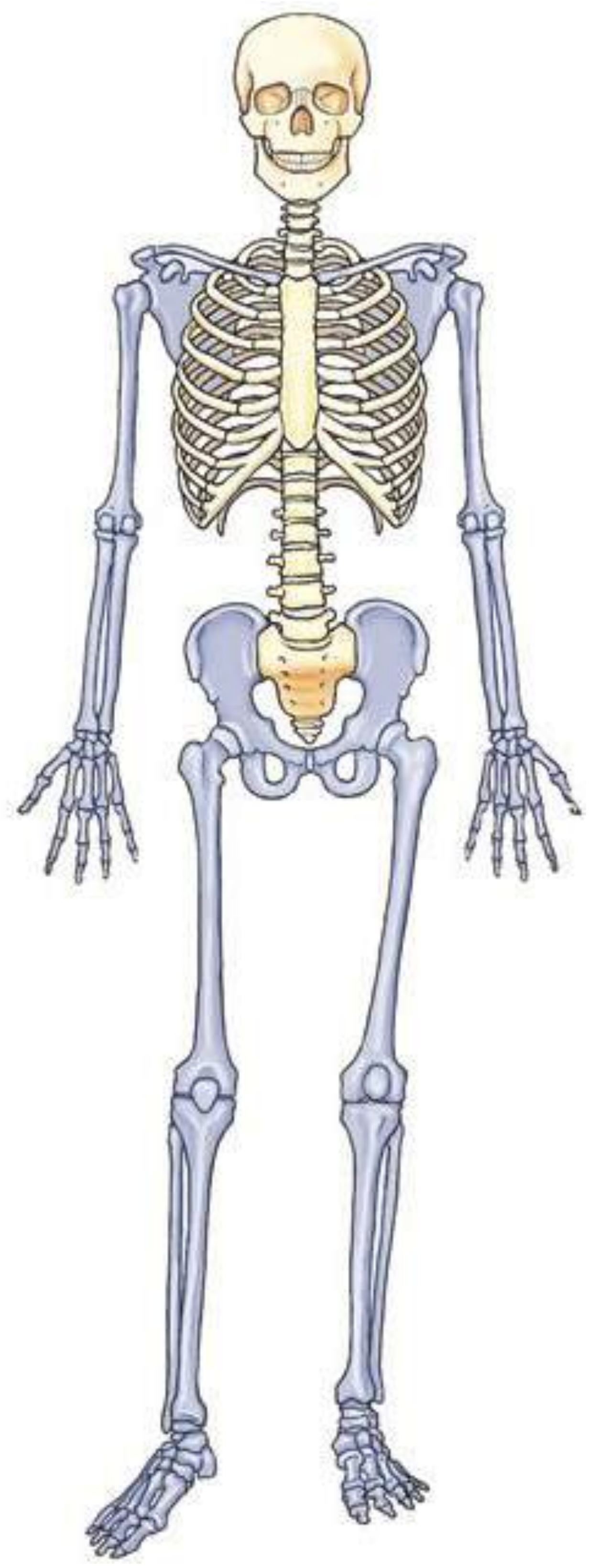


Fig. 1.13 Appendicular skeleton-126 bones.

TABLE 1.2 ADULT APPENDICULAR SKELETON

Shoulder girdles	Clavicles	2
	Scapula (scapulae)	2
Upper limbs	Humerus (humeri)	2
	Ulna (ulnae)	2
	Radius (radii)	2
	Carpals	16
	Metacarpals	10
	Phalanges	28
Pelvic girdle	Hip bones (**innominate** bones)	2
Lower limbs	Femur (femora)	2
	Tibia	2
	Fibula (fibulae)	2
	Patella (patellae)	2
	Tarsals	14
	Metatarsals	10
	Phalanges	28
Total bones in adult appendicular skeleton		126
Entire number of separate bones in adult skeleton*		206

*This includes the two sesamoid bones anterior to the knees: the right and left patellae.

Sesamoid Bones

A sesamoid bone is a special type of small, oval-shaped bone that is embedded in certain tendons (most often near joints). Although sesamoid bones are present even in a developing fetus, they are not counted as part of the normal axial or appendicular skeleton except for the two patellae, the largest sesamoid bones. The other most common sesamoid bones are located in the posterior foot at the base of the first toe (Figs. 1.14 and 1.15).

In the upper limb, sesamoid bones are found most commonly in tendons near the anterior (palmar) surface of the hand at the base of the thumb. Others may be found in tendons of other upper or lower limb joints.

Sesamoid bone may be fractured by trauma; sesamoid bones can be demonstrated radiographically or by CT (computed tomography).

Fig. 1.14 Sesamoid bones on the posterior base of the first toe.

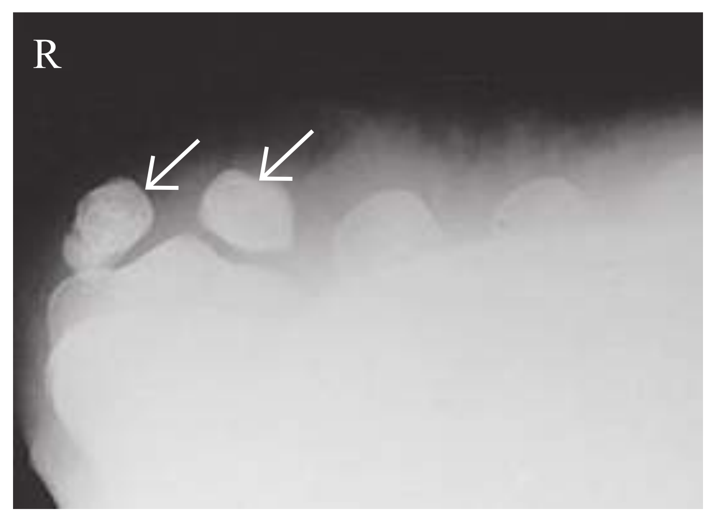


Fig. 1.15 Sesamoid bones. Tangential projection (base of first toe).

CLASSIFICATION OF BONES

Each of the 206 bones of the body can be classified according to shape as follows:

- Long bones
- Short bones
- Flat bones
- Irregular bones

Long Bones

Long bones consist of a **body** and two **ends** or extremities. Long bones are found only in the appendicular skeleton. (Fig. 1.16 is a radiograph of a humerus, a typical long bone of the upper arm.)

Fig. 1.16 Long bone (humerus).

Composition The outer shell of most bones is composed of hard or dense bone tissue known as **compact bone**, or **cortex**, meaning an external layer. Compact bone has few intercellular empty spaces and serves to protect and support the entire bone.

The **body** (older term is **shaft**) contains a thicker layer of compact bone than is found at the ends, to help resist the stress of the weight placed on them.

Inside the shell of compact bone and especially at both ends of each long bone is found **spongy**, or **cancellous**, **bone**. Cancellous bone is highly porous and usually contains red bone marrow, which is responsible for the production of red blood cells.

The body of a long bone is hollow. This hollow portion is known as the **medullary** (med′-u-lar″-e) **cavity**. In adults, the medullary cavity usually contains fatty yellow marrow. A dense fibrous membrane, the **periosteum** (per″-e-os′-te-am), covers bone except at the articulating surfaces. The articulating surfaces are covered by a layer of **hyaline cartilage** (Fig. 1.17).

Hyaline (hi′-ah-lin), meaning glassy or clear, is a common type of cartilage or connecting tissue that is also known as "gristle." Its name comes from the fact that it is not visible with ordinary staining techniques, and it appears "clear" or glassy in laboratory studies. It is present in many places, including within the covering over ends of bones, where it is called **articular cartilage**.

The **periosteum** is essential for bone growth, repair, and nutrition. Bones are richly supplied with blood vessels that pass into them from the periosteum. Near the center of the body of long bones, a **nutrient artery** passes obliquely through the compact bone via a **nutrient foramen** into the medullary cavity.

