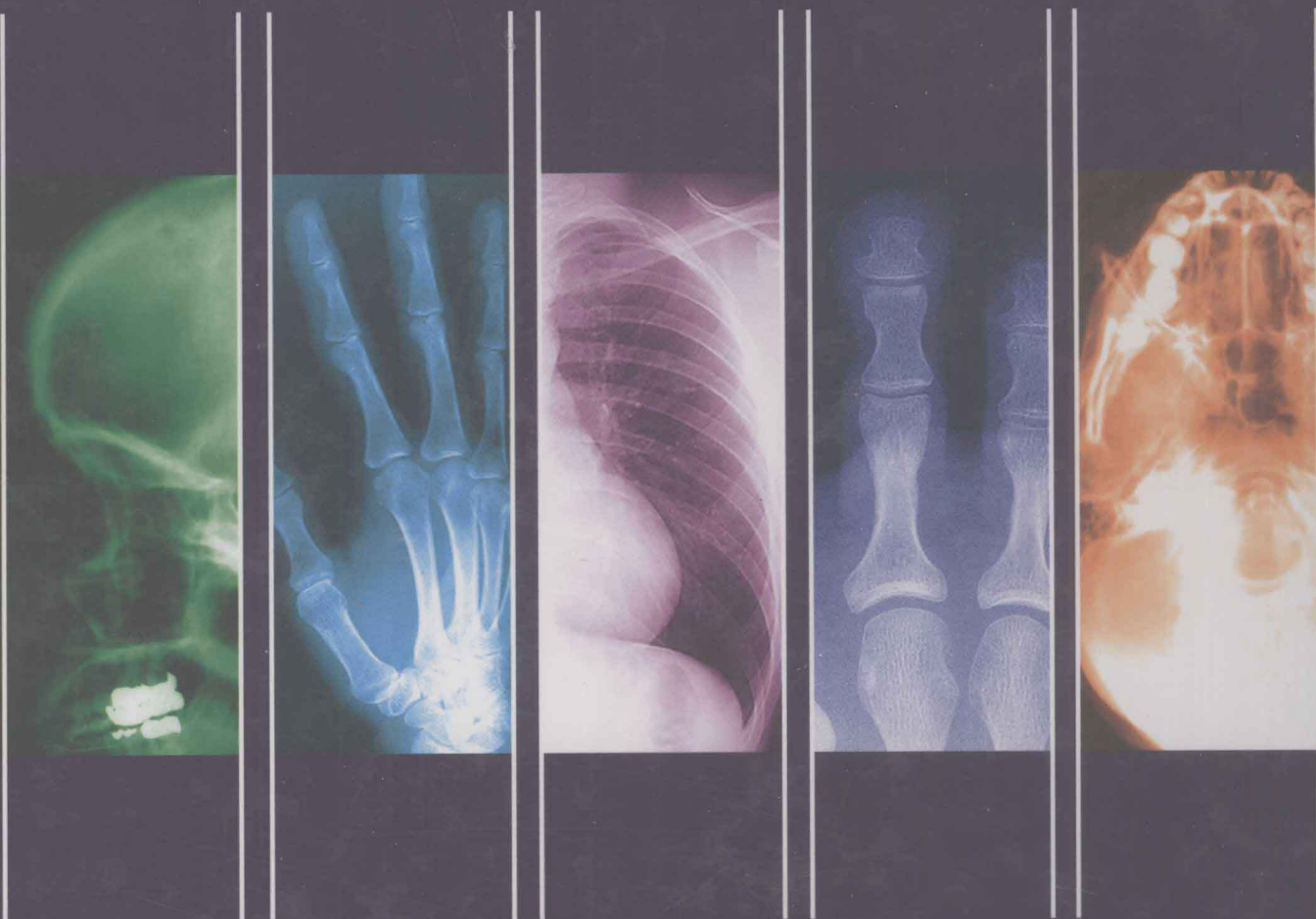


Seventh Edition

TEXTBOOK OF

# Radiographic Positioning and Related Anatomy



Kenneth L. Bontrager  
John P. Lampignano

Seventh Edition

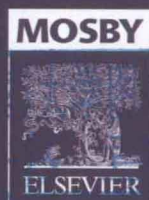
TEXTBOOK OF  
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and Related Anatomy



