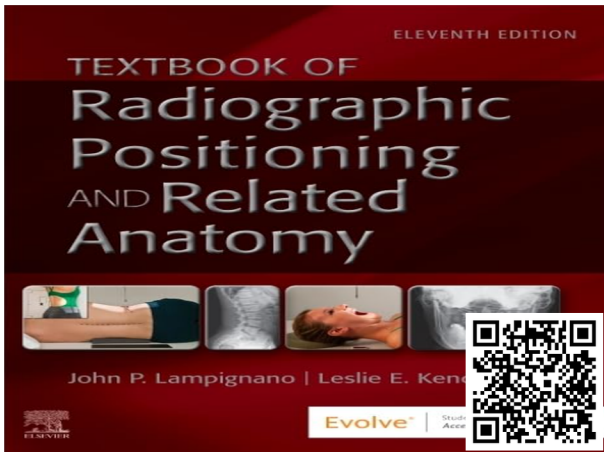


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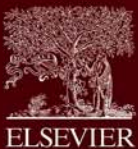
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ELEVENTH EDITION

# Radiographic Positioning AND Related Anatomy



John P. Lampignano | Leslie E. Kendrick



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ELEVENTH EDITION

TEXTBOOK OF

Radiographic  
Positioning  
AND Related  
Anatomy

John P. Lampignano, MEd, R.T.(R)(CT)(ARRT)

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TEXTBOOK OF RADIOGRAPHIC POSITIONING AND RELATED ANATOMY,  
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# Acknowledgments and Dedication

John P. Lampignano



First, I must acknowledge the contributions from students and imaging faculty throughout the United States and various regions of the world, including Puerto Rico and South America. We hear frequently from them, as they provide feedback on the text and ancillaries. They have shared with us with fresh ideas and perspectives for the text and how to improve it.

The Radiologic Sciences faculty and staff at Boise State University are outstanding role models for their students and the profession—Leslie Kendrick, Cathy Masters, Travis Armstrong, Natalie Maurant Hodges, Monica Breedlove, and Anastasia Tracy. They have given me support and friendship during my time at BSU. To the BSU students, you have provided me with joy, challenges, and support during my tenure. I can't thank you enough for the many smiles and laughs we have shared.

The contributing authors for the 11th edition did an outstanding job in researching and writing the content for various chapters. My heartfelt gratitude to each of them for making this edition truly reflective of the current practice in medical imaging. Special thanks to the faculty at GateWay Community College: Bradley Johnson, Nicole Hightower, Janelle Black, and Michelle Wilt. Bradley redesigned [Chapters 1 and 19](#) in this edition and served as consultant for all of the digital imaging concepts. I spent 35 years at GWCC and have tremendous respect for the program, its graduates, and its faculty.

Leslie E. Kendrick formally became coauthor 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, completing her research for a doctorate, and taking care of her family. You can't measure the character of a writer until he or she is tested by long hours, pressing deadlines, and personal sacrifice. Leslie has the character and heart of a writer. Thank you for the friendship and trust you have placed in me. Allowing me to serve as faculty at Boise State University was such a positive endpoint to my teaching career.

A special thanks to Dr. Chad Hensley, who edited the 11th edition of the workbook. Chad is an excellent writer, valued colleague, and close friend.

More than 80 photographs were taken for the 11th edition. This feat would not have been possible without the special talents of KJ Filmworks, including Jack Quirk and Ken Helms.

Our gratitude to photography models and the support team: Meg Benson, Tina Kaemmerer, Misti Walker, Livia Kendrick, Atticus Rosenkoetter, Aubrie Rosenkoetter, Robyn Pedraza, and Shylenta Zimmerman, 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 Meg Benson as our Executive Content Strategist. Meg was our editor for the 11th edition from inception to completion. Meg made the process of creating the new edition seamless. I truly admire her integrity, professionalism, sense of humor, and friendship.

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. She is an outstanding professional and fine person. We shall always treasure our friendship with Tina.

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

Most importantly, sincere gratitude to Elsevier Publishing for allowing us to continue to be part of this wonderful reference for the past 52 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. Now 17 years old, she has turned into a loving, bright, and caring young person. She recently got accepted at the University of Arizona. Tatum will always own my heart. Finally, my thanks to Buddy and Segen—the family dogs—for the joy (and occasional challenges) they provide us.

Deborah has been at my side for more than 45 years. She has been the loving anchor that provides our family with the stability and encouragement to be successful in all our professional and personal endeavors. 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.

Finally, my mother-in-law Joan Bowden has always been supportive of me. She has treated me like a son, for which I am truly grateful. She has taught me what true courage is in facing health challenges. Mom, I dedicate this edition to you.

JPL

# Acknowledgments and Dedication

Leslie E. Kendrick



John Lampignano has eloquently acknowledged many incredible individuals from the realms of medical imaging and publishing. I sincerely echo his sentiments of appreciation and recognize that this 11th edition has been made possible with the time and talents of many. Special thanks to Dr. José Rafael Moscoso-Alvarez, of the Universidad Central de Caribe, Puerto Rico, for his invaluable contributions to Chapter 1 regarding the various patient populations we imaging technologists serve. José is a cherished colleague and friend. We respect and appreciate his contributions to this edition. Working alongside and with so many amazing professionals is an incredible honor. Your resilience, advocacy for patients, and tremendous respect for each other are what makes this profession such a joy. I genuinely appreciate the opportunity to give back to the profession as the coauthor of this textbook and ancillaries with utmost gratitude.

I am especially grateful to John Lampignano, Cathy Masters, Travis Armstrong, Natalie Mourant Hodges, Monica Breedlove, and Anastasia Tracy of Boise State University for freely sharing

their professional perspectives and expertise in the field of medical imaging. You foster in me a drive to think outside the bounds set before us and to grow in newly imagined ways. It is truly an honor to be your colleague.

I also thank my lovely family for their boundless support and patience. My youngest, Livia, has sat by patiently many times waiting for Mom to finish revising a paragraph for the 10th time. My incredible husband, Travis, recognizes the honor of my participation in this project and continues to support 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; seven lovely grandchildren—each filled with wonder and delight: Fox, Killian, Kellen, Charlie, Haydin, Addison, and Calliope; one amazing husband who loves me unconditionally and makes my life complete. There aren't enough words to express the joy you each bring to me. Thank you for sharing so much of yourselves.