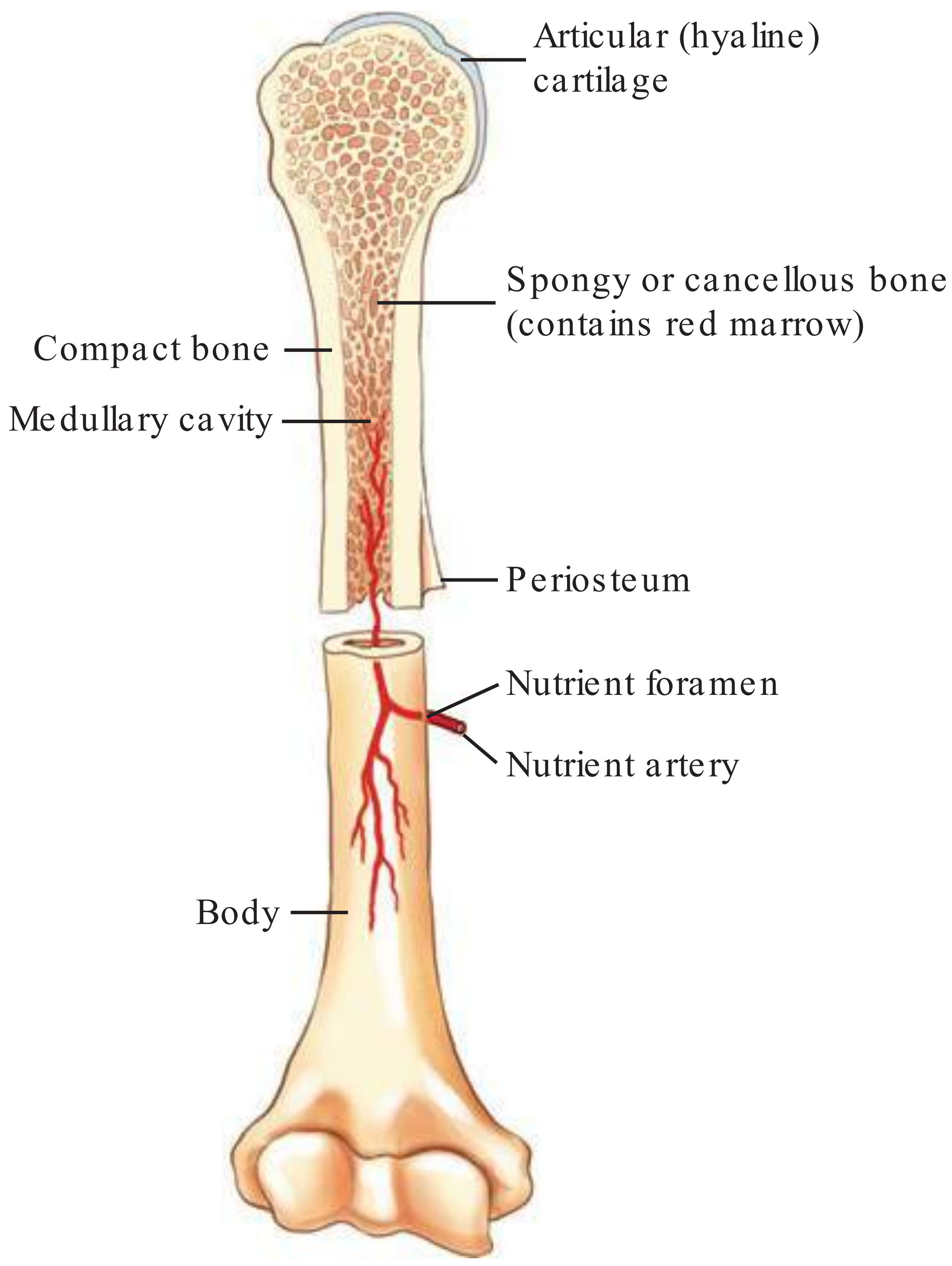


Fig. 1.17 Long bone.

Short Bones

Short bones are roughly cuboidal and are found only in the wrists and ankles. Short bones consist mainly of cancellous tissue with a thin outer covering of compact bone. The eight **carpal** bones of each wrist (Fig. 1.18) and the seven **tarsal** bones of each foot are short bones.

Fig. 1.18 Short bones (carpals).

Flat Bones

Flat bones consist of two plates of compact bone with cancellous bone and bone marrow between them. Examples of flat bones are the bones that make up the **calvaria** (skull cap) (Fig. 1.19), **sternum**, **ribs**, and **scapulae**.

Fig. 1.19 Flat bones (calvaria).

The narrow space between the two layers of compact bone of flat bones within the cranium is known as the diploe (dip′-lo-e). Flat bones provide protection for interior contents and broad surfaces for muscle attachment.

Irregular Bones

Bones that have peculiar shapes are lumped into one final category—irregular bones. **Vertebrae** (Fig. 1.20), **facial bones**, **bones of the base of the cranium**, and **bones of the pelvis** are examples of irregular bones.

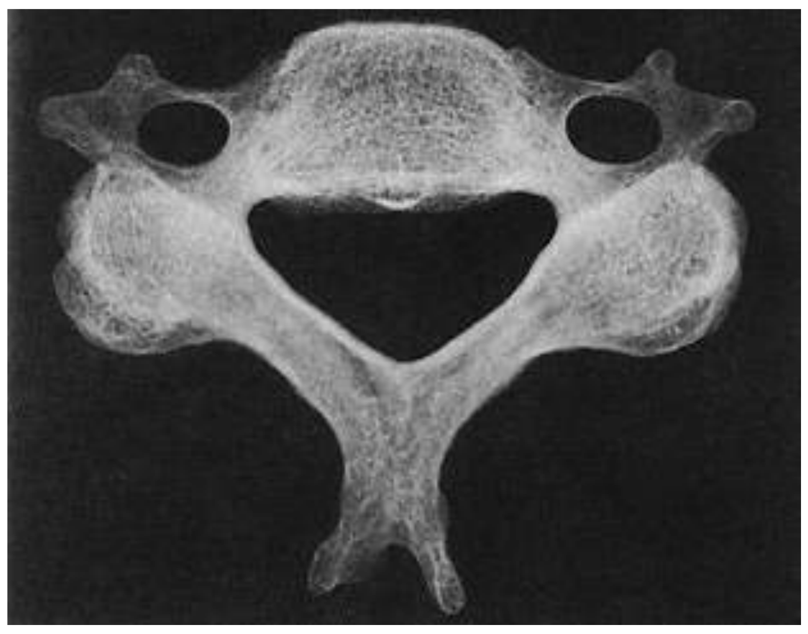


Fig. 1.20 Irregular bone (vertebra).

1

DEVELOPMENT OF BONES

The process by which bones form within the body is known as **ossification** (os″-i-*fi*-ka′-shun). The embryonic skeleton is composed of fibrous membranes and hyaline cartilage. Ossification begins at about the sixth embryonic week and continues until adulthood.

Blood Cell Production

In adults, **red blood** cells (RBCs) are produced by the red bone marrow of certain flat and irregular bones such as the **sternum**, **ribs**, **vertebrae**, and **pelvis**, as well as the ends of the long bones.

Bone Formation

Two types of bone formation are known. When bone replaces membranes, the ossification is called **intramembranous** (in″-trah-mem′-brah-nus). When bone replaces cartilage, the result is **endochondral** (en″-do-kon′-dral) (intracartilaginous) ossification.

Intramembranous Ossification Intramembranous ossification occurs rapidly and takes place in bones that are needed for protection, such as sutures of the flat bones of the calvaria (skullcap), which are centers of growth in early bone development.

Endochondral Ossification Endochondral ossification, which is much slower than intramembranous ossification, occurs in most parts of the skeleton, especially in the long bones.

Primary and Secondary Centers of Endochondral Ossification (Fig. 1.21)

The first center of ossification, which is called the **primary center**, occurs in the midbody area. This primary center of ossification in growing bones is called the **diaphysis** (di-af′-i-sis). This becomes the **body** in a fully developed bone.

Secondary centers of ossification appear near the ends of the limbs of long bones. Most secondary centers appear after birth, whereas most primary centers appear before birth. Each secondary center of ossification is called an epiphysis (e-pif′-i-sis). Epiphyses of the distal femur and the proximal tibia are the first to appear and may be present at birth in a term newborn. Cartilaginous plates, called **epiphyseal plates**, are found between the metaphysis and each epiphysis until skeletal growth is complete. The **metaphysis** is the wider portion of a long bone adjacent to the epiphyseal plate. The metaphysis is the area where bone growth in length occurs. Growth in the length of bones results from a longitudinal increase in these epiphyseal cartilaginous plates. This is followed by progressive ossification through endochondral bone development until all the cartilage has been replaced by bone, at which time growth to the skeleton is complete. This process of epiphyseal fusion of the long bones occurs progressively from the age of puberty to full **maturity**, which is between the ages of 20 to 25 years.[1] However, the time for each bone to complete growth varies for different regions of the body. On average, the female skeleton matures more quickly than the male skeleton. Also, geography, socioeconomic, genetic factors, and disease impacts epiphyseal fusion.[1]

Radiograph Demonstrating Bone Growth

Fig. 1.22 shows a radiograph of the knee region of a 6-year-old child. Primary and secondary centers of endochondral ossification or bone growth are well demonstrated and labeled.

