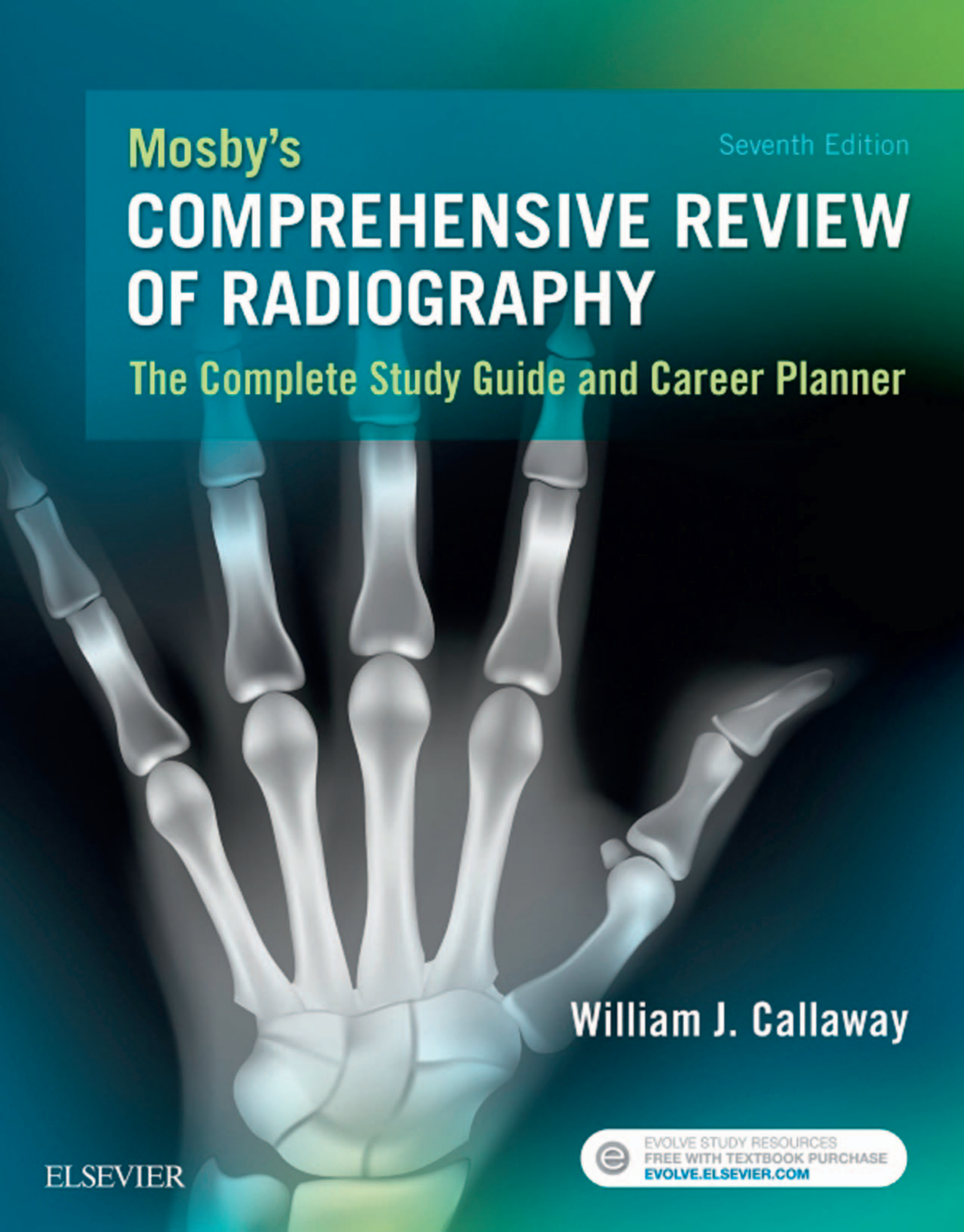


Mosby's

Seventh Edition

COMPREHENSIVE REVIEW OF RADIOGRAPHY

The Complete Study Guide and Career Planner



William J. Callaway

ELSEVIER



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

evolve

ELSEVIER

YOU'VE JUST PURCHASED MORE THAN A TEXTBOOK!*

Evolve Student Resources for *Callaway: Mosby's Comprehensive Review of Radiography: The Complete Study Guide and Career Planner, Seventh Edition*, include the following:

- Radiography Practice Exams
- Flashcards
- Sample Resumes and Cover Letters



Activate the complete learning experience that comes with each *NEW* textbook purchase by registering with your scratch-off access code at

<http://evolve.elsevier.com/Callaway/radiography/>

If you purchased a used book and the scratch-off code at right has already been revealed, the code may have been used and cannot be re-used for registration. To purchase a new code to access these valuable study resources, simply follow the link above.

Place Peel Off
Sticker Here

REGISTER TODAY!

You can now purchase Elsevier products on Evolve!
Go to evolve.elsevier.com/html/shop-promo.html to search and browse for products.

* Evolve Student Resources are provided free with each *NEW* book purchase only.