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藏书章

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*New line drawings by Jeannie Robertson*  
*New photography and radiographic overlays by Jim Winters*



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TEXTBOOK OF  
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# Acknowledgments and Dedication

BY **Kenneth L. Bontrager**

This edition is again the culmination of a team effort by numerous contributors and reviewers. I appreciate more and more the advantage of new editions of the same works with the opportunity to correct, add to, and improve from each previous edition. For this reason, and with increased contributions by specialty contributors and reviewers, I believe this new seventh edition is the latest and best textbook on radiographic positioning available today. This is evident by the worldwide use of this text.

I want to recognize and thank all those contributors and reviewers of this edition and past editions as listed elsewhere in the front matter of this text. I thank each of you for the significant contributions you have made in your area of expertise. Your efforts will be greatly appreciated by the many students, technologists, and educators who will be using this text over the coming years in both English and numerous non-English translations.

I thank **Jeanne Olson**, Publisher; **Rebecca Swisher**, Senior Developmental Editor; and **Karen Rehwinkel**, Senior Project Manager, from Elsevier (Mosby) for their support and assistance in the planning and completion of this complex project. **Jeanne Robertson**, Medical Illustrator, rendered the new line drawings, and **Jim Winters** completed the new labeled overlays for radiographs for the positioning pages. Each of these persons, along with other graphics personnel at Elsevier, have been very helpful and encouraging and have functioned well as a team to meet author and editor requests, including the new art with complex color graphics for this new edition.

**John Lampignano**, who has been a key contributor for several past editions and co-author for the last edition, is a gifted and popular RT educator with keen knowledge and an astute memory of anatomy, positioning, and imaging facts and principles. I have been blessed by working with him and experienced first hand his exceptional dedication and work ethic as applied to each task and

assignment that he has undertaken. I'm pleased and honored that he has joined me as co-author of this textbook, workbooks, and pocket handbook.

Lastly, as always, I am most indebted to my family—not only for their love, support, and encouragement but also for their assistance in the various production aspects of these works. My wife, **Mary Lou**, as my life partner, continues to be my most valuable assistant and helpmate. Our two sons, **Neil** and **Troy**, not only literally grew up with “the book” but also spent time between their college years and thereafter in the graphics and literal page-by-page layout of early editions of this textbook and accompanying ancillaries. I thank each of them for their continuing help, support, and advice, and I'm happy that both of them can experience the satisfaction of knowing that they are making a difference in the careers they have chosen.

I thank our two daughters-in-law, **Kim** and **Robyn**, for joining the Bontrager family and thus also becoming part of the family publishing efforts. I sincerely thank both of them for their continuing help and support and also for giving us those special grandchildren, **Hallie**, **Alexis**, **Ashton**, and **Jonathan**. I love and appreciate each and every one of you very much and I dedicate this edition to my family.

Finally, as I look back over the past 40 plus years of my involvement in radiologic technology education, I realize that my most significant contributions to this field may be behind me. Therefore I dedicate this book to those future generations of students who will be learning from this text, and to those educators and graduate technologists who will be helping these students reach their goal of serving in a helping profession and thus making a difference, each in their own way.

**KLB**

# Acknowledgments and Dedication

BY **John P. Lampignano**

First, I must acknowledge the current and past Diagnostic Medical Imaging students from GateWay Community College. Their thirst for knowledge has driven me to ensure that we write the most complete and accurate text possible. They remain my inspiration. This text is a reflection of each student's dedication to the profession that we love dearly.

The Diagnostic Medical Imaging and Therapy faculty at GateWay are outstanding role models for the students and the profession. **Mary Carrillo, Nancy Johnson, Bradley Johnson, Manjusha Namjoshi, Bryan Dodd, Nicolle Hightower, Jeanne Dial, Sue Hoyle, and Julia Jacobs** were instrumental in contributing to this text, providing images, and allowing us to use the imaging labs for many photo shoots. Special thanks to **Jerry Olson** for teaching me radiography over 30 years ago and for his assistance during this project. Jerry continues to inspire students that he touches through his positive and mentoring spirit. Special thanks also to **Mark Richard** for being my spiritual leader each day.