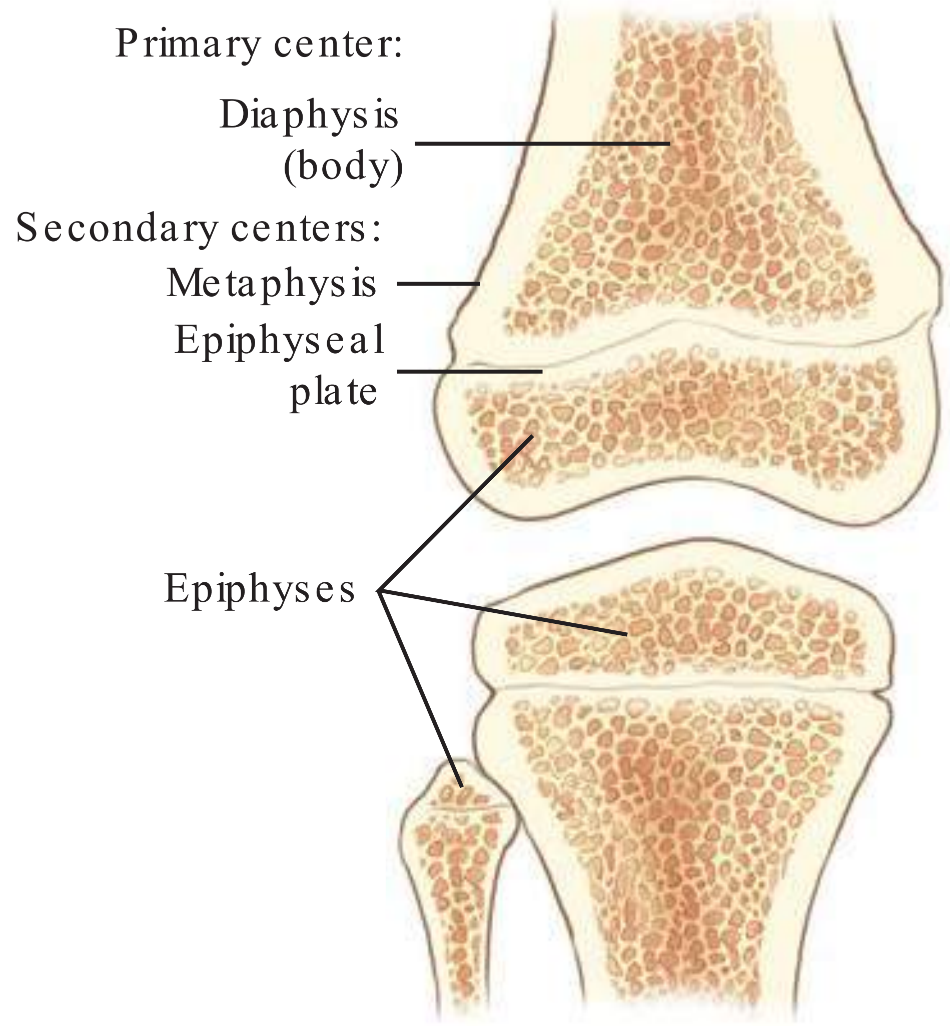


Fig. 1.21 Endochondral ossification.

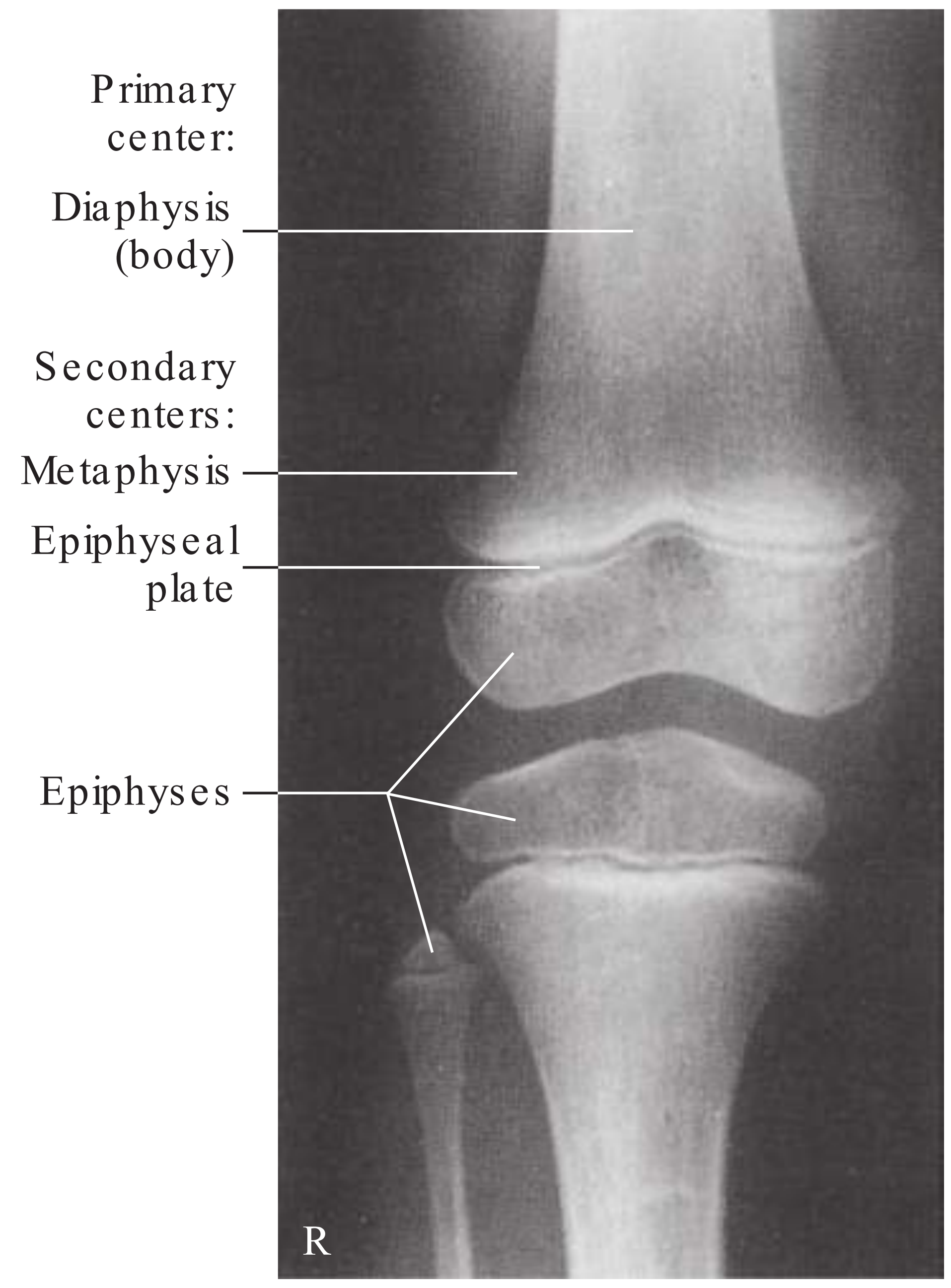


Fig. 1.22 Knee region (6-year-old child).

Arthrology (Joints)

The study of joints or articulations is called **arthrology**. It is important to understand that movement does not occur in all joints. The first two types of joints to be described are immovable joints and only slightly movable joints, which are held together by several fibrous layers, or cartilage. These joints are adapted for growth rather than for movement.

CLASSIFICATION OF JOINTS

Functional

Joints may be classified according to their function in relation to their mobility or lack of mobility as follows:

- **Synarthrosis** (sin″-ar-thro′-sis)—immovable joint
- **amphiarthrosis** (am″-fe-ar-thro′-sis)—joint with limited movement
- **diarthrosis** (di″-ar-thro′-sis)—freely movable joint

Structural

The primary classification system of joints, described in Gray's Anatomy[2] and used in this textbook, is a **structural classification** based on the **three** types of tissue **that separate** the **ends** of **bones** in the different joints. These three classifications by tissue type, along with their subclasses, are as follows:

1. Fibrous (*fi*′-brus) joints
   - Syndesmosis (sin″-des-mo′-sis)
   - Suture (su′-tur)
   - Gomphosis (gom-*fo*′-sis)
2. Cartilaginous (kar″-ti-laj′-i-nus) joints
   - Symphysis (sim′-*fi*-sis)
   - Synchondrosis (sin″-kon-dro′-sis)
3. Synovial (si-no′-ve-al) joints

Fibrous Joints

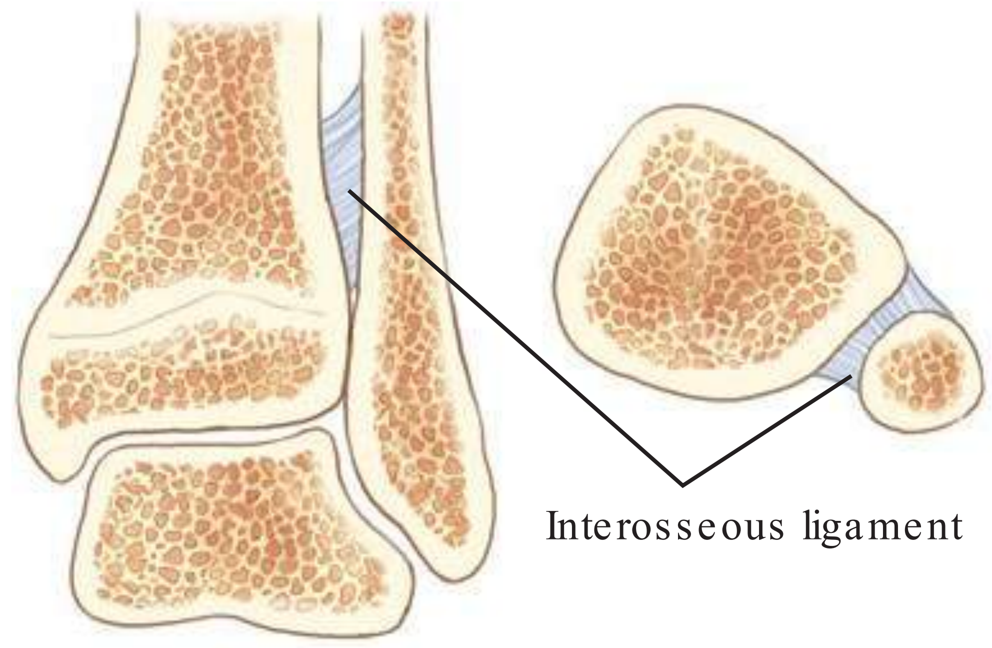
Fibrous joints lack a joint cavity. The adjoining bones, which are nearly in direct contact with each other, are held together by fibrous connective tissue. Three types of fibrous joints are syndesmoses, which are slightly movable; sutures, which are immovable; and gomphoses, a unique type of joint with only very limited movement (Fig. 1.23).