Mosby's Comprehensive
Review of Radiography

*The Complete Study Guide
and Career Planner*

Seventh Edition

This page intentionally left blank

Mosby's Comprehensive Review of Radiography

The Complete Study Guide and Career Planner

Seventh Edition

William J. Callaway, MA, RT(R)

Radiography Educator, Author, Speaker
Springfield, Illinois

ELSEVIER

ELSEVIER

3251 Riverport Lane
St. Louis, Missouri 63043

MOSBY'S COMPREHENSIVE REVIEW OF RADIOGRAPHY:
THE COMPLETE STUDY GUIDE AND CAREER PLANNER,
SEVENTH EDITION

ISBN: 978-0-323-35423-3

Copyright © 2017 Elsevier Inc. All Rights Reserved.
Previous editions copyrighted 2013, 2008, 2006, 2002, 2000, 1998, 1995.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies, and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency can be found at our website: www.elsevier.com/permissions.

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods, they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

With respect to any drug or pharmaceutical products identified, readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of practitioners, relying on their own experience and knowledge of their patients, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data

Callaway, William J. (William Joseph), 1951- , author.
Mosby's comprehensive review of radiography : the complete study guide and career planner /
William J. Callaway. -- Seventh edition.
p. ; cm.
Comprehensive review of radiography
Includes bibliographical references and index.
ISBN 978-0-323-35423-3 (pbk. : alk. paper)
I. Title. II. Title: Comprehensive review of radiography.
[DNLM: 1. Radiography--Examination Questions. 2. Technology, Radiologic--
Examination Questions. 3. Vocational Guidance--Examination Questions. WN 18.2]
RC78.17
616.07'572076--dc23

2015036336

Content Strategist: Sonya Seigafuse
Content Development Manager: Billie Sharp
Content Development Specialist: Sarah Vora
Publishing Services Manager: Hemamalini Rajendrababu
Senior Project Manager: Kamatchi Madhavan
Design Direction: Ashley Miner

Printed in United States of America

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



Working together
to grow libraries in
developing countries

www.elsevier.com • www.bookaid.org

About the Author

William J. Callaway, MA, RT(R), has been involved in radiography education for more than 40 years. He has directed both collegiate associate degree and hospital-sponsored radiography programs in addition to teaching the subjects covered in this text. He is co-author of *Introduction to Radiologic Technology*, also published by Elsevier, and has had writings published in state and national radiologic technology journals. Mr. Callaway has held elected office in the Association of Collegiate Educators in Radiologic Technology (ACERT) and the Association of Educators in Imaging and Radiologic Sciences (AEIRS).

He is widely known for his conference presentations for students, educators, and practicing technologists at international, national, state, and local radiologic technology meetings. He has given more than 500 presentations, which include “Pass It the First Time: Preparing for the Certification Exam”; “And You Thought X-Ray Physics Had to Be Boring!”; “It’s More Than a Smile: A Fresh Perspective on Patient Care”; “Giving Effective Conference Presentations”; and “Win That Job!”

This page intentionally left blank

To our family's next generation, our grandchildren:

*Alex, Kailin, Mariab, Jacob, Mikella,
Makenna, Troy, Madalyn, and Freddy*

This page intentionally left blank

Reviewers

Karen Callaway, MA, SPHR

Executive Vice President, Organizational Strategy
H.D. Smith
Springfield, Illinois

Mary Ellen Carpenter, MA, RT(R)(CV)(CT)

Radiography Program Directory
Essex County College
Newark, New Jersey

Tammara M. Chaffee, M.Ed, RT(R)(M)

Assistant Professor
Dona Ana Community College
Las Cruces, New Mexico

Tiffany Goodwin, RT(R)

Radiologic Technologist
Poplar Bluff, Missouri

Jim Partin, RT(R)

Radiology Instructor
Spencerian College
Louisville, Kentucky

Anna N. Phillips, MS, RT(R)(CT)

Department Head
Radiography
Randolph Community College
Asheboro, North Carolina

Jeannean Hall Rollins, MRC, RT(R)(CV)(ARRT)

Associate Professor
Medical Imaging and Radiation Sciences
Arkansas State University
Jonesboro, Arkansas

Breanna Wright

Radiologic Technologist Student
Medical Imaging and Radiologic Sciences
Arkansas State University
Jonesboro, Arkansas

This page intentionally left blank

Preface

Content and Organization

Completely updated for the latest certification exam specifications, *Mosby's Comprehensive Review of Radiography* is designed for students as a study guide throughout their radiography education and as a review book as they prepare to take the Registry examination.

Part I begins right where students need to begin, guiding them through an assessment of their study skills and time management, both critical to success in the radiography program and reviewing. The complete topic outline of the radiography exam administered by the American Registry of Radiologic Technologists (ARRT) is provided to help students visualize the breadth of information they need to master. Tips on answering questions ensure that students will be able to manage the styles of questions they will encounter on the ARRT exam.

The highlight of Part I is a comprehensive review, in outline form, of the major content areas covered on the ARRT exam in radiography. Each content review is followed by a set of 100 questions related specifically to that topic. After students have reviewed all subject areas, they are ready to take the three 200-question challenge tests in [Chapter 6](#). All questions are written in formats used by the ARRT. Answers and rationales for the review questions and challenge tests are provided in the appendix.