The contributing authors for the seventh edition did an outstanding job in updating the content for numerous chapters. Special thanks to each of them for making this edition truly reflective of the current practice in medical imaging.

**Ken Bontrager**, with the help and support of his family, has been dedicated to this text and other instructional media in radiologic technology for over 40 years. They have given of themselves fully to this text and its ancillaries; it has always been more than just another project to them. As a co-author, I will dedicate myself to maintaining the same standards as have been established by Ken and his wife, **Mary Lou**. Ken has taken the time to develop me as an author. His mentoring has always been positive, gentle, and constant. To be tutored by one of the best humbles me and I'm grateful to have been given this opportunity to work with Ken. Ken Bontrager is a true pioneer of the profession. His impact on the practice of diagnostic imaging has been deep, especially for our students. I hope the profession never forgets Ken Bontrager and his contributions.

Special thanks to **Toni Homa**, Supervisor Diagnostic Imaging Clinical Instructor at Maricopa Integrated Health Systems, who was a tremendous help in gathering images for us. **Dan Hobbs** not only edited three chapters but provided many of the new images used in the seventh edition. Dan also contributed numerous new

positions to this edition. My thanks to **Cindy Murphy, Joseph Popovitch, Dan Ferlic, and Leslie Kendrick** for providing a vast number of photographs and images used in this edition.

Countless photographs and illustrations were created for or replaced in the seventh edition. This feat would not have been possible without the special talents of **Jim Winters** and **Paul Sebring**. Their photography, imagination, and creativity are imprinted throughout this edition. Special thanks to **Jeanne Robertson** for redesigning every piece of art in the seventh edition and to **John Gulley** and **Cody J. Haren** for graphic design assistance. Thanks to **Megan Accordino, Laura Ballard, Barbie Childs, Ramon Thomas, Kaia Remme, and Adeline Nichols** who served as models for many of the photographs taken for this seventh edition. They maintained a high degree of professionalism and patience throughout the process.

I was pleased to have **Rebecca Swisher**, Senior Developmental Editor for Elsevier, work with us once again. Becky was an incredible source of encouragement and drive to keep us on task and to do our very best work. I hope young writers find such an individual as they begin their careers. **Jeanne Olson**, Publisher, has been a special friend to Ken and me for numerous editions. She treats us with professionalism and compassion. My deep thanks to **Karen M. Rehwinkel**, Senior Project Manager, for her expertise and patience during the editing phase of the text and ancillaries.

Finally, thanks to my wonderful family for their ongoing support. **Deborah, Daniel, and Molly** have provided me with unconditional love and encouragement to meet every task that I have faced in my life, including this text. I'm especially proud that Daniel and Molly have entered the medical profession. They are both excellent professionals and understand the importance of treating their patients with dignity and compassion. Deborah has been at my side for over 30 years. What a kind and generous soul! She is the anchor that holds our family together.

My true inspiration is my granddaughter, **Tatum**, who has changed my life in many new and profound ways. 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. I dedicate this edition to her.

**JPL**

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# Preface

## Purpose and History

Early in my teaching career, first at a hospital-based program and then at a citywide college-affiliated program in radiologic technology, I discovered that other allied health programs were far ahead of us in the type and quality of instructional media available in their fields of study. We had no audiovisuals or teaching ancillaries at that time, and many of our textbooks were outdated, incomplete, and difficult to read and comprehend. In the late 1960s and early 1970s, as I was completing my graduate degree in education and instructional media, I began to develop audiovisuals and self-paced instructional programs for my students, which later turned out to be the first commercially available programmed audiovisual education media in radiologic technology. I chose as my subject radiographic anatomy and positioning because it is the one subject that all radiography students need to master.

This comprehensive audiovisual series was soon being widely used throughout the United States and Canada. It became apparent, however, that students also needed a thorough, clearly written, and easy-to-understand textbook on the important subject of radiographic anatomy and positioning. In the early 1980s the first edition of this textbook took shape, and it too was soon being widely used to supplement our audiovisual self-paced instructional series. Students and instructors now for the first time had access to a complete multimedia audiovisual package, a two-volume student workbook, an instructor's manual, and a new, comprehensive, but clearly written textbook.