1. Syndesmoses[1] Syndesmoses are fibrous types of articulations that are held together by interosseous ligaments and slender fibrous cords that allow slight movement at these joints. Some earlier references restricted the fibrous syndesmosis classification to the inferior tibiofibular joint. However, fibrous-type connections also may occur in other joints, such as the sacroiliac junction with its massive interosseous ligaments that in later life become almost totally fibrous articulations. The carpal and tarsal joints of the wrist and foot also include interosseous membranes that can be classified as syndesmosis-type joints that are only slightly movable, or amphiarthrodial.

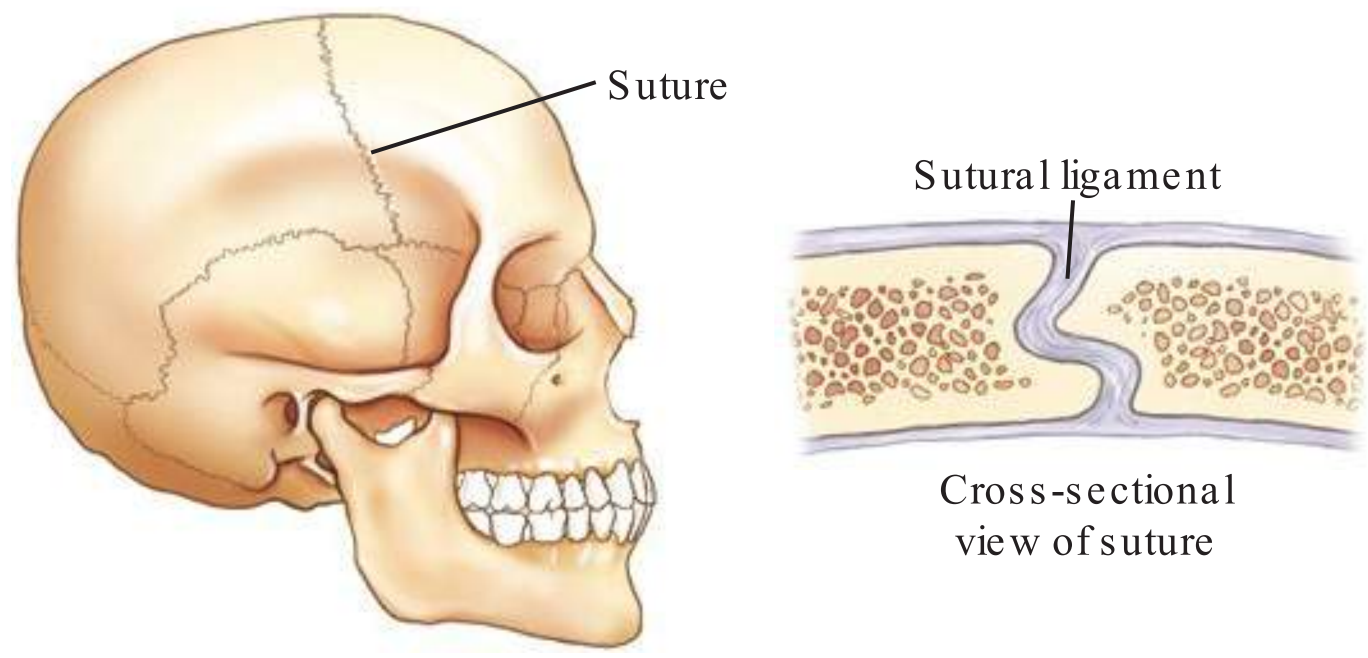
2. Sutures Sutures are found only between bones in the skull. These bones make contact with one another along interlocking or serrated edges and are held together by layers of fibrous tissue, or sutural ligaments. Movement is very limited at these articulations; in adults, these are considered immovable, or **synarthrodial**, joints.

Limited expansion- or compression-type movement at these sutures can occur in the infant skull (e.g., during the birth process). However, by adulthood, active bone deposition partially or completely obliterates these suture lines.

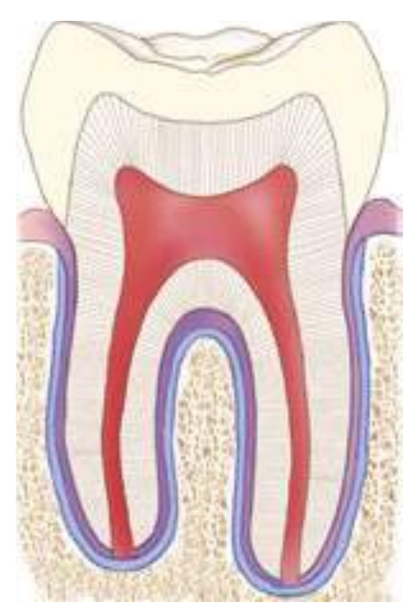
3. Gomphoses A gomphosis joint is the third unique type of fibrous joint, in which a conical process is inserted into a socket-like portion of bone. This joint or fibrous union—which, strictly speaking, does not occur between bones but between the roots of the teeth and the alveolar sockets of the mandible and the maxillae—is a specialized type of articulation that allows only very limited movement.



Distal tibiofibular joint
1. Syndesmosis–Amphiarthrodial (slightly movable)



Skull suture
2. Suture–Synarthrodial (immovable)



Roots of teeth
3. Gomphosis–Amphiarthrodial (only limited movement)

Fig. 1.23 Fibrous joints—three types.

Cartilaginous Joints

Cartilaginous joints also lack a joint cavity, and the articulating bones are held together tightly by cartilage. Similar to fibrous joints, cartilaginous joints allow little or no movement. These joints are synarthrodial or amphiarthrodial and are held together by two types of cartilage-symphyses and synchondroses (Fig. 1.24).

1. Symphyses The essential feature of a symphysis is the presence of a broad, flattened disk of fibrocartilage between two contiguous bony surfaces. These fibrocartilage disks form relatively thick pads that are capable of being compressed or displaced, allowing some movement of these bones, which makes these joints amphiarthrodial (slightly movable).

Examples of such symphyses are the intervertebral disks (between bodies of the vertebrae), between the manubrium (upper portion) and body of the sternum, and the symphysis pubis (between the two pubic bones of the pelvis).

2. Synchondroses A typical synchondrosis is a temporary form of joint wherein the connecting hyaline cartilage (which on long bones is called an epiphyseal plate) is converted into bone at adulthood. These temporary types of growth joints are considered synarthrodial or immovable.

Examples of such joints are the epiphyseal plates between the epiphyses and the metaphysis of long bones and at the three-part union of the pelvis, which forms a cup-shaped acetabulum for the hip joint.