To prepare students to master the material and be fully prepared for the Registry exam, the Evolve website that accompanies the text provides hundreds of additional questions based on the Registry exam content outline and written in formats used by the ARRT.

Unlike other review books, *Mosby's Comprehensive Review of Radiography* also serves students as a career planner. Part II, Career Planning, provides students the opportunity to inventory their interests and set goals for professional development. It gives suggestions for satisfying professional continuing education requirements. Valuable information and resources on radiologic specialties and academic degrees are presented to further assist students with career planning. Part II also offers examples of actual resumes and important information and tips on interviewing. To further ease the transition into the health care workplace, Part II describes employer expectations in detail. No other book provides all of this valuable information to help students make the transition into their careers as practicing radiographers.

New Content and Features

This new edition is written to the latest radiography exam content specifications used by the ARRT effective January 1, 2017, making this the most up-to-date review book available. Coverage of digital imaging, already included in previous editions, has been once again updated to reflect its importance on the certification exam. The relative number of questions asked in each of the four new ARRT content categories has been updated in the challenge tests in chapter 6 as well as the tests on Evolve. New ARRT question formats are included, such as exhibits, sorted list, multi-select, and combined response. The relative number of questions asked in each of the four new ARRT content categories has been updated in the challenge tests in chapter 6 as well as the tests on Evolve. New ARRT question formats are included, such as exhibits, sorted list, multi-select, and combined response.

One of the most popular features of this study guide is the material available on the Evolve website. Those questions can be accessed anywhere the student has Internet access, whether at home or in the palm of the hand. These questions are designed to simulate the computer-based exam administered by the ARRT. In tutorial mode, students may answer hundreds of multiple-choice questions for each ARRT content area. Rationales and study tips provide immediate feedback, and questions can be bookmarked for later reference. In test mode a virtually unlimited number of randomly generated 200-question multiple-choice exams are available.

These resources make this the premier radiography review book and study guide, all in one product.

How to Use This Book

This study guide is particularly effective for use throughout the radiography program. The content outline may be referenced as a supplement to courses in the radiography curriculum. The study questions are excellent aids to learning in all of the subject areas.

As a review book, this text provides a logical, well-thought-out approach to preparing for the Registry exam. The content outline, so effective throughout the educational program, is particularly appreciated at review time. Content that may be tested is presented in a format that is easy to use and understand. Because I teach these subjects, my

approach to the reader is the same as if class were being held each time the book is opened. I have provided rationales to answers where appropriate. In most cases, I provide key points regarding the answer, study suggestions, or both. For other questions, such as labeled drawings or radiographs, the answers may be obvious and do not require a detailed explanation. You will also encounter facts asked in multiple ways, challenging you to think about information in different ways. This will help prepare you for whatever form the questions may be asked on the certification examination and will also reinforce the material by causing you to interact with it more than once. In any case, be sure to return to the chapter and use the study outline for detailed review and to reinforce concepts, facts, and illustrations that need extra attention.

Care has been taken to create questions that cover the primary information taught in radiography programs and that are therefore relevant to the ARRT exam. This philosophy, coupled with the outline form, helps students make optimal use of study time. Explanations of answers are written in the same style I use in my own classes. This student-friendly approach will be appreciated for its direct communication to the users of this text. Students who have difficulty understanding an answer are advised to return to the study guide for additional review. This text should not be viewed as a substitute for a textbook or coursework that comprehensively covers a subject area.

A final note on the use of this guide: Variation in the details of test content occurs across certification exams. Therefore inclusion of specific information in this guide does not guarantee that it will be tested, and the exclusion of certain information is not meant to suggest its absence from the exam. The ARRT does not review, evaluate, or endorse

publications. Permission to reproduce ARRT copyrighted materials within this publication should not be construed as an endorsement of the publication by the ARRT.

Acknowledgments

Elsevier once again assembled a great team to bring this project to fruition. Special acknowledgment goes to Sonya Seigafuse and Billie Sharp for their leadership and enthusiastic support of this text. Sarah Vora provided expert editing, as well as guided manuscript development throughout this entire project. Kamatchi Madhavan moved the project toward completion by providing copyedited chapters and page proofs in a timely and workable manner. Given the talents of the entire Elsevier staff, any errors or omissions from this book are solely mine.

I extend my thanks to the hundreds of educators and tens of thousands of students who have used this text and given it their overwhelming support. Their positive comments and suggestions have been incorporated and make it better than ever. I express my sincere appreciation to the reviewers for going over this text line by line and question by question.

Very special recognition goes to my family for their love and support of my professional endeavors, from speaking to writing. Thanks to my wife, Karen; our children Amy, Cara, David, Adam, and Kim; and our grandchildren Alex, Kailin, Mariah, Jacob, Mikella, Makenna, Troy, Madalyn, and Freddy. A very special recognition goes to Tootsie for keeping me company during extended hours at the computer.