Thus began my writing and publishing career 35 plus years ago. Our motivation for writing and developing instructional media remains the same today—to provide students and instructors with thorough, easy-to-use resources that are current and necessary for understanding radiographic anatomy and routine positioning. All imaging technologists should also be familiar with those special radiographic procedures and other newer imaging modalities that are in use in modern imaging departments today.

KLB

## Unique Features

### DISTINCTIVE PRESENTATION

We believe the most unique and distinctive feature of this *Textbook of Radiographic Positioning and Related Anatomy* is its “show-and-tell” style of presentation. We have used the principle of presenting information from simple to complex, from known to unknown, and showing what is being talked about as it is being described. This maximizes the potential for comprehension and retention. Most of us remember best through mental images; we remember much more of what we see than what we hear. When we see with our eyes and *hear* as we read and *do* as we complete the positioning and workbook exercises, we gain the greatest opportunity for understanding and retaining what we have learned.

## ALTERNATIVE MODALITIES, PATHOLOGY, AND POSITIONING

Today's health care workers are expected to expand their roles and be more “cross-functional” in their duties and responsibilities. Therefore all imaging technologists should understand at least the **basic principles** and the **possible procedures and exams** that can be performed in each of the imaging modalities. With these expanding roles for technologists also comes more responsibility for determining and understanding the **clinical** and **pathologic indications** for the exam or procedure being ordered. Technologists are expected to do more than just position a patient to demonstrate the anatomic part being examined per the order chart or exam requisition. They need to understand **why** the procedure is being ordered to ensure that the best projections or positions are obtained. They also need to know which pathologies affect the exposure factors required. Evaluating and critiquing obtained radiographic images requires knowledge and some understanding of how that disease or condition should appear on the radiographic image.

## New to This Edition

The seventh edition has significant additions, improvements, and changes. Imaging factors and technical considerations have largely been moved from the various chapters and consolidated into Chapter 2, **Image Quality, Digital Technology, and Radiation Protection**. Concepts related to manual and digital imaging, grids, radiographic quality factors, and radiation protection have been placed into Chapter 2. This will provide a central resource for these principles and concepts.

Certain additional projections have been added to this seventh edition. These projections have been researched and found to be valuable as alternative projections that are commonly performed in various clinical environments. Specifically, several new projections for the humerus and shoulder girdle and the lower limb have been added as follows.

- Chapter 6, **Humerus and Shoulder Girdle**
  - *Transthoracic lateral humerus projection*
  - *Inferosuperior axial shoulder projection (Clements modification)*
  - *Superoinferior axial shoulder projection (Hobbs modification)*
- Chapter 7, **Lower Limb**
  - *PA axial weight-bearing knee projection (Rosenberg method)*
  - *PA axial projection for intercondylar fossa (variations of Holmblad method)*
  - *Superoinferior Sitting Tangential projection for patellofemoral joint space*
- Chapter 16, **Gallbladder and Biliary Ducts**, has been eliminated as a separate chapter in this seventh edition. With oral cholecystography (OCG) no longer being commonly performed today, content from this chapter has been either removed or

relocated to other chapters. The anatomy and pathology of the biliary system has been placed in Chapter 14, now titled, **Biliary Tract and Upper Gastrointestinal System**. Advanced procedures such as T-tube cholangiography and ERCP have been placed in Chapter 22, **Additional Diagnostic Procedures**. Thus the total number of chapters for the seventh edition has been reduced from 24 to 23 chapters.

Over 150 **positioning photographs** have been replaced in the seventh edition. These new photos provide an updated look to this seventh edition and demonstrate new positions and projections. Essentially all of the **anatomy art** has been replaced in each chapter to provide clearer identification of anatomy.

Most of the **labeled line drawings** in the positioning pages have been replaced with labeled overlays of the final radiograph. This assists students in reviewing radiographic anatomy and also aids in learning to critique the completed image. Students will thus learn to examine these images for possible positioning and exposure errors and also how to recognize those desirable positioning qualities for each specific projection.