Lastly, I thank John P. Lampignano for opening a new level of our profession to me by extending the invitation of coauthorship. It is exciting how this project continually presents opportunities for collaboration across the United States and around the globe. The professional growth from exposure to new ideas, concepts, and intellects has been exponential. Working with John is an incredible privilege. He is an icon in our profession and a giant in the field. John is an inspiration as an educator, scientist, and individual. He has instilled in me a recognition of the value in global collaboration with imaging professionals to ensure currency, quality, and accuracy. I will forever be in John's debt for the trust he granted me with this partnership.

I encourage communication from all readers of these materials on how to improve and be the resources needed by our communities of educators, students, and imaging professionals.

LEK

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# Preface

## Purpose and Goal of the Eleventh Edition

The 11th edition of the *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 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 healthcare providers to make an accurate diagnosis. In many respects, the patient's health and well-being are in the hands of the technologist. The authors and contributors had this goal in mind as we made the revisions for the 11th edition. Each position and procedure were evaluated carefully 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, digital imaging systems, physical and virtual grids, radiographic quality factors, and radiation protection that provide a central resource for these principles and concepts. Analog imaging concepts have been eliminated in this edition. Information on digital imaging concepts has been updated and reflects current practices. Expanded information has been added on the bariatric patient. The chapter on radiation protection reinforces the recommendations and practices promoted by the ImageGently and ImageWisely initiatives.
- **Chapter 4, Upper Limb** added the Bilateral PA (stress) method, which may demonstrate scapholunate dislocations of the carpal bones.
- **Chapter 5, Shoulder Girdle and Humerus** added the Superoinferior Transaxillary method for the scapulohumeral joint space.
- **Chapter 6, Lower Limb** added the Dorsoplantar Axial (weight-bearing) calcaneus projection.
- **Chapter 7, Femur and Pelvis** added the Oblique (False and Modified False profile) projections for the acetabulum.
- **Chapter 14, Urinary System** updated information on iodinated contrast media and related reactions.
- **Chapter 15, Trauma, Mobile, and Surgical Radiography** revised extensively to focus on key concepts of mobile, trauma, and surgical radiography. The section on mobile radiographic equipment was updated to reflect the current technology.
- **Chapter 16, Pediatric Radiography** updated to reflect best practices in reducing dose to young patients. ImageGently principles are stressed in this chapter and **Chapter 1**. Photographs of pediatric immobilization devices have been updated.
- **Chapter 17, Angiography and Interventional Procedures** added new art and photographs to illustrate current procedures and angiographic devices currently seen in clinical practice.
- **Chapter 18, Computed Tomography** revised to reflect the newest technology available. New procedures and current CT technology were added in this chapter. Higher-resolution CT images were added.
- **Chapter 19, Special Radiographic Procedures** updated to reflect new procedures and imaging modalities including digital tomosynthesis (DTS). Linear tomography concepts were removed.
- **Chapter 20, Diagnostic and Therapeutic Procedures** updated each modality to reflect current imaging systems and procedures. Magnetic resonance imaging (MR) section was revised to include current technology, current protocols, and high-quality images.
- The 11th edition closely follows the procedures and positioning concepts required by the American Registry of Radiologic Technologists (ARRT) Examination Content Specifications for the Radiography.
- More than **80 positioning photographs** have been replaced in the 11th edition. A different perspective was used with these photos. They demonstrate close-ups of the positioning model so that students and technologists can better view positioning landmarks, CR centering points, and collimation. Erect versions of positions have been expanded to reflect current clinical practice.
- **New images** have been added throughout the 11th 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.
- **Radiographic Critique.** At the end of **Chapters 2-11 and 18**, the radiographic critique section has been updated to provide students a method to compare an ideal image to others than demonstrate common positioning and technical

errors. Solutions for these critique assessments are provided in the faculty Evolve site.

- **Digital imaging** continues to be emphasized in the 11th edition. Terminology, technical factors, part centering, and kVp ranges are described with a primary focus on digital systems.
- kVp 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 that are formally recognized in the profession are used. All projections match those stated in the ARRT Content Specifications in Radiography.
- **Twenty chapters.** The number of chapters for the 11th edition **remains 20**. 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. The radiographic critique section was expanded to include images in the workbook pages.

### EVOLVE INSTRUCTOR RESOURCES

A computerized test bank is available on Evolve to instructors who use this textbook in their classrooms. The test bank features more than 2100 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 LMS format. The text bank is restricted to faculty use, which can be found in Evolve resources.

Also available on Evolve is an electronic image collection featuring more than 2700 images that are fully coordinated with the 11th 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.

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

### EVOLVE STUDENT RESOURCES

For the 11th edition, students will have access to 400 additional review questions (20 questions per chapter) to help them review important concepts. Each question includes detailed rationales.

### HANDBOOK

The new 11th edition revised pocket *Handbook*, also authored by John P. Lampignano and Leslie E. 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 for Textbook of Radiographic Positioning and Related Anatomy* is a unique online courseware program promoting problem-based learning with the goal of developing critical thinking skills 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 recommended field size for the average adult; whether the IR should be placed portrait or landscape in relation to the patient; a grid, if one is needed; recommended kVp ranges; the minimum SID (source-to-image receptor distance) is listed.
- 5 IMAGE RECEPTOR ICONS** give a visual display of the suggested collimation field size (cm) and orientation (portrait or landscape), location of R and L markers, and the recommended AEC cell location (if AEC is used).
- 6 PATIENT POSITION** section indicates the general body position required for the projection.
- 7 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 central ray (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 it during the positioning process for that projection.
- 8 CENTRAL RAY (CR)** section describes the precise location of the CR in relation to both the IR and the body part.
- 9 RECOMMENDED COLLIMATION** section describes the collimation of the x-ray field recommended for that projection.
- 10 RESPIRATION** section lists the breathing requirements for that projection.
- 11 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.
- 12 POSITIONING PHOTOGRAPHS** shows a correctly positioned patient and part in relation to the CR and IR.