William J. Callaway

Contents

Part I: Review and Study Guide 1

- 1 Preparation for Review 2
- 2 Patient Care 15
- 3 Safety 39
- 4 Image Production 58
- 5 Procedures 91
- 6 Challenge Tests 154

Part II: Career Planning 195

- 7 Career Paths 196
- 8 Writing a Professional Resume 210

- 9 Interviewing Techniques 217

- 10 Employment Expectations 221

Appendixes

- Answers to Review Questions 228

- Bibliography 250

- Illustration Credits 251

- Index 252

Please note:

The ARRT does not review, evaluate, or endorse publications. Permission to reproduce ARRT copyrighted materials within this publication should not be construed as an endorsement of the publication by the ARRT.

PART I

Review and Study Guide

1

Preparation for Review

Welcome to Your Study Guide and Career Planner!

Congratulations on acquiring the most complete study guide available to prepare for radiography classes throughout the educational program and to master the radiography certification exam. This student-friendly guide, coupled with your commitment to excellence and management of study time, will take you on a journey culminating in the achievement of your goals.

By reviewing the major subject areas contained in Part One, “Review and Study Guide,” of this book, answering and studying the exam questions in the text and online resource, and understanding the skills involved in various areas of radiography, you will be well on your way to achieving the goal of excelling in class and passing the radiography exam.

Passing the courses and the exam is only one of several steps in building your new career, however. As you look toward graduation, you are probably contemplating your transition into the work environment or considering further education. In addition to preparing you thoroughly for the exam, this book helps you develop your career goals. In Part Two, “Career Planning,” you will have an opportunity to describe the events that have been rewarding and motivating during your education. This activity will enable you to set goals for establishing your practice of medical radiography and to plan for either immediate employment or continued education.

The most important tools used during the transition into the workforce are the resume and the interview, which are covered in Chapters 8 and 9 to prepare you thoroughly for marketing yourself in today’s ever-changing health care environment. So that you may be fully aware of your role as an entry-level radiographer, [Chapter 10](#) is dedicated to helping you anticipate on-the-job expectations for your first postgraduate position. The competitive and, at times, chaotic nature of health care delivery requires that you understand these expectations well as you prepare your first resume or have your first interview. This information is presented to ease your transition from student to entry-level radiographer.

Because the American Registry of Radiologic Technologists (ARRT) requires proof of continuing education for

recertification, this important topic is included in [Chapter 7](#), “Career Paths.” [Chapter 7](#) also addresses advanced-level exams, academic degrees, and many options available to you as you plan your professional career.

If you are using this text as a program-long study guide, you will want to become familiar with Chapters 2, 3, 4, and 5 quickly. These chapters may be used as a supplement to the text you have for each course in your program. They are effective for a quick overview of subject matter and a review before a quiz or test. Whether using this guide throughout the program or as a Registry review, be sure to take time with the rest of [Chapter 1](#). A key to success in your classes and the radiography exam is prioritizing and managing your time. Investing time now in this chapter will pay big dividends as your review process moves along in an organized fashion.

Prioritizing Subjects and Scheduling Study Time

Determining the Length of Review

As you begin the task of planning your review for the ARRT exam, take a few moments to think about how you want to go about the review process. It is never too early to begin studying for the exam. Because you may take the exam immediately after graduation, you will probably want to begin your review very soon. If you are also using this text as a study guide throughout your radiography program, you are already becoming familiar with the topics and use of the book. Most radiography educators recommend that students begin a well-thought-out review approximately 6 months before taking the exam. Not all students require that much time to prepare adequately; students who are better able to retain the material they have already learned may complete their review more quickly.

Another factor that can greatly influence how far in advance you should begin studying is the amount of time you have available. In all likelihood, you are beginning to review while still taking other courses in your educational program. Those courses must be given a high priority as you begin budgeting your time. It does little good to review for the certification exam only to find that you are hopelessly

behind in another required course. In addition, you may have employment obligations that take up a considerable amount of time or family commitments that must not be allowed to falter while you prepare for the exam. Be aware, however, that exam preparation takes a lot of time and that your success depends on it.

Begin reviewing at least 6 months before the exam. If you need to begin reviewing earlier, based on the exercises that follow, then do so. If you finish your review before 6 months is up, you can either stop reviewing or go back over the material in less detail one more time. If you wait to begin reviewing only 3 or 4 months before the exam, you may have insufficient time to go over the material thoroughly and, as a result, may need to postpone your exam date.

Before you begin budgeting your review time, consider the suggestions and encouragement provided by your instructors, who probably have several years' experience in working with students about to prepare for the exam. Their wisdom and advice should be taken seriously. If you follow the routine they suggest and the guidelines contained in this review book, you should be more than adequately prepared to pass the exam. Remember, however, that managing the quality and quantity of your review time is ultimately up to you. Although your educational program may include some review classes, do not rely on them alone. Your own personal review is crucial to passing the exam. Now that you have successfully reached this point in your educational program, you should use your energy, time, and skills wisely during these final months of preparation. Just as with running a race, finish strong!

Planning the Review Process

If one advances confidently in the direction of his dreams, and endeavors to lead the life which he has imagined, he will meet with a success unexpected in common hours.