The authors and contributors believe the changes and improvements in this seventh edition will enhance learning and reflect current clinical practice.

## Ancillaries

### WORKBOOK

The **two-volume workbook** set has been fully revised to coordinate with all the changes in the seventh edition of this textbook. This edition contains new learning-exercise and self-test questions, including more situation-based questions and new questions on digital imaging. New advanced imaging questions have been added to the review exercises, along with the self-tests. All questions have been reviewed by a team to ensure the accuracy of the content and answers.

### EVOLVE INSTRUCTOR RESOURCES

A **computerized test bank** is available on Evolve (<https://evolve.elsevier.com>) to instructors who use this textbook in their class-

rooms. 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 both ExamView and document formats.

Also available on Evolve is an **electronic image collection** featuring over 2700 images that are fully coordinated with the seventh edition textbook and workbooks. 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 coincides with the text, as well as complete Lesson Plans for each chapter.

## HANDBOOKS

**Bontrager's Pocket Handbook** The new seventh edition revised pocket handbook by Ken Bontrager, now also co-authored with John Lampignano, 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 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 Bontrager/Lampignano text and workbooks, 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 BAR** The projection title bar describes the specific position/projection to be radiographed, including the proper name of the position, if such applies.
- 2 PATHOLOGY DEMONSTRATED** The pathology demonstrated section gives a summary of conditions or pathologies that may be demonstrated by the exam and/or projection. This summary helps the technologist understand the purpose of the exam and which structures or tissues should be most clearly demonstrated.
- 3 PROJECTION SUMMARY BOX** The projection summary box lists all the specific **basic** or **special projections** most commonly performed for that body part. The projection highlighted in blue is the projection described on that page.
- 4 TECHNICAL FACTORS** The technical factors section lists the technical factors for the projection. Technical factors include the **image receptor (IR) size** recommended for the average adult; whether the IR should be placed **crosswise** or **lengthwise** in relation to the patient; a **grid**, if one is needed; and the **kV range** for the projection.
- 5 TECHNIQUE AND DOSE BAR** The technique and dose bar summarizes a suggested starting technique for the projection for an average adult and the **approximate patient dose** for the exposure and the size of the exposure field. This is given in millirads of skin dose, midline dose, and specific radiosensitive organ dose. See Chapter 2, p. 67, for a more complete discussion of patient dosages.
- 6 IMAGE RECEPTOR ICON** The image receptor icon gives a visual display of the IR relative size (cm) and orientation (crosswise or lengthwise), patient ID blocker location, relative collimated field size, location of R and L markers, and the recommended AEC cell location if AEC is used.
- 7 SHIELDING** The shielding section describes shielding that should be used for the projection. See Chapter 2, p. 65, for more information on specific area shielding.
- 8 PATIENT POSITION** The patient position section indicates the **general body position** required for the projection.
- 9 PART POSITION** The 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.
- 10 CENTRAL RAY** The central ray section provides a description of the **precise location of the CR** in relation to both the IR and the body part. The **minimum SID** (source-to-image receptor distance) is listed. See Chapter 2, p. 45 for the advantages of increasing the SID from 40 inches (100 cm) to 44 or 48 inches (110 to 120 cm) for general tabletop procedures.
- 11 COLLIMATION** The collimation section describes the collimation of the x-ray field recommended for that projection.
- 12 RESPIRATION** The respiration section lists the breathing requirements for that projection.

186 CHAPTER 6 HUMERUS AND SHOULDER GIRDLE
1

**AP PROJECTION—INTERNAL ROTATION: SHOULDER (NONTRAUMA)**


**6** **Warning:** Do NOT attempt to rotate arm if fracture or dislocation is suspected (see trauma routine).

**2** **Pathology Demonstrated**  
Fractures and/or dislocations of the proximal humerus and the shoulder girdle may demonstrate calcium deposits in the muscles, tendons, or bursal structures. Some pathology, such as osteoporosis, osteoarthritis, and bony tumors, also may be evident.