**TANGENTIAL PROJECTION—INTERTUBERCULAR (BICIPITAL) SULCUS: SHOULDER (NONTRAUMA)**

**FIK MODIFICATION**

**1 Clinical Indications**

- Pathologies of intertubercular sulcus (groove), including bony spurs of the humeral tubercles

**2 Technical Factors**

- Minimum SID—40 inches (100 cm)
- Recommended field size—8 × 10 inches (18 × 24 cm) or 10 × 12 inches (24 × 30 cm), landscape
- Nongrid
- kVp range: 70–80

**3 Patient and Part Position**

**Erect (Fisk Modification)**

- Patient standing, leaning over end of table with elbow flexed and posterior surface of forearm resting on table, hand supinated holding image receptor, head turned away from affected side (lead shield placed between back of IR and forearm reduces backscatter to IR) (Fig. 5.65)
- Patient leaning forward slightly to place humerus 10° to 15° from vertical

**Supine**

- Patient supine, arm at side, hand supinated
- Vertical image receptor placed on table against top of shoulder and against neck (head turned away from affected side) (Fig. 5.66)
- CR 10° to 15° posterior from horizontal, directed to groove at midanterior margin of humeral head

**CR**

- CR perpendicular to IR, directed to groove area at midanterior margin of humeral head (groove can be located by careful palpation)

**Recommended Collimation Field Size** Collimate closely on four sides to area of anterior humeral head.


**Respiration** Suspend respiration during exposure.


**Evaluation Criteria**


**Anatomy Demonstrated:** • Anterior margin of the humeral head is seen in profile. • Humeral tubercles and the intertubercular sulcus are seen in profile (Figs. 5.67 and 5.68).


**Position:** • Correct CR angle of 10° to 15° to the long axis of the humerus demonstrates the intertubercular sulcus and the tubercles in profile without superimposition of the acromion process. • Collimation field size to area of interest.


**Exposure:** • Optimal image receptor exposure and contrast with no motion visualize sharp borders and sharp bony trabecular markings and demonstrate the complete intertubercular sulcus seen through soft tissue.


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
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
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
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**Fig. 5.65** Erect superiorinferior tangential projection.

**Fig. 5.66** Supine inferosuperior tangential projection.

**Fig. 5.67** Erect tangential projection for intertubercular sulcus.

**Fig. 5.68** Erect tangential (Fisk modification) projection.

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

X

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# Terminology, Positioning, and Imaging Principles

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## 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<sup>1</sup> 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:

**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

**Connective:** Supportive tissues that bind together and support various structures

**Muscular:** Tissues that make up the substance of a muscle

**Nervous:** Tissues that make up the substance of nerves and nerve centers

**Organs**

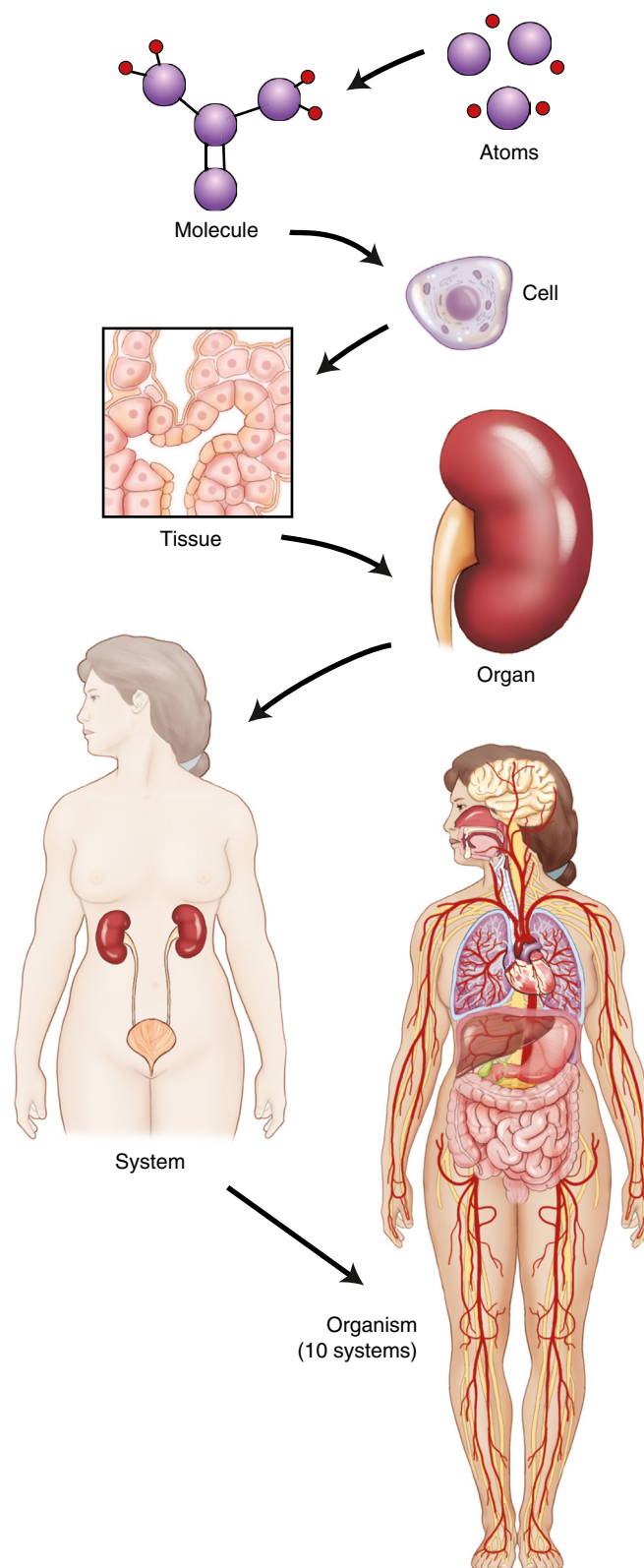
When complex assemblies of tissues are joined to perform a specific function, the result is an organ. Organs usually have a specific shape. Examples of organs of the human body are the kidneys, heart, liver, lungs, stomach, and brain.

**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 are the (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*) systems.

**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

**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:

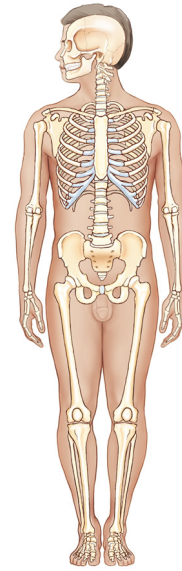
1. Distribute oxygen and nutrients to the cells of the body
2. Transport cell waste and carbon dioxide from the cells
3. Transport water, electrolytes, hormones, and enzymes
4. Protect against disease
5. Prevent hemorrhage by forming blood clots
6. Assist in regulating body temperature

**Digestive System**

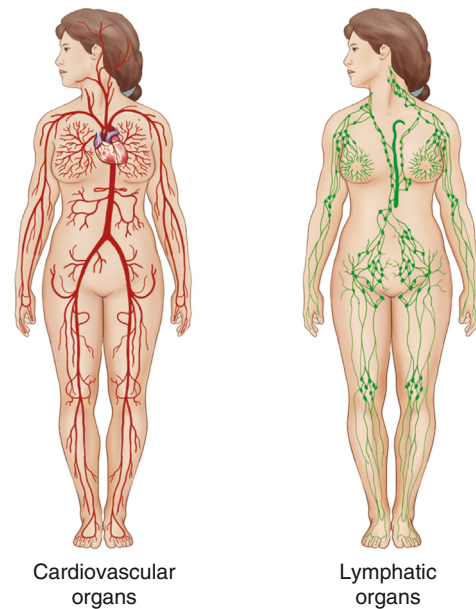
The digestive system includes the alimentary canal and certain accessory organs (Fig. 1.4). The alimentary canal is made up of the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus. Accessory organs of digestion include the salivary glands, liver, gallbladder, and pancreas.