HENRY DAVID THOREAU

It is now time to turn your attention to the review process and begin to set priorities. Look through the chapters containing the review material if you have not already done so. In the following space provided, make a list of the subject areas in which you feel particularly strong or weak. By listing the subject areas in this way, you will be able to prioritize the material you need to cover. Second-year radiography students preparing for the exam commonly make the mistake of reviewing the easiest material first. This is the opposite of what you should do.

Weakest Subjects

Strongest Subjects

Look again at the entries you made. Transfer these subjects to the spaces that follow, ranking the weakest subjects first. Then progress in order to the subjects in which you are strongest.

Priority of Study Topics, Weakest to Strongest

I need to study the following subjects in this order:

The rationale for studying more difficult content first is twofold: (1) The more difficult material will require more time, which you will have in greater supply at the beginning of the 6-month period than at the end; (2) if you have had serious difficulty with some of the subject areas and you study those first, you will have additional time to seek explanation from your instructors and to read the material again. Save for last the subjects with which you are most comfortable. These will require the least amount of study time and, if your time becomes limited, reviewing them quickly will not be as detrimental.

The time you spend now on planning a study calendar and prioritizing your study needs will pay great dividends as you begin the review process. Such planning should allow you to proceed more efficiently and dedicate more time to studying. If you are not filling in a calendar or prioritizing your study needs as you read this chapter, take the time right now to select a day and time within the next 5 days when you will reread [Chapter 1](#) and follow the directions for time management and prioritizing.

_____ I have completed my planner calendar and prioritized my subject areas for study.

_____ I will complete my planner calendar and prioritize my subject areas for study on _____ (day), _____ (date) at _____ a.m./p.m.

Now that you have established your priorities or made an appointment with yourself to plan your calendar, you have set your first goal for reviewing and passing the certification exam. Even more important, you have taken the initial step toward your first radiography job or continued education. Be sure to congratulate yourself on accomplishing this task, and then finish reading this chapter.

Although some may scoff at your calendar planning and the amount of time you choose to spend reviewing, others may feel you are not spending enough time preparing. If you are receiving conflicting advice, you may become confused by all of the suggestions, hints, and guidelines. You should refer to the suggestions made by your instructors and the suggestions contained in this study guide.

Scheduling Your Study Time

Go through the process of planning your study time and evaluating your commitments so that you may set goals for reviewing all of the material. Browse through Chapters 2 through 5 and briefly refresh your memory about the topics. Are there large amounts of information that you can't recall? Is information there that you have never seen before? Does most of it look familiar, and is it easy to recall?

Try answering a few of the exam questions after each section, and sample some of the questions from the comprehensive exams in Chapter 6. Were you able to answer the questions easily? Do you feel confident about your answers, or were they educated guesses? How many did you get correct compared with the number you missed? Are there specific subject areas in which you feel particularly strong or weak? Will you need to spend more time studying one area than another? You have to answer all of these questions as

you attempt to budget your review time. Pause now to consider each of them carefully.

If you are already using some form of a daily, weekly, or monthly calendar, either on paper or on an electronic device, to plan your study time, you simply need to decide where within your study schedule to include your review. If you have not been using a calendar to budget your time, this is a great time to start. You don't have to buy an expensive time planner. Most students use a calendar with squares large enough to write in times and planned activities. Others plan their time using the software in their particular brand of smartphone, tablet, or other mobile device. Figure 1-1 is an example of a tablet-based calendar being used to budget time for current classes and for review.

The importance of writing study time on a calendar cannot be overemphasized. You are much more likely to adhere to a study schedule if you have thought it through, written it down, and posted it where you see it daily. It is highly recommended that once you plan your review time, you print a copy of your calendar and give it to your instructor. Educators can be powerful motivators by occasionally reminding a student of a written commitment to review. Filling in a calendar in this way is also a form of establishing a written contract with yourself. In so doing, you recognize that only *you* are ultimately responsible for covering the review material. If the college or hospital you are attending provides you access to a study skills department, meet with

SEPTEMBER 20XX						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 10:00 Advanced Positioning Pathology Class 1:00	2 7:30 Clinical Education 7:00 Review: Radiation Biology	3 No Study Day
4 7:00 Review: Radiation Biology	5 7:30 Clinical Education	6 10:00 Advanced Positioning Pathology Class 1:00	7 7:30 Clinical Education	8 10:00 Advanced Positioning Pathology Class 1:00	9 7:30 Clinical Education 7:00 Review: Physics	10 No Study Day
11 7:00 Review: Physics	12 7:30 Clinical Education	13 10:00 Advanced Positioning Pathology Class 1:00	14 7:30 Clinical Education	15 10:00 Advanced Positioning Pathology Class 1:00	16 7:30 Clinical Education 7:00 Review: Quality Control	17 No Study Day
18 7:00 Review: Quality Control	19 7:30 Clinical Education	20 10:00 Advanced Positioning Pathology Class 1:00	21 7:30 Clinical Education	22 10:00 Advanced Positioning Pathology Class 1:00	23 7:30 Clinical Education 7:00 Review: Image Intensifier	24 No Study Day
25 7:00 Review: Image Intensifier	26 7:30 Clinical Education	27 10:00 Advanced Positioning Pathology Class 1:00	28 7:30 Clinical Education	29 10:00 Advanced Positioning Pathology Class 1:00	30 7:30 Clinical Education 7:00 Review: Skull Anatomy	

• Figure 1-1 Calendar for scheduling study time.

one of the professionals there, share your ideas for time and study management, and gain even more support for attaining your goals.