**4** **Technical Factors**  
• IR size—24 × 30 cm (10 × 12 inches), crosswise (or lengthwise to demonstrate entire humerus if injury includes proximal half of humerus)  
• Moving or stationary grid  
• 70 ± 5 kV range  
• Technique and dose: 


cm	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
rad	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120

**3** **Shoulder (nontrauma) BASIC**  
• AP internal rotation (AP)  
• AP internal rotation (lateral)

**5** 

**7** **Shielding** Shield pelvic area.

**8** **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.


**9** **Part Position**   
• Position patient to center scapulohumeral joint to center of IR.  
• Abduct extended arm slightly, then **internally rotate** arm (prone hand) until epicondyles of distal humerus are perpendicular to IR.


**10** **Central Ray**  
• CR perpendicular to IR, directed to 1 inch (2.5 cm) inferior to coracoid process (see Note on preceding page)  
• Minimum SID of 40 inches (100 cm)


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

**12** **Respiration** Suspend respiration during exposure.

**13** **Radiographic Criteria**  
**Structures Shown:** • Lateral view of proximal humerus and lateral two-thirds of the clavicle and upper scapula are demonstrated, including the relationship of the humeral head to the glenoid cavity.  
**Position:** • Full internal rotation position is evidenced by the 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 and CR:** • Collimation should be visible on four sides to area of affected shoulder. • CR and center of the collimation field should be at scapulohumeral joint.  
**Exposure Criteria:** • Optimal density and contrast with no motion will demonstrate clear, sharp bony trabecular markings with soft tissue detail visible for possible calcium deposits.

**14** 

**15** 

**16** 

**Fig. 6-40.** Internal rotation-lateral.

**Fig. 6-41.** Internal rotation-lateral.

**Fig. 6-42.** Internal rotation-lateral.

- 13 RADIOGRAPHIC CRITERIA BOX** The radiographic criteria box describes the four-step evaluation/critique process that should be completed for each processed radiographic image. This process is divided into four categories of information as related to the following: (1) **structures that should be shown**; (2) **evidence of correct positioning**; (3) **correct collimation and CR location**; and (4) **acceptable exposure factors**.
- 14 POSITIONING PHOTOGRAPH** The positioning photograph demonstrates the correct patient and part position in relation to the CR and IR.
- 15 RADIOGRAPHIC IMAGE** The radiographic image demonstrates a correctly positioned and correctly exposed radiographic image of the featured projection.
- 16 ANATOMY OVERLAY IMAGE** This labeled overlay image indicates and interprets the specific anatomy that should be visible on the radiographic image shown for this position.

TEXTBOOK OF  
Radiographic Positioning  
and Related Anatomy



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# General Anatomy, Terminology, and Positioning Principles

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## 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. Radiographic study of the human body, however, is primarily a study of the anatomy of the various systems with lesser emphasis on the physiology. Consequently, anatomy of the human system will be emphasized in this radiographic anatomy and positioning textbook.

**Note:** Phonetic respelling\* of anatomic and positioning terms is included throughout this text to facilitate correct pronunciation of those 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**