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



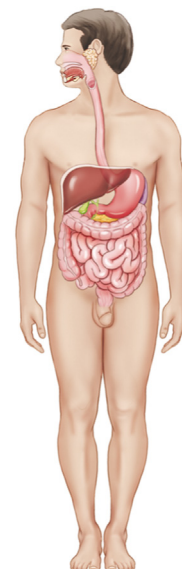
**Fig. 1.2** Skeletal system.



Cardiovascular organs

Lymphatic organs

**Fig. 1.3** Circulatory system.



**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

### 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).

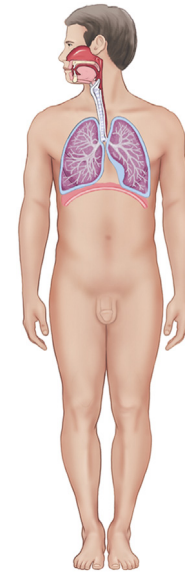
The four functions of the urinary system are as follows:

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

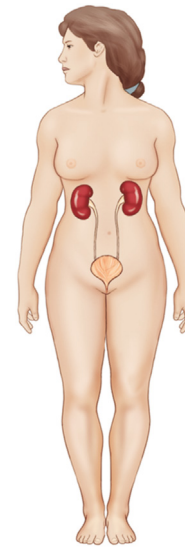
### Reproductive System

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 (Fig. 1.7).

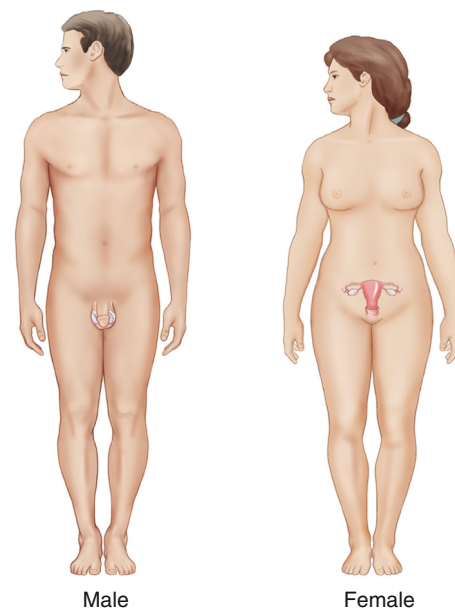
The function of the reproductive system is to reproduce the organism.



**Fig. 1.5** Respiratory system.



**Fig. 1.6** Urinary system.



Male

Female

**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.

**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

**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.

**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 3000 in<sup>2</sup> (7620 cm<sup>2</sup>) 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

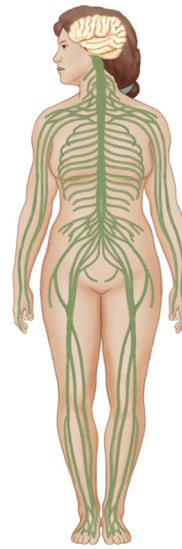


Fig. 1.8 Nervous system.

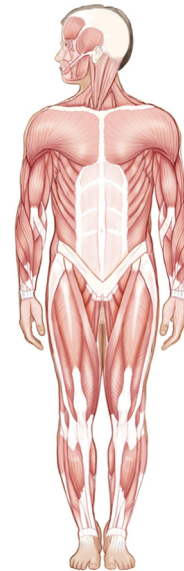


Fig. 1.9 Muscular system.

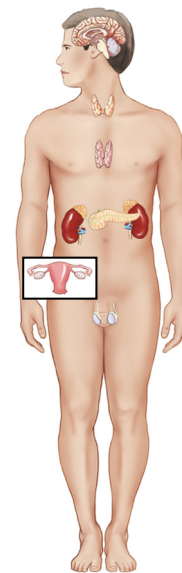


Fig. 1.10 Endocrine system.



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.

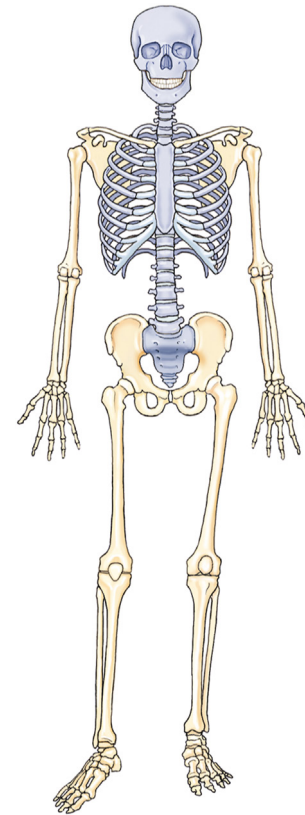
### OSTEOLOGY

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
<i>Total bones in adult axial skeleton</i>		<i>80</i>

### 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).

**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 ( <b>innominate bones</b> )	2
Lower limbs	Femur (femora)	2
	Tibia	2
	Fibula (fibulae)	2
	Patella (patellae)	2
	Tarsals	14
	Metatarsals	10
	Phalanges	28
<i>Total bones in adult appendicular skeleton</i>		126
<i>Entire number of separate bones in adult skeleton<sup>a</sup></i>		206

<sup>a</sup>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 computed tomography (CT).