When you are setting up a review calendar, being regular and consistent is important. Set aside specific times to review on a regular basis. Don't save review for times when you have nothing else to do. State your commitment in such terms as the following: "I will review physics every Thursday evening for the next 8 weeks for approximately 2 hours each time." This contract with yourself describes the activity, the time commitment, and the subject involved. Avoid such entries as "I will study physics four times this month." There is little commitment to that statement, and the goal it sets forth is not likely to be accomplished.

As an adult learner, you have probably developed an awareness of your strengths and weaknesses relative to time management and commitment to studies. Whatever your self-appraisal, the fact that you are using this book suggests that you are a successful student with the capability to manage your time effectively. You should now spend some time applying your scheduling and time management skills to the planning of your review.

If you are allotting at least 6 months to prepare for the exam, you should have plenty of time to cover all of the material and take and review the exams in this book and online. If you do all of the expected regular studies and review, you should have little difficulty on the exam. I hope that by the time you take the exam, you will regard it as just another quiz.

Study Habits

Study habits mirror the individuality of each student. Some students prefer to study alone. They may read small sections of a chapter at a time, pausing to reflect on the content and taking additional notes, if necessary, or they may recite the material aloud. Others choose to read over a section or an entire chapter many times, reviewing the material to facilitate their recall. Some students find it helpful to study in groups, taking turns quizzing one another and answering practice questions.

By now, you probably have formed your own set of effective study habits. In using this book to prepare for the exam, you should consider every suggestion that may improve your method of study. However, do not greatly alter study habits that have already proved successful. Also, keep in mind that as you review for the exam, you should not be learning new material. By definition, a *review* should be a revisiting of material that you have already learned and learned well. In addition, your review should be as comprehensive as possible, including all of the topics.

Before discussing study habits, let's address concerns that many second-year students have after talking with others who have recently taken the exam. You may have been told to give little attention to certain subject areas because they did not appear on the exam. You may hear that the

exam was particularly easy and that you should not worry about it. You may also be surprised to hear such comments as "There was almost no positioning on the exam" or "It was *all* physics!" The radiography exam adheres to content specifications that are included in this chapter. In most cases, when test takers think one category had significantly more questions than another category, this is a reflection of their command of the category's content or of their preparation, or lack thereof, for the exam. Although individuals who are providing you with feedback about the exam may have good intentions, the reliability of their memory of the exam items is questionable. Besides, because of the size of the item bank for the exam, the questions vary each time the exam is administered. Even if the individuals with whom you are speaking accurately recall the exam content, you will not be answering the same set of questions on your exam. Each radiography exam is different from the preceding exam.

Most importantly, you should be aware that passing along test question content is a violation of the ARRT Standards of Ethics, specifically addressed in the Rules of Ethics. It is best to avoid such conversations from both preparation and ethical standpoints. Finally, by choosing to ignore advice from even the most well-intentioned person who has recently taken the exam and instead following the study routine that you are planning under the guidance of your instructors and this book, you will guarantee that you are the one controlling the exam outcome and can be assured that you are undertaking the best preparation for the exam.

A few reminders about study habits or study conditions are in order. Remember to choose your most difficult subjects to study first. You have already listed these in the previous section. When you study, be sure you have set aside time when you can be quiet with no interruptions. Some people study better with soft music in the background, whereas others prefer silence. Other types of music and television simply interfere with concentration. Although you should be comfortable while studying, you should not be too comfortable. Remaining upright is particularly important.

Take regular but infrequent breaks. Be sure that lighting is adequate and the room temperature is controllable and comfortable. Arrange the study conditions so that you can focus all of your attention on what you are doing. Regardless of the study method used, quiet concentration is of utmost importance. You may wish to reinforce your learning by reciting the material aloud—a practice requiring a study setting that is isolated and free from distractions. In addition, study at the time of day when your mind is most alert. Some students prefer to study early in the morning, whereas others have found that they study better later in the afternoon or early evening. Cramming late at night or into the early hours of the morning is ineffective for most individuals. Besides, if review is a priority, you will want to assign it an important place in your schedule.

Exam Specifications

Although the specifications for the ARRT radiography exam (Table 1-1) do not divulge specific questions, they do give the reader the outline from which the exam is constructed. In addition, the approximate number of questions in each category is listed to allow you to see the relative importance placed on the different subject areas.

KEY REVIEW POINTS

Reviewing

- Begin at least 6 months before test day.
- Perform an inventory of strengths and weaknesses by topic.
- Commit your study schedule to a calendar.
- Base your review on ARRT exam specifications; avoid coaching from previous test takers.
- Use study habits that have proven successful in the past.
- Study difficult subjects first.
- Study with no interruptions.
- Be comfortable when studying, but not too comfortable.
- Review during the time of day when you are most alert.

You may wonder why these particular categories were selected for the exam and are weighted in this way. The ARRT periodically performs an extensive study called a *task inventory*. The result (see Chapter 10) for radiographers lists all of the specific skills normally performed by an entry-level radiographer.