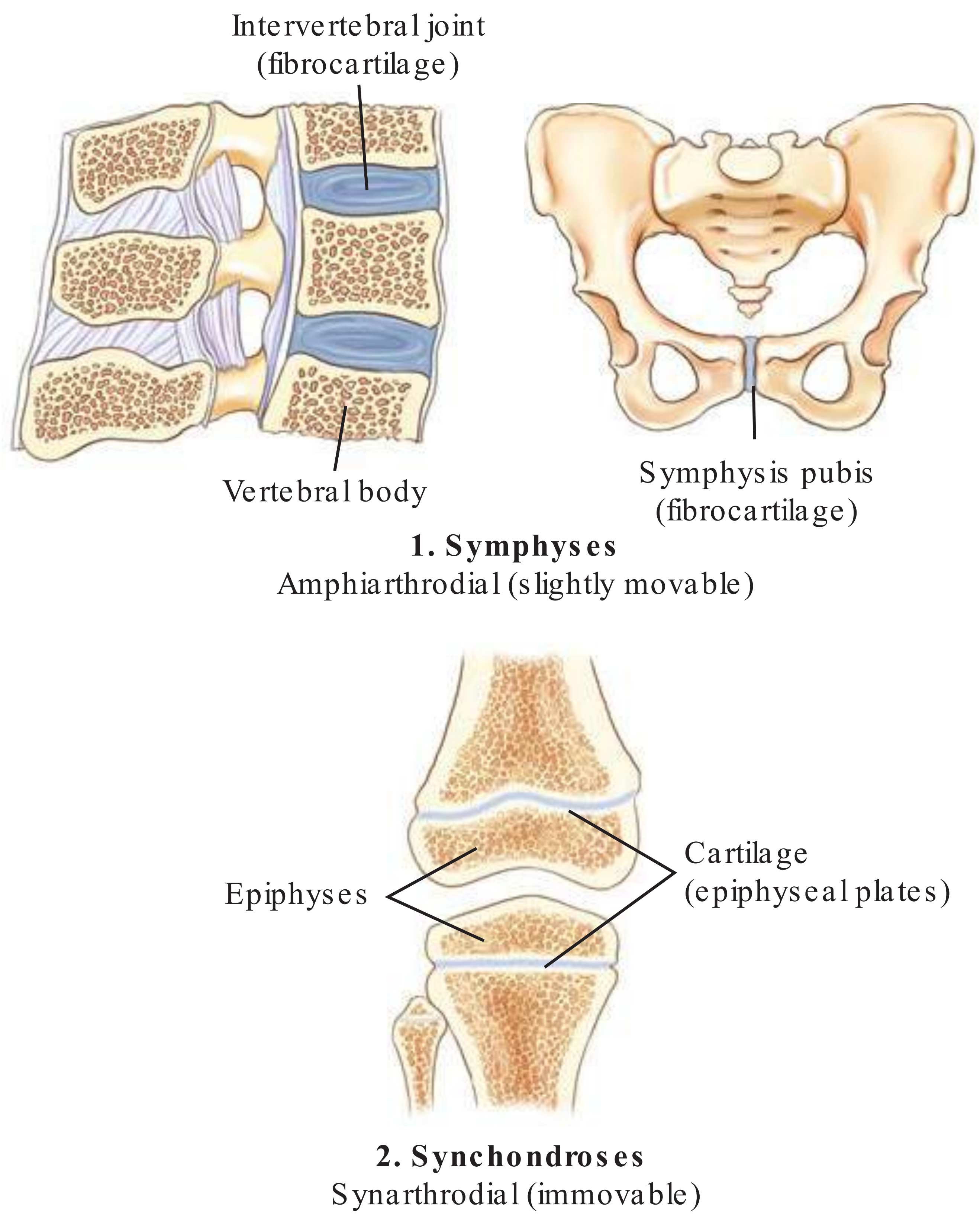


Fig. 1.24 Cartilaginous joints—two types.

Synovial Joints

Synovial joints are freely movable joints, most often found in the upper and lower limbs, which are characterized by a fibrous capsule that contains synovial fluid (Fig. 1.25). The ends of the bones that make up a synovial joint may make contact but are completely separate and contain a joint space or cavity, which allows for a wide range of movement at these joints. Synovial joints are generally diarthrodial, or freely movable. (Exceptions include the sacroiliac joints of the pelvis, which are amphiarthrodial, or slightly movable.)

The exposed ends of these bones contain thin protective coverings of articular cartilage. The joint cavity, which contains a viscous lubricating synovial fluid, is enclosed and surrounded by a fibrous capsule that is reinforced by strengthening accessory ligaments. These ligaments limit motion in undesirable directions. The inner surface of this fibrous capsule is thought to secrete the lubricating synovial fluid.

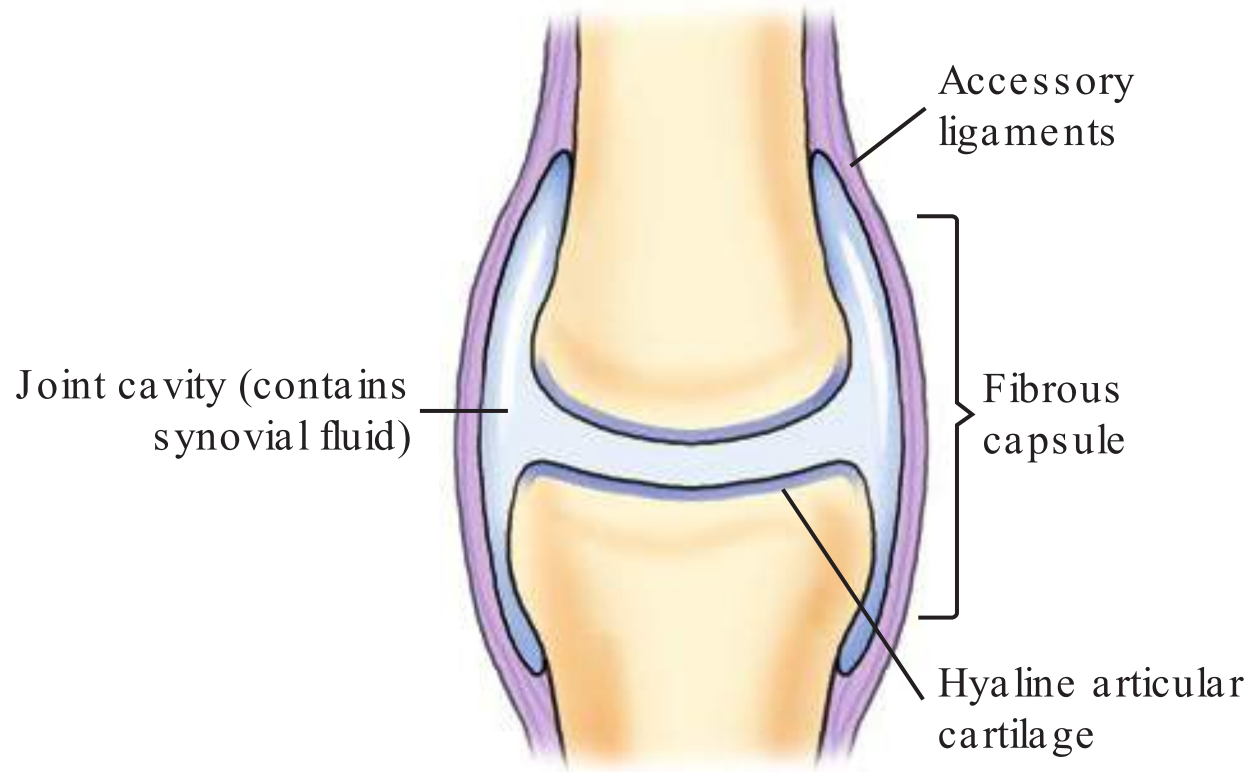


Fig. 1.25 Synovial joints—diarthrodial (freely movable).

Movement Types of Synovial Joints There are a considerable number and variety of synovial joints, and they are grouped according to the seven types of movement that they permit. These are listed in order from the least to the greatest permitted movement.

NOTE: The preferred name is listed first, followed by a synonym in parentheses. (This practice is followed throughout this textbook.)

1. Plane (gliding) joints This type of synovial joint permits the least movement, which, as the name implies, is a sliding or gliding motion between the articulating surfaces.

Examples of plane joints are the intermetacarpal, carpometacarpal, and intercarpal joints of the hand and wrist (Fig. 1.26). The right and left lateral atlantoaxial joints between C1 and C2 vertebrae are also classified as plane, or gliding, joints; they permit some rotational movement between these vertebrae, as is described in Chapter 8.