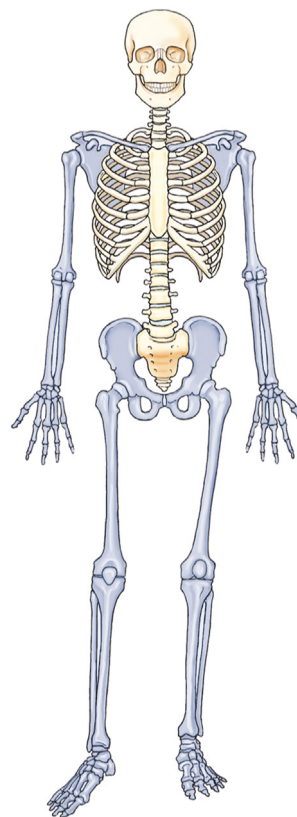
### CLASSIFICATION OF BONES

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

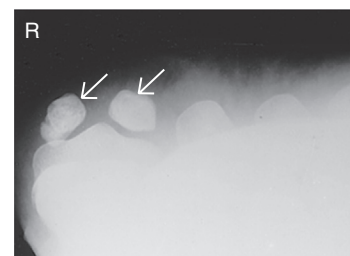
Long bones consist of a **body** and **two ends** or **extremities**. Long bones are found only in the appendicular skeleton. (Fig. 1.16 is a radiograph of a humerus, a typical long bone of the upper arm.)



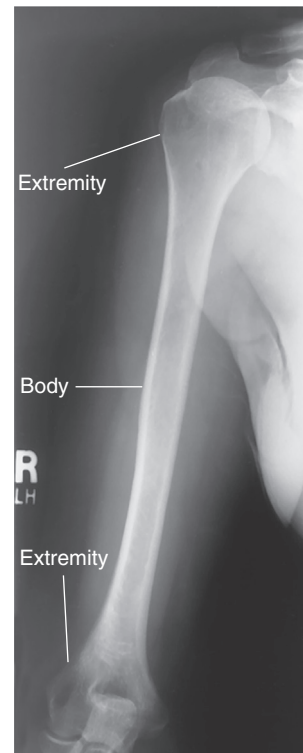
**Fig. 1.13** Appendicular skeleton—126 bones.



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



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



**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.

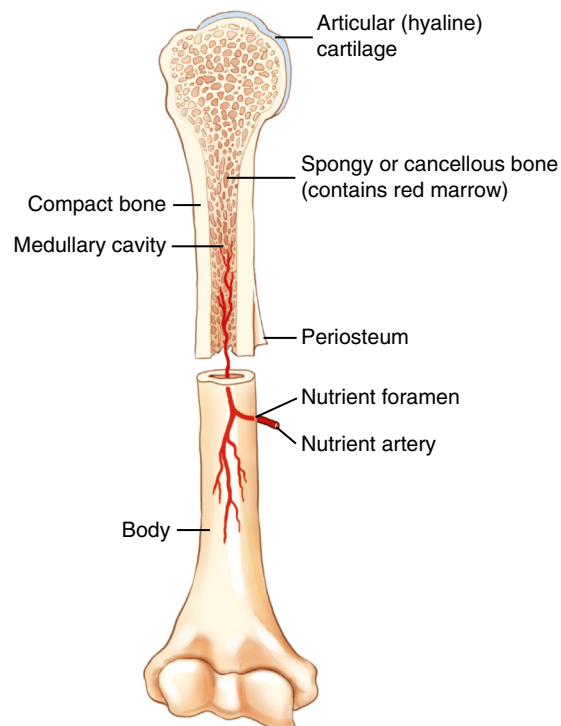
The **body** (older term is **shaft**) contains a thicker layer of compact bone than is found at the ends, to help resist the stress of the weight placed on them.

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. 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.

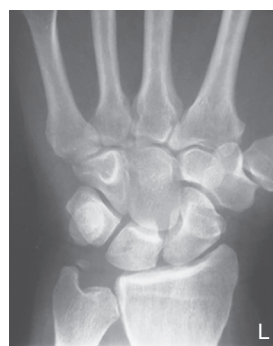
### Flat Bones

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**.

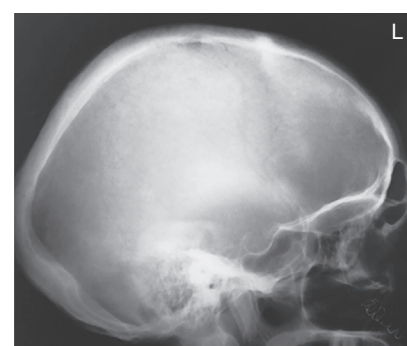
The narrow space between the two layers of compact bone of flat bones within the cranium is known as the **diploe** (*dip'-lo-e*). Flat bones provide protection for interior contents and broad surfaces for muscle attachment.

### Irregular Bones

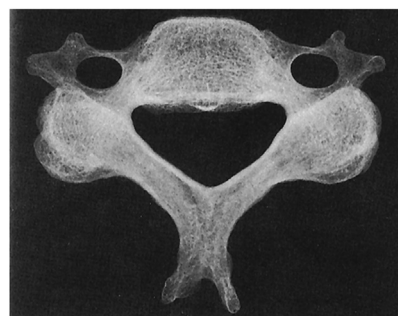
Bones that have peculiar shapes are lumped into one final category—irregular bones. **Vertebrae** (Fig. 1.20), **facial bones**, **bones of the base of the cranium**, and **bones of the pelvis** are examples of irregular bones.



**Fig. 1.18** Short bones (carpals).



**Fig. 1.19** Flat bones (calvaria).



**Fig. 1.20** Irregular bone (vertebra).

## 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 of 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 and 25 years**.<sup>1</sup> 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 and genetic factors, and disease affect epiphyseal fusion.<sup>1</sup>

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.

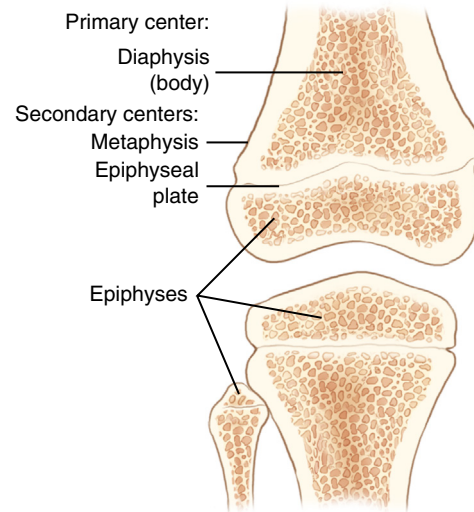


Fig. 1.21 Endochondral ossification.