The skills in the task inventory should coincide with the terminal competencies of all approved educational programs. From this task inventory, the categories for the exam are

TABLE 1-1 Specifications for the ARRT Radiography Exam

Content Category	Number of Scored Questions
Patient Care Patient Interactions and Management	33
Safety Radiation Physics and Radiobiology Radiation Protection	53
Image Production Image Acquisition and Technical Evaluation Equipment Operation and Quality Assurance	50
Procedures Head, Spine, and Pelvis Procedures Thorax and Abdomen Procedures Extremity Procedures	64
<i>Total</i>	<i>200</i>

From The American Registry of Radiologic Technologists® *Radiography examination content specifications*, St Paul, MN, 2015. Implementation date January 2017.

constructed, and the relative importance of each is weighted. The review of the major categories on the exam is covered in the next four chapters.

Analysis of Category Components

An approximate number of questions for each of the major subject areas is shown in the detailed list that follows.* The number of questions of subcategory content within the major areas are general guidelines and may vary to a certain extent with each exam administration.

Patient Care (33 questions)

1. Patient Interactions and Management (33)

A. Ethical and Legal Aspects

1. Patient's Rights
 - a. informed consent (e.g., written, oral, implied)
 - b. confidentiality (HIPAA)
 - c. American Hospital Association (AHA) Patient Care Partnership (Patient's Bill of Rights)
 1. privacy
 2. extent of care (e.g., DNR)
 3. access to information
 4. living will, health care proxy, advanced directives
 5. research participation
2. Legal Issues
 - a. verification (e.g., patient identification, compare order to clinical indication)
 - b. common terminology (e.g., battery, negligence, malpractice, beneficence)
 - c. legal doctrines (e.g., respondeat superior, res ipsa loquitur)
 - d. restraints versus immobilization
 - e. manipulation of electronic data (e.g., exposure indicator, processing algorithm, brightness and contrast, cropping or masking off anatomy)
3. ARRT Standards of Ethics

B. Interpersonal Communication

1. Modes of Communication
 - a. verbal/written
 - b. nonverbal (e.g., eye contact, touching)
2. Challenges in Communication
 - a. interaction with others
 1. language barriers
 2. cultural and social factors
 3. physical or sensory impairments
 4. age
 5. emotional status, acceptance of condition
 - b. explanation of medical terms
 - c. strategies to improve understanding

*From American Registry of Radiologic Technologists: *Radiography examination content specifications*, St Paul, MN, 2015, ARRT. Implementation date January 2017.

3. Patient Education
 - a. explanation of current procedure (e.g., purpose, exam length)
 - b. verify informed consent when necessary
 - c. pre- and post-examination instructions (e.g., preparation, diet, medications and discharge instructions)
 - d. respond to inquiries about other imaging modalities (e.g., CT, MRI, mammography, sonography, nuclear medicine, bone densitometry regarding dose differences, types of radiation, patient preps)

C. Physical Assistance and Monitoring

1. Patient Transfer and Movement
 - a. body mechanics (e.g., balance, alignment, movement)
 - b. patient transfer techniques
2. Assisting Patients with Medical Equipment
 - a. infusion catheters and pumps
 - b. oxygen delivery systems
 - c. other (e.g., nasogastric tubes, urinary catheters, tracheostomy tubes)
3. Routine Monitoring
 - a. vital signs
 - b. physical signs and symptoms (e.g., motor control, severity of injury)
 - c. fall prevention
 - d. documentation

D. Medical Emergencies

1. Allergic Reactions (e.g., contrast media, latex)
2. Cardiac or Respiratory Arrest (e.g., CPR)
3. Physical Injury or Trauma
4. Other Medical Disorders (e.g., seizures, diabetic reactions)

E. Infection Control

1. Cycle of Infection
 - a. pathogen
 - b. reservoir
 - c. portal of exit
 - d. mode of transmission
 1. Direct
 - a. droplet
 - b. direct contact
 2. Indirect
 - a. airborne
 - b. vehicle borne-fomite
 - c. vector borne-mechanical or biological
 - e. portal of entry
 - f. susceptible host
2. Asepsis
 - a. equipment disinfection
 - b. equipment sterilization
 - c. medical aseptic technique
 - d. sterile technique
3. CDC Standard Precautions
 - a. hand hygiene
 - b. use of personal protective equipment (e.g., gloves, gowns, masks)

- c. safe injection practices
- d. safe handling of contaminated equipment/surfaces
- e. disposal of contaminated materials
 1. linens
 2. needles
 3. patient supplies
 4. blood and body fluids
4. Transmission-Based Precautions
 - a. contact
 - b. droplet
 - c. airborne
5. Additional Precautions
 - a. neutropenic precautions (reverse isolation)
 - b. healthcare associated (nosocomial) infections