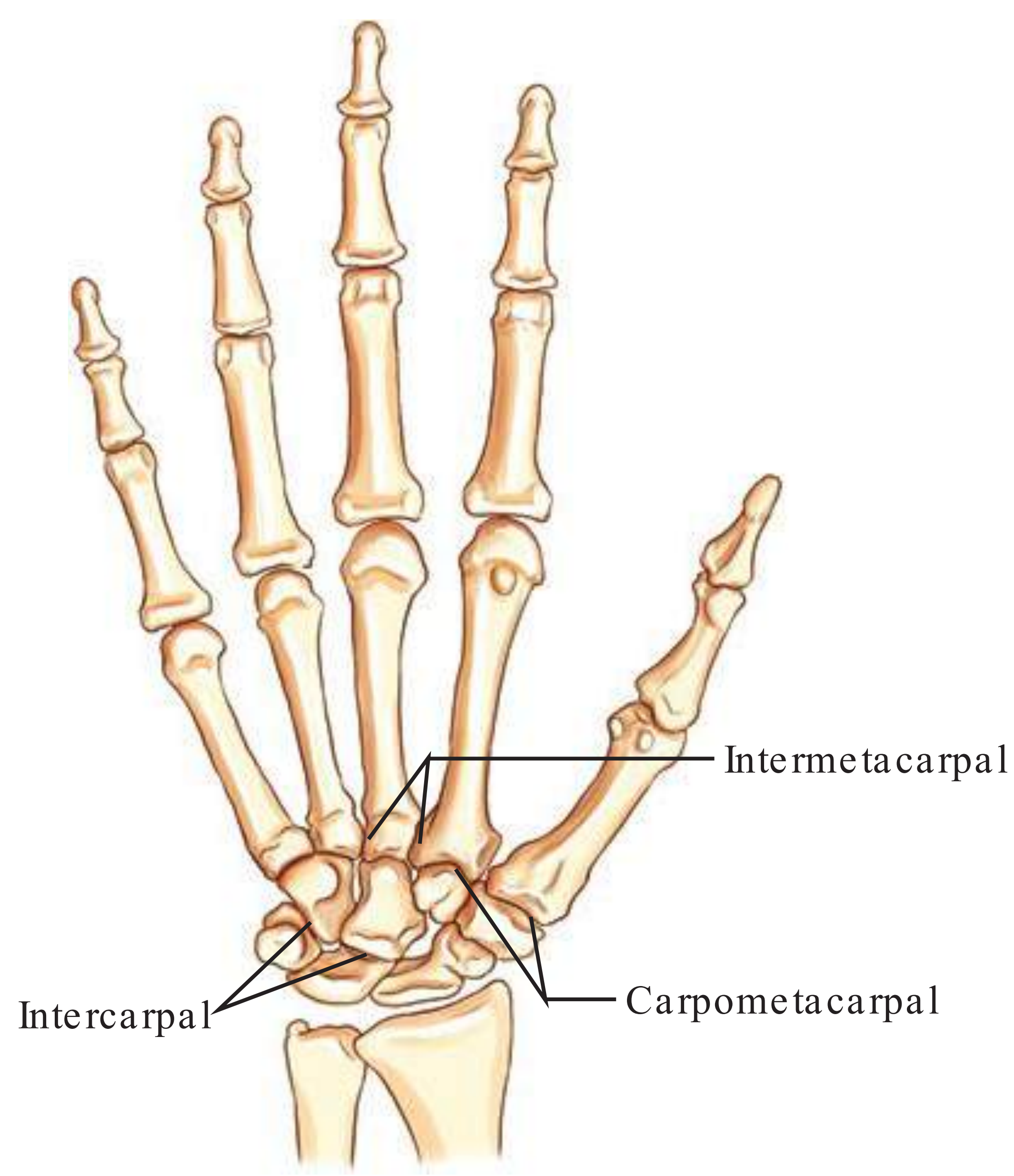


Fig. 1.26 Plane (gliding) joints.

2. Ginglymus (hinge) joints The articular surfaces of ginglymi, or ginglymus (jin′-gli-mus) joints, are molded to each other in such a way that they permit flexion and extension movements only. The articular fibrous capsule on this type of joint is thin on surfaces where bending takes place, but strong collateral ligaments firmly secure the bones at the lateral margins of the fibrous capsule.

Examples of ginglymi include the interphalangeal joints of fingers and toes and the elbow joint (Fig. 1.27).

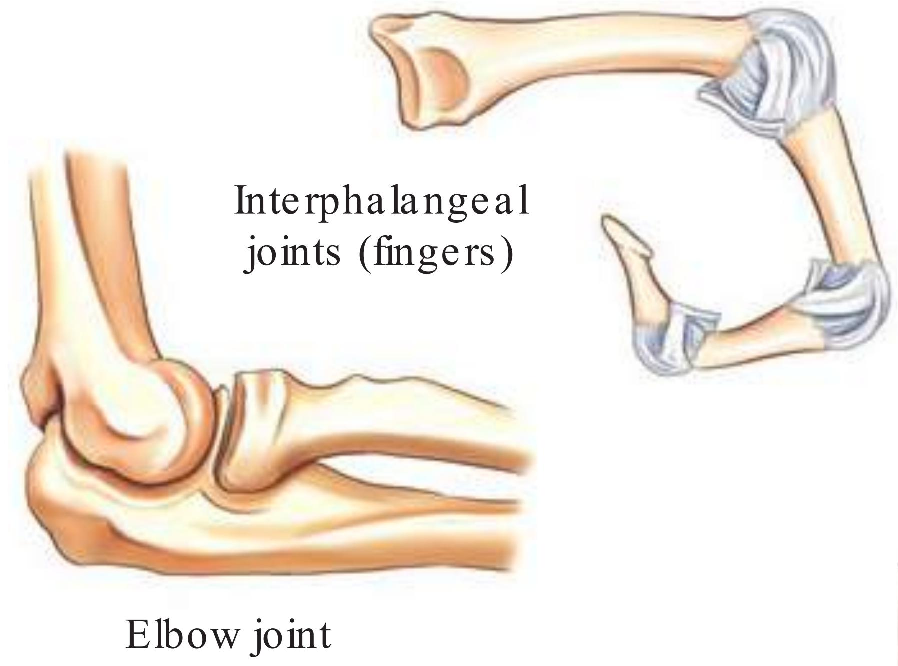


Fig. 1.27 Ginglymus (hinge) joints.

3. Pivot (trochoid) joints The pivot or trochoid (tro′-koid) joint is formed by a bony, pivot-like process that is surrounded by a ring of ligaments or a bony structure or both. This type of joint allows rotational movement around a single axis.

Examples of pivot joints are the proximal and distal radioulnar joints of the forearm, which demonstrate this pivot movement during rotation of the hand and wrist.

Another example is the joint between the first and second cervical vertebrae. The odontoid process (dens) of the axis (C2) forms the pivot, and the anterior arch of the atlas (C1), combined with posterior ligaments, forms the ring (Fig. 1.28).

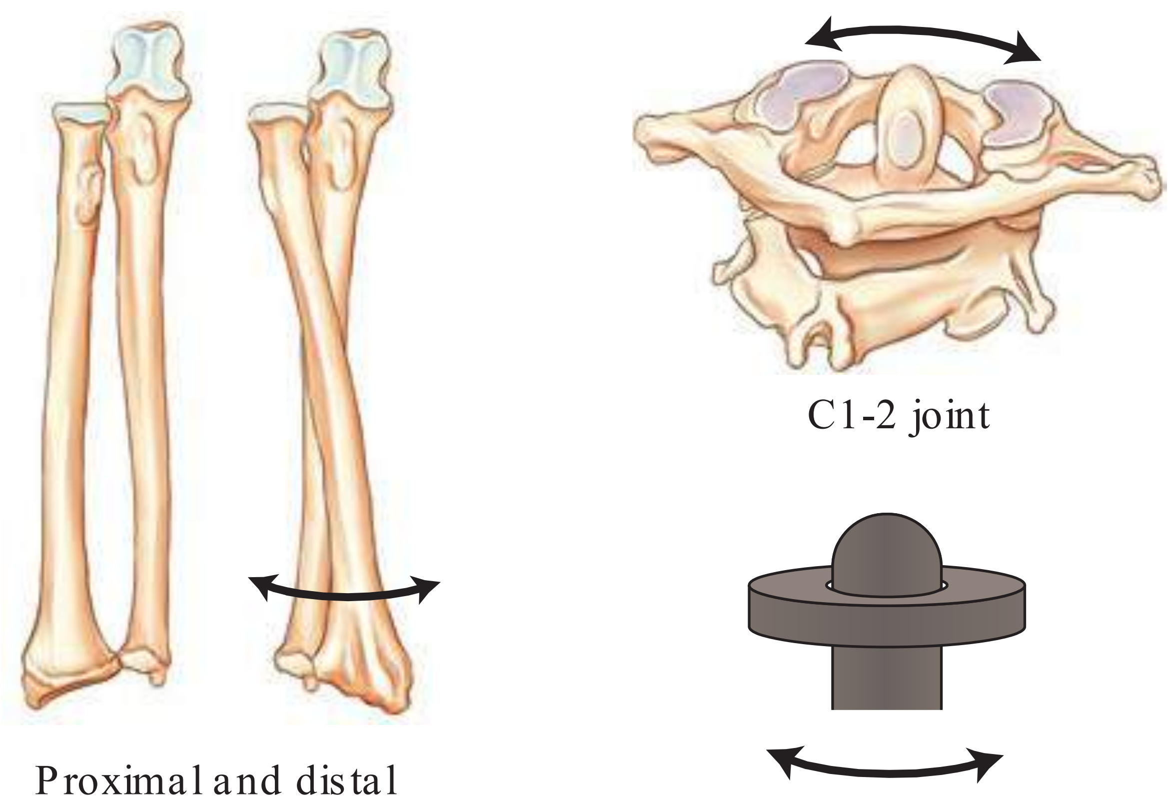


Fig. 1.28 Pivot (trochoid) joints.

4. Ellipsoid (condylar) joints In the ellipsoid (e-lip′-soid) joint, movement occurs primarily in one plane and is combined with a slight degree of rotation at an axis at right angles to the primary plane of movement. The rotational movement is limited by associated ligaments and tendons.

This type of joint allows primarily four directional movements: flexion and extension, and abduction and adduction. Circumduction movement also occurs; this results from conelike sequential movements of flexion, abduction, extension, and adduction.