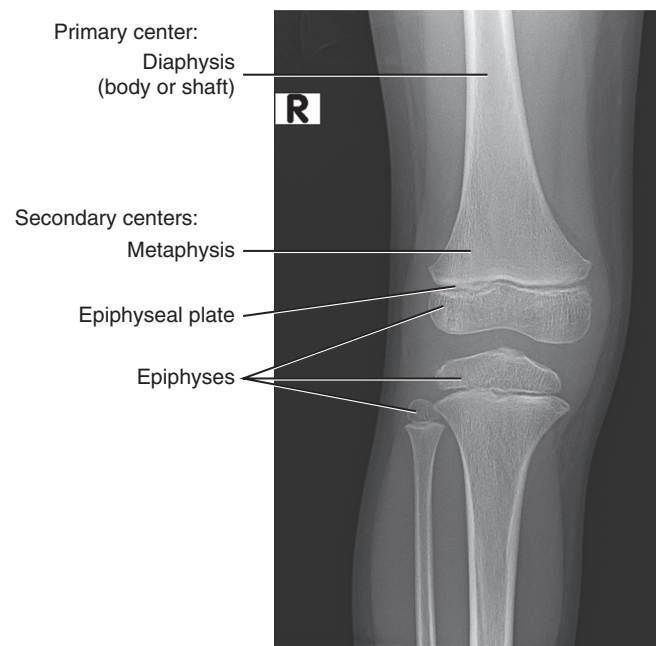


Fig. 1.22 Knee region (6-year-old child).

## 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*<sup>2</sup> 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

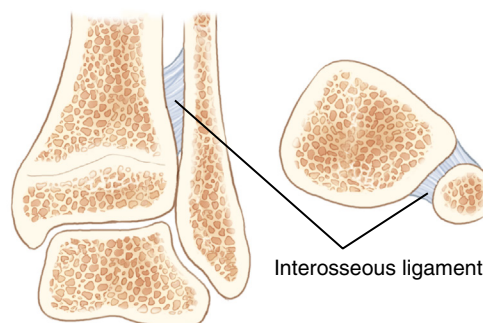
Fibrous joints lack a joint cavity. The adjoining bones, which are nearly in direct contact with each other, are held together by fibrous connective tissue. Three types of fibrous joints are syndesmoses, which are slightly movable; sutures, which are immovable; and gomphoses, a unique type of joint with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

**Syndesmoses**<sup>1</sup> 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.

**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 limited at these articulations; in adults, these are considered **immovable**, or **synarthrodial**, joints.

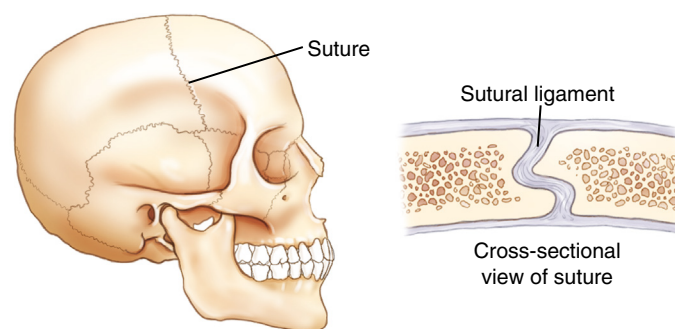
Limited expansion- or compression-type movement at these sutures can occur in the infant skull (e.g., during the birth process). However, by adulthood, active bone deposition partially or completely obliterates these suture lines.

**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 limited movement.



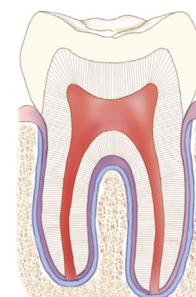
Distal tibiofibular joint

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).

**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).

**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.

### 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.

**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.)

**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.

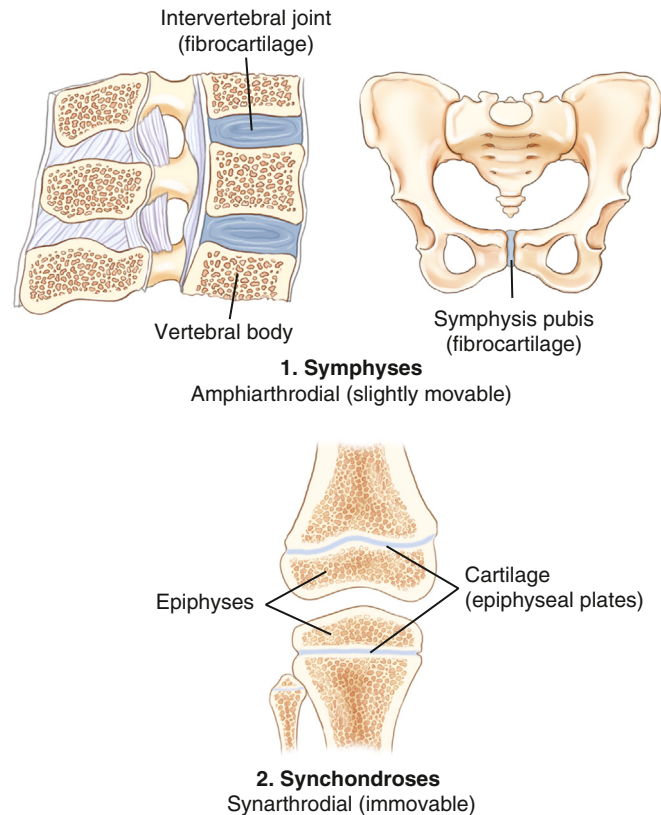


Fig. 1.24 Cartilaginous joints—two types.

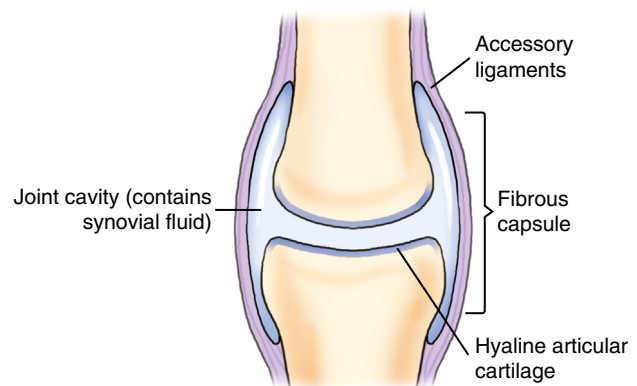


Fig. 1.25 Synovial joints—diarthrodial (freely movable).