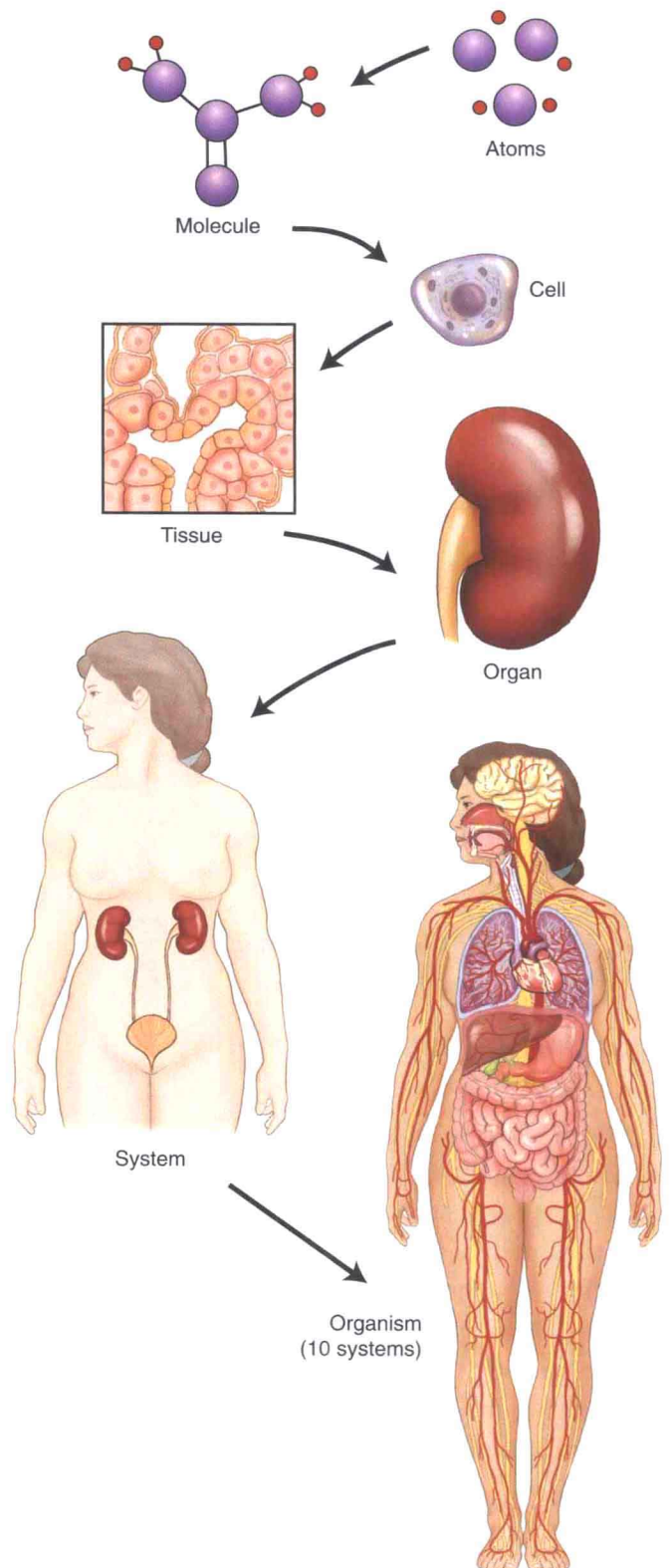
When complex assemblies of tissues are joined to perform a specific function, the result is an organ. Organs usually have a specific shape. Examples of organs of the human body are the kidneys, heart, liver, lungs, stomach, and brain.

**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. A total of **10 individual body systems** constitute the total body.

**Organism**

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



**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 is an important system for the technologist to study. 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. To support and protect many soft tissues of the body
2. To allow movement through interaction with the muscles to form a system of levers
3. To produce blood cells
4. To store calcium

#### Circulatory System

The circulatory system 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. To distribute oxygen and nutrients to the cells of the body
2. To carry cell waste and carbon dioxide from the cells
3. To transport water, electrolytes, hormones, and enzymes
4. To protect against disease
5. To prevent hemorrhage by forming blood clots
6. To help regulate body temperature

#### Digestive System

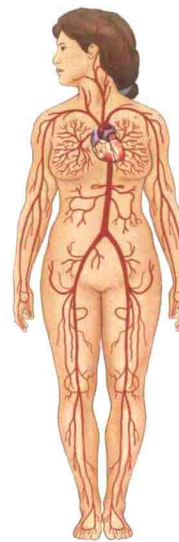
The digestive system includes the alimentary canal and certain accessory organs. The alimentary canal is made up of the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus. Accessory organs of digestion include the salivary glands, liver, gallbladder, and pancreas.

The twofold function of the digestive system is as follows:

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



Fig. 1-2. Skeletal system.



Cardiovascular organs



Lymphatic organs

Fig. 1-3. Circulatory system.

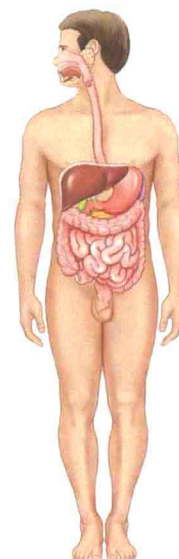


Fig. 1-4. Digestive system.