Examples of ellipsoid joints include the metacarpophalangeal joints of the fingers, the wrist joint, and the metatarsophalangeal joints of the toes (Fig. 1.29).

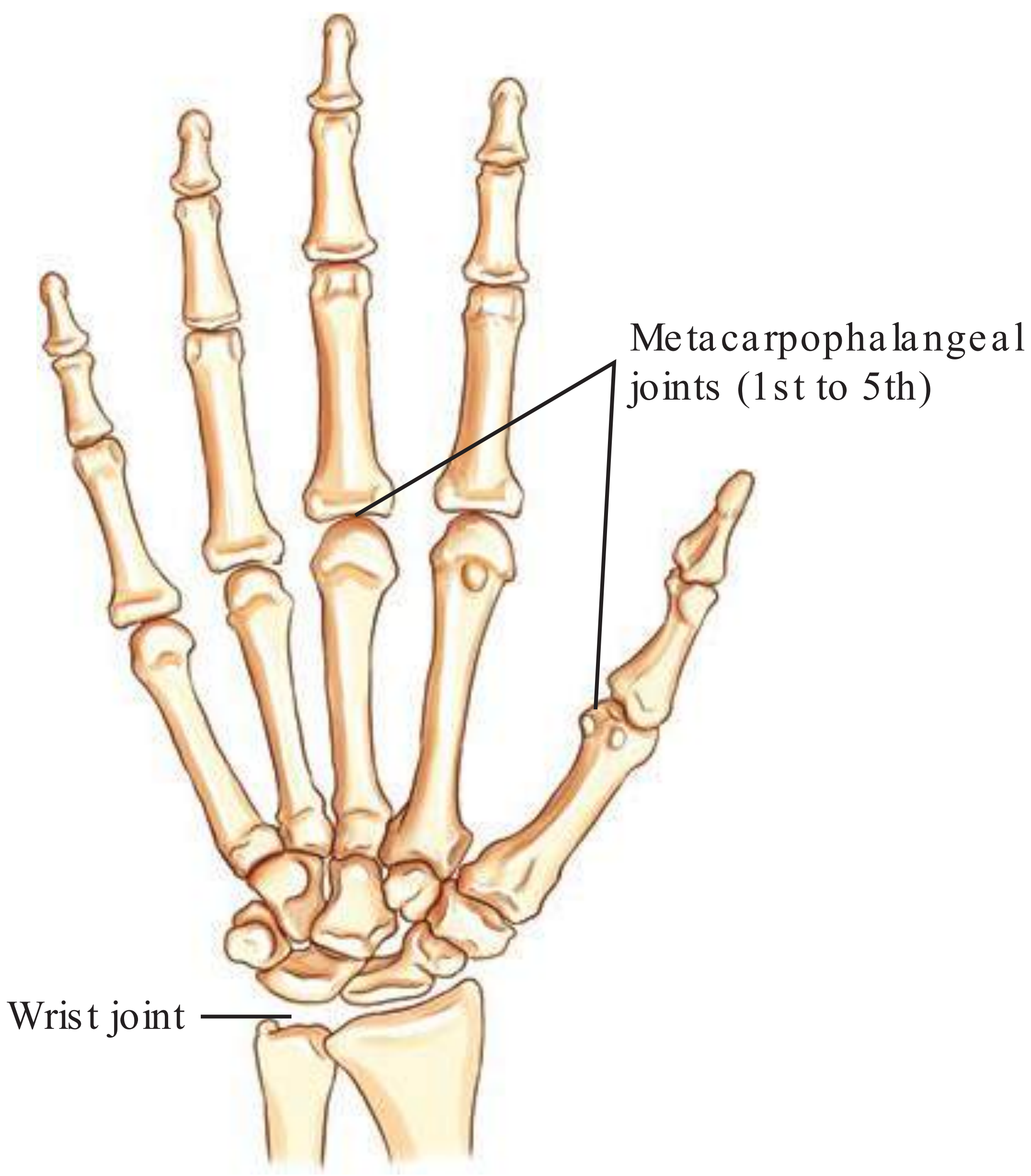


Fig. 1.29 Ellipsoid (condylar) joints.

5. Saddle (sellar) joints The term saddle, or sellar (sel′-ar), describes this joint structure well in that the ends of the bones are shaped concave-convex and are positioned opposite each other (Fig. 1.30). (Two saddle-like structures fit into each other.)

Movements of this biaxial type of saddle joint are the same as for ellipsoidal joints—flexion, extension, adduction, abduction, and circumduction.

The best example of a true saddle joint is the first carpometacarpal joint of the thumb. Other sellar joints include the ankle and the calcaneocuboid joints. Although the ankle joint was classified as a ginglymus in earlier references, current references classify it as a saddle joint.[3]

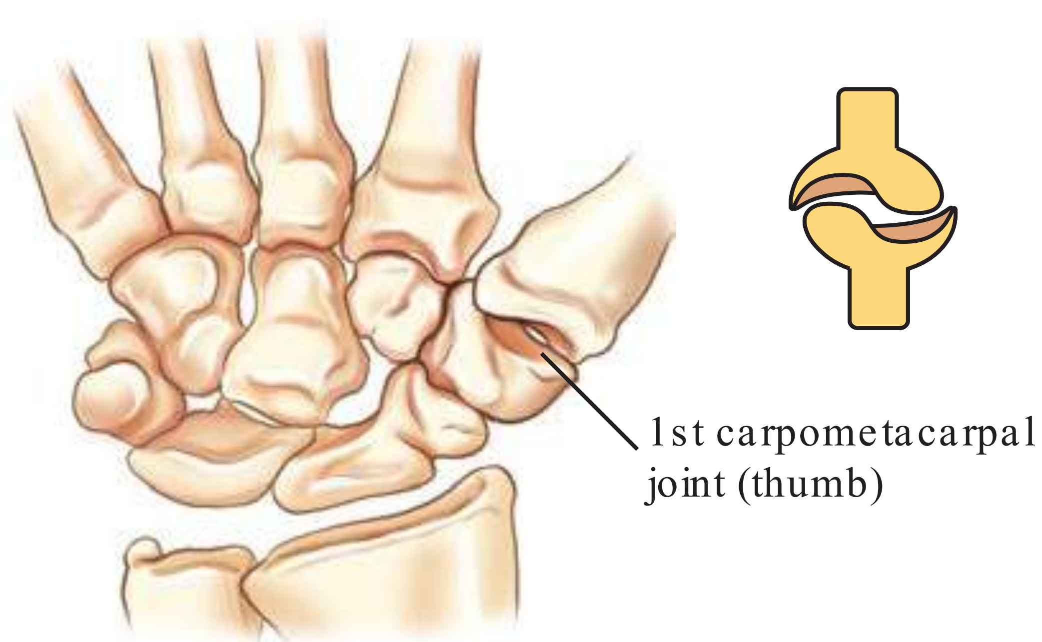


Fig. 1.30 Saddle (sellar) joints.

6. Ball and socket (spheroidal) joints The ball and socket or spheroidal (sfe′-roid-el) joint allows for the greatest freedom of motion. The distal bone (humerus) that makes up the joint is capable of motion around an almost indefinite number of axes, with one common center.

The greater the depth of the socket, the more limited is the movement. However, the deeper joint is stronger and more stable. For example, the hip joint is a much stronger and more stable joint than the shoulder joint, but the range of movement is more limited in the hip.

Movements of ball and socket joints include flexion, extension, abduction, adduction, circumduction, and medial and lateral rotation.

Two examples of ball and socket joints are the hip joint and the shoulder joint (Fig. 1.31).