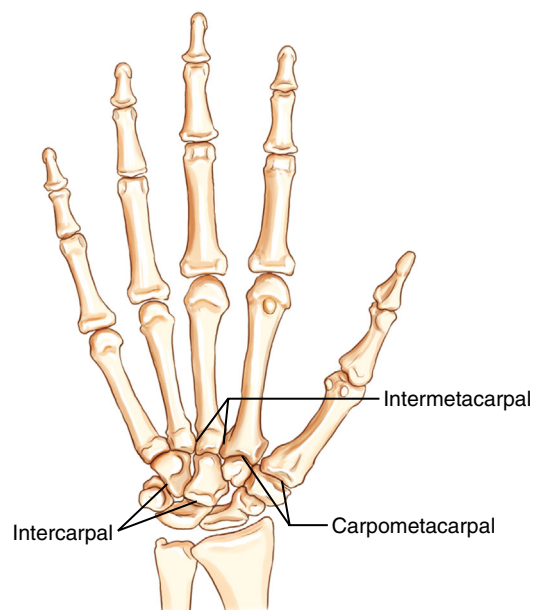


Fig. 1.26 Plane (gliding) joints.

**Ginglymus (hinge) joints** The articular surfaces of ginglymi, or ginglymus (*jīn'-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).

**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 ligaments, forms the ring (Fig. 1.28).

**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.

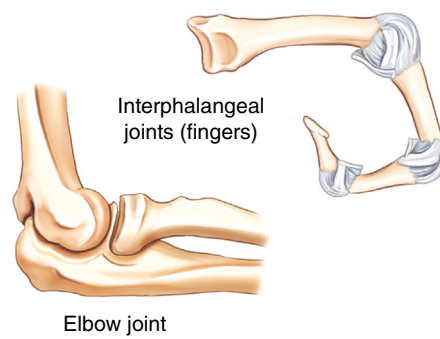
This type of joint allows primarily four directional movements: **flexion and extension** and **abduction and adduction**. **Circumduction** movement also occurs; this results from conelike sequential movements of flexion, abduction, extension, and adduction.

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

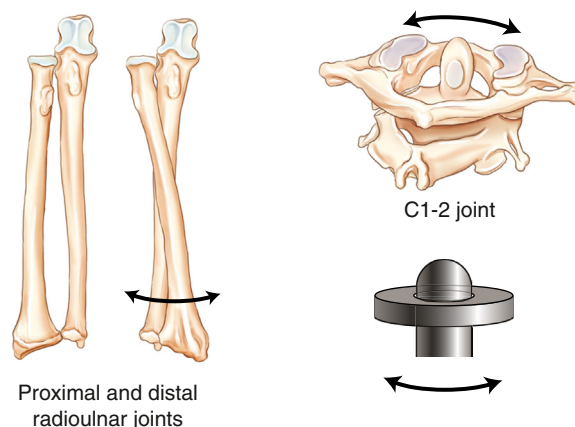
**Saddle (sellar) joints** The term saddle, or *sellar* (*sel'-ar*), describes this joint structure well in that the ends of the bones are shaped concave-convex and are positioned opposite each other (Fig. 1.30). (Two saddle-like structures fit into each other.)

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

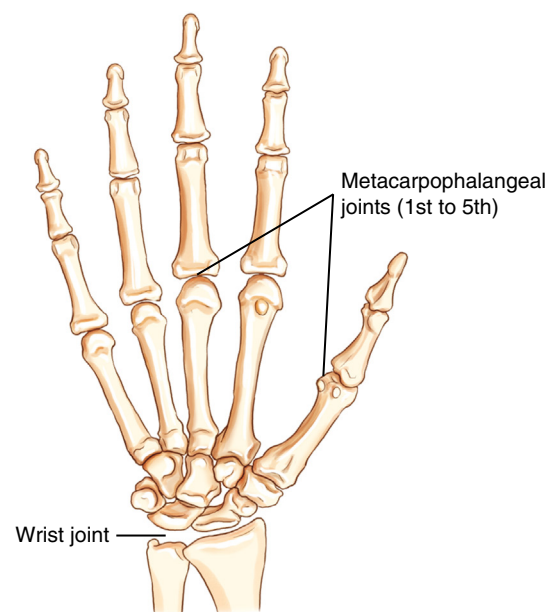
The best example of a true *saddle* joint is the **first carpometacarpal joint** of the thumb. Other sellar joints include the ankle and the calcaneocuboid joints. Although the ankle joint was classified as a ginglymus in earlier references, current references classify it as a saddle joint.<sup>2</sup>



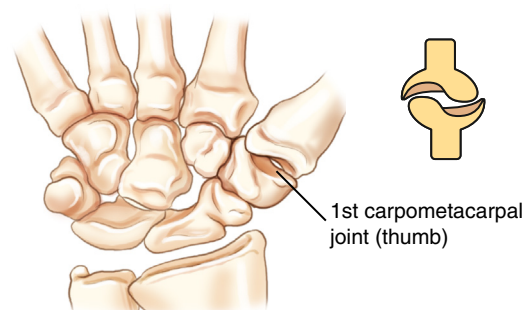
**Fig. 1.27** Ginglymus (hinge) joints.



**Fig. 1.28** Pivot (trochoid) joints.



**Fig. 1.29** Ellipsoid (condylar) joints.



**Fig. 1.30** Saddle (sellar) joints.

**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.

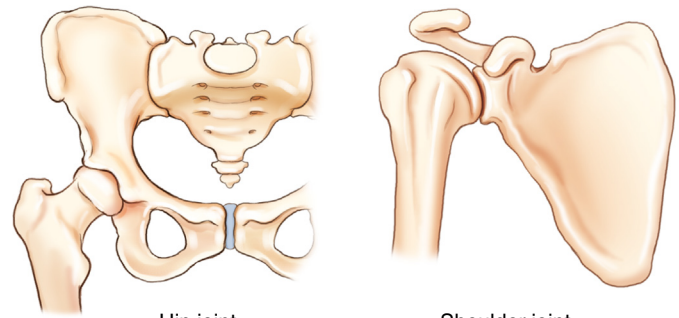
Movements of ball-and-socket joints include flexion, extension, abduction, adduction, circumduction, and medial and lateral rotation.

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

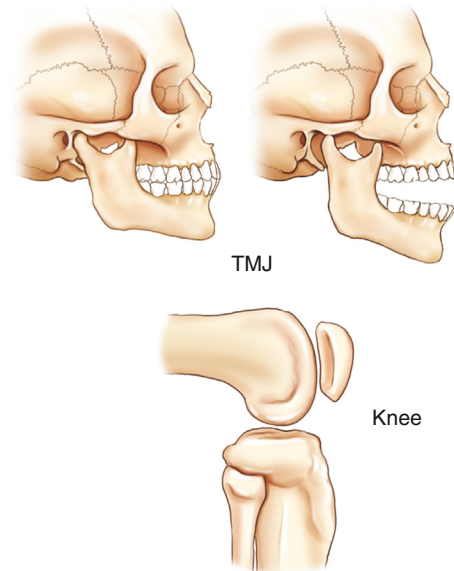
**Bicondylar joints<sup>2</sup>** Bicondylar joints usually provide movement in a single axis, such as flexion and extension. They can permit limited rotation. Bicondylar joints are formed by two convex condyles, which may be encased by a fibrous capsule.