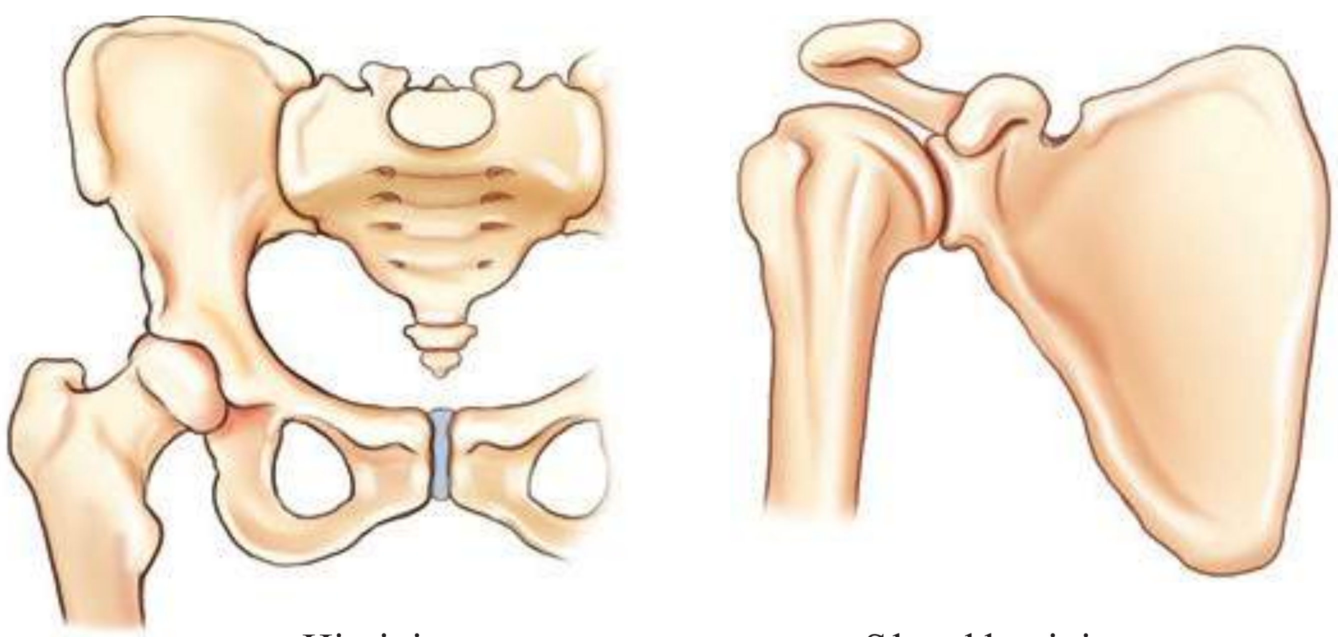


Fig. 1.31 Ball and socket (spheroidal) joints.

7. Bicondylar joints[3] Bicondylar joints usually provide movement in a single direction. They can permit limited rotation. Bicondylar joints are formed by two convex condyles, which may be encased by a fibrous capsule.

Two examples of bicondylar joints are the knee (formerly classified as ginglymus) and the temporomandibular joint (TMJ) (Fig. 1.32).

See Table 1.3 for a summary of joint classification.

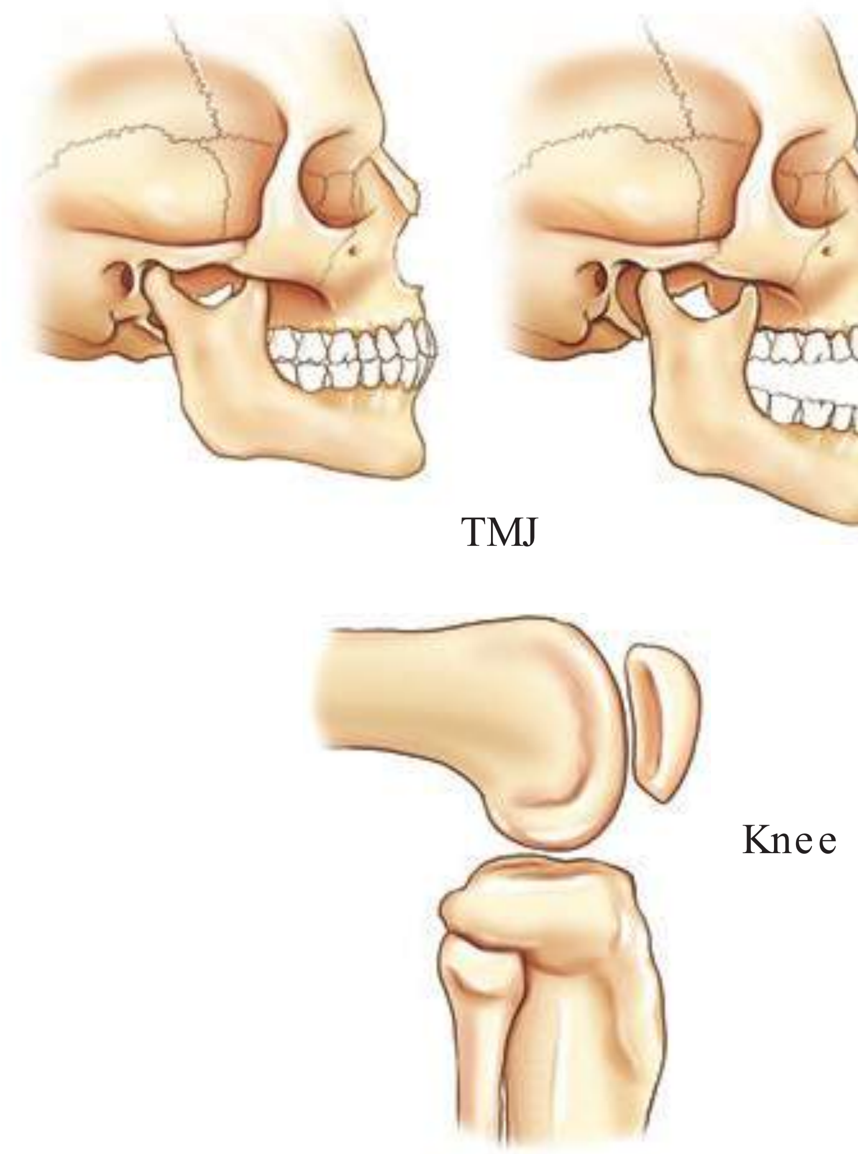


Fig. 1.32 Bicondylar joints.

TABLE 1.3 SUMMARY OF JOINT CLASSIFICATION

JOINT CLASSIFICATION	MOBILITY CLASSIFICATION	MOVEMENT TYPES	MOVEMENT DESCRIPTION	EXAMPLES
Fibrous Joints				
Syndesmoses	Amphiarthrodial (slightly movable)	—	—	Distal tibiofibular, sacroiliac, carpal, and tarsal joints
Sutures	Synarthrodial (immovable)	—	—	Skull sutures
Gomphoses	Very limited movement	—	—	Areas around roots of teeth
Cartilaginous Joints				
Symphyses	Amphiarthrodial (slightly movable)	—	—	Intervertebral disks Symphysis pubis
Synchondroses	Synarthrodial (immovable)	—	—	Epiphyseal plates of long bones and between the three parts of the pelvis
Synovial joints	Diarthrodial (freely movable) except for the sacroiliac joints (synovial joints with only very limited motion [amphiarthrodial])	Plane (gliding)	Sliding or gliding	Intermetacarpal, intercarpal, and carpometacarpal joints, C1 on C2 vertebrae
		Ginglymi (hinge)	Flexion and extension	Interphalangeal joints of fingers, toes, and elbow joints
		Pivot (trochoid)	Rotational	Proximal and distal radioulnar and between C1 and C2 vertebrae (atlantoaxial joint)
		Ellipsoid (condylar)	Flexion and extension Abduction and adduction Circumduction	Metacarpophalangeal and wrist joints
		Saddle (sellar)	Flexion and extension Abduction and adduction Circumduction	First carpometacarpal joint (thumb), ankle, and calcaneocuboid joints
		Ball and socket (spheroidal)	Flexion and extension Abduction and adduction Circumduction Medial and lateral rotation	Hip and shoulder joints
		Bicondylar	Movement primarily in one direction with some limited rotation	Knee and temporomandibular joints

NOTE: Arthrology is the study of joints. The nomenclature for joints described in this chapter will be used in subsequent chapters throughout the text.

Body Habitus

Body habitus is generally defined as the build, physique, and general shape of the human body. The size, dimensions, and shape of the patient's body impacts positioning of specific regions of the body such as the respiratory, gastrointestinal, and biliary systems.

Body habitus is classified into four general body styles:

1. **Sthenic**: Approximately 50% of the population falls into this category. For the purpose of radiographic positioning, sthenic body styles are considered average in shape and internal organ location (Fig. 1.33).
2. **Hyposthenic**: A thin body style, which is more slender than the sthenic body habitus. Approximately 35% of the population is classified as hyposthenic (Fig. 1.34).
3. **Hypersthenic**: A massive body style, which has a large and broad frame as compared to the sthenic body habitus. Approximately 5% of the population is classified as hypersthenic (Fig. 1.35).
4. **Asthenic**: Approximately 10% of the population is very thin or slender with a long and narrow body build. More slight in stature than even the hyposthenic patient.

IMPACT OF BODY HABITUS ON RADIOGRAPHIC POSITIONING

The technologist must consider the patient's body habitus and alter centering and image receptor placement accordingly. This is especially a concern during adult chest radiography described in Chapter 2. For the hyposthenic and asthenic patient, the image receptor is placed in portrait (lengthwise) alignment because the lungs are longer than those of the hypersthenic patient. For the hypersthenic patient, the image receptor is placed in landscape (crosswise) alignment because the lungs are shorter in length but broader in width than those of the hyposthenic or asthenic patient. The IR placement for the sthenic adult patient may be placed portrait or landscape depending on age, height, and even pathology. Other anatomical regions are affected as well by body habitus. This will be discussed further in Chapter 12, Biliary Tract and Upper Gastrointestinal System.

Fig. 1.33 Sthenic body habitus.

Fig. 1.34 Hyposthenic/asthenic body habitus.

Fig. 1.35 Hypersthenic body habitus.