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.



Hip joint                      Shoulder joint  
**Fig. 1.31** Ball-and-socket (spheroidal) joints.



**Fig. 1.32** Bicondylar joints.

TABLE 1.3 SUMMARY OF JOINT CLASSIFICATION				
JOINT CLASSIFICATION	MOBILITY CLASSIFICATION	MOVEMENT TYPES	MOVEMENT DESCRIPTION	EXAMPLES
<b>Fibrous Joints</b>				
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
<b>Cartilaginous Joints</b>				
Symphyses	Amphiarthrodial (slightly movable)	—	—	Intervertebral disks Symphysis pubis
Synchondroses	Synarthrodial (immovable)	—	—	Epiphyseal plates of long bones and between the three parts of the pelvis
<b>Synovial joints</b>				
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 along one axis 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 affect the 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 body style that is slenderer than the sthenic body habitus. Approximately 35% of the population is classified as hyposthenic (Fig. 1.34).
3. **Hypersthenic:** A body style that has a broad frame as compared with the sthenic body habitus. Approximately 5% of the population is classified as hypersthenic (Fig. 1.35).



**Fig. 1.33** Sthenic body habitus.



**Fig. 1.35** Hypersthenic body habitus.



**Fig. 1.34** Hyposthenic body habitus.

4. **Asthenic:** Approximately 10% of the population is thin or slender with a long and narrow body build. Slighter in stature than the hyposthenic patient.

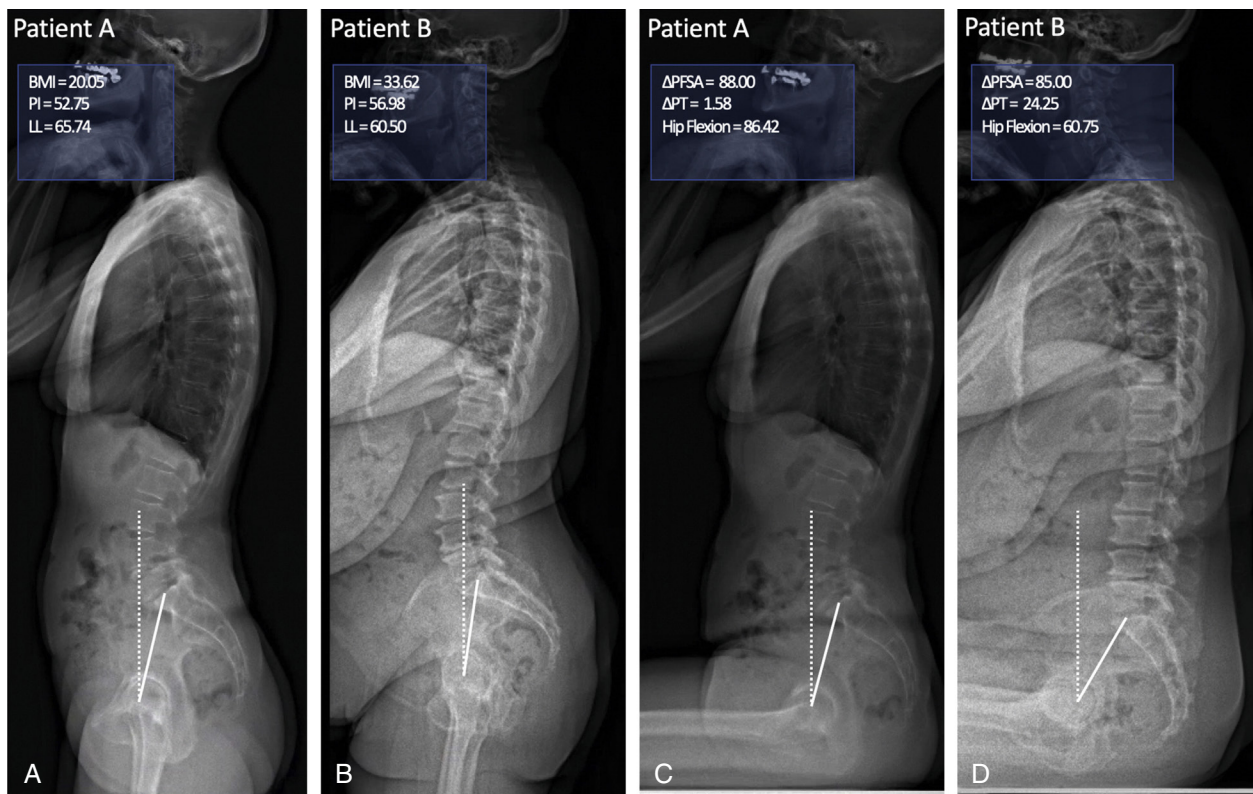
## BARIATRIC PATIENT (OBESITY)

Obesity is defined as "abnormal or excessive fat accumulation that may impair health" and has nearly tripled since 1975 worldwide (Fig. 1.36). In 2016, 650 million adults (18 years or older) were obese. In 2020, 39 million children younger than the age of 5 were overweight or obese.<sup>3</sup>

The term *obesity* is referred to in this text as the "bariatric patient." Bariatrics is a specialty in medicine that deals with the study and treatment of obesity. One frequent definition of bariatrics is the medical service and treatment provided to the obese patient. Even though it has not been considered a body habitus, the bariatric patient brings new challenges to radiographic procedures and image quality evaluation. Fig. 1.37 shows lateral radiographs comparing average with obese patients.



**Fig. 1.36** Bariatric patient (patient with morbid obesity). (iStock/Stocker Things. ID: 1395280044 and 1395814831.)



**Fig. 1.37** Standing lateral radiographs comparing obese and normal patients are shown. (a) Standing alignment of a patient with normal BMI. (b) Standing alignment of a patient with obese BMI. (c) Sitting alignment of a patient with average BMI. (d) Sitting alignment of a patient with obese BMI. (From Buckland AJ, Burapachaisri A, Stekas N, Vasquez-Montes D, Protopsaltis T, Vigdorichik J, et al: Obesity alters spinopelvic alignment changes from standing to relaxed sitting: the influence of the soft-tissue envelope. *Arthroplasty Today* 6[3]:590–595.e1, 2020.)

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