F. Handling and Disposal of Toxic or Hazardous Material

1. Types of Materials
 - a. chemicals
 - b. chemotherapy
2. Safety Data Sheet (e.g., material safety data sheets)

G. Pharmacology

1. Patient History
 - a. medication reconciliation (current medications)
 - b. premedications
 - c. contraindications
 - d. scheduling and sequencing exams
2. Administration
 - a. routes (e.g., IV, oral)
 - b. supplies (e.g., enema kits, needles)
3. Venipuncture
 - a. venous anatomy
 - b. supplies
 - c. procedural technique
4. Contrast Media Types and Properties (e.g., iodinated, water soluble, barium, ionic versus non-ionic)
5. Appropriateness of Contrast Media to Exam
 - a. patient condition (e.g., perforated bowel)
 - b. patient age and weight
 - c. laboratory values (e.g., BUN, creatinine, GFR)
6. Complications/Reactions
 - a. local effects (e.g., extravasation/infiltration, phlebitis)
 - b. systemic effects
 1. mild
 2. moderate
 3. severe
 - c. emergency medications
 - d. radiographer's response and documentation

Safety (53 questions)

Radiation Physics and Radiobiology (22)

A. Principles of Radiation Physics

1. X-Ray Production
 - a. source of free electrons (e.g., thermionic emission)
 - b. acceleration of electrons
 - c. focusing of electrons
 - d. deceleration of electrons

2. Target Interactions
 - a. bremsstrahlung
 - b. characteristic
3. X-Ray Beam
 - a. frequency and wavelength
 - b. beam characteristics
 1. quality
 2. quantity
 3. primary versus remnant (exit)
 - c. inverse square law
 - d. fundamental properties (e.g., travel in straight lines, ionize matter)
4. Photon Interactions with Matter
 - a. Compton effect
 - b. photoelectric absorption
 - c. coherent (classical) scatter
 - d. attenuation by various tissues
 1. thickness of body part
 2. type of tissue (atomic number)

B. Biological Aspects of Radiation

1. SI Units of Measurement
 - a. absorbed dose
 - b. dose equivalent
 - c. exposure
 - d. effective dose
 - e. air kerma
2. Radiosensitivity
 - a. dose-response relationships
 - b. relative tissue radiosensitivities (e.g., LET, RBE)
 - c. cell survival and recovery (LD_{50})
 - d. oxygen effect
3. Somatic Effects
 - a. short-term versus long-term effects
 - b. acute versus chronic effects
 - c. carcinogenesis
 - d. organ and tissue response (e.g., eye, thyroid, breast, bone marrow, skin, gonadal)
4. Acute Radiation Syndromes
 - a. hematopoietic
 - b. gastrointestinal (GI)
 - c. central nervous system (CNS)
5. Embryonic and Fetal Risks
6. Genetic Impact
 - a. genetic significant dose
 - b. goals of gonadal shielding

2. Radiation Protection (31 questions)

A. Minimizing Patient Exposure (ALARA)

1. Exposure Factors
 - a. kVp
 - b. mAs
 - c. automatic exposure control (AEC)
2. Shielding
 - a. rationale for use
 - b. types
 - c. placement

3. Beam Restriction
 - a. purpose of primary beam restriction
 - b. types (e.g., collimators)
4. Filtration
 - a. effect on skin and organ exposure
 - b. effect on average beam energy
 - c. NCRP recommendations (NCRP #102, minimum filtration in useful beam)
5. Patient Considerations
 - a. positioning
 - b. communication
 - c. pediatric
 - d. morbid obesity
6. Radiographic Dose Documentation
7. Image Receptors
8. Grids
9. Fluoroscopy
 - a. pulsed
 - b. exposure factors
 - c. grids
 - d. positioning
 - e. fluoroscopy time
 - f. automatic brightness control (ABC) or automatic exposure rate control (AERC)
 - g. receptor positioning
 - h. magnification mode
 - i. air kerma display
 - j. last image hold
 - k. dose or time documentation
 - l. minimum source-to-skin distance (21 CFR)
10. Dose Area Product (DAP) Meter

B. Personnel Protection

1. Sources of Radiation Exposure
 - a. primary x-ray beam
 - b. secondary radiation
 1. scatter
 2. leakage
 - c. patient as source
2. Basic Methods of Protection
 - a. time
 - b. distance
 - c. shielding
3. Protective Devices
 - a. types
 - b. attenuation properties
 - c. minimum lead equivalent (NCRP #102)
4. Special Considerations
 - a. mobile units
 - b. fluoroscopy
 1. protective drapes
 2. protective Bucky slot cover
 3. cumulative timer
 4. remote-controlled fluoroscopy
 - c. guidelines for fluoroscopy and mobile units (NCRP #102, 21 CFR)

1. fluoroscopy exposure rates (normal and high-level control)
2. exposure switch guidelines
5. Radiation Exposure and Monitoring
 - a. dosimeters
 1. types
 2. proper use
 - b. NCRP recommendations for personnel monitoring (NCRP #116)
 1. occupational exposure
 2. public exposure
 3. embryo/fetus exposure
 4. dose equivalent limits
 5. evaluation and maintenance of personnel dosimetry records
 6. handling and disposal of radioactive material

Image Production (50 questions)

1. Image Acquisition and Technical Evaluation (21)

A. Selection of Technical Factors Affecting Radiographic Quality

(X indicates topics covered on the examination.)

Factors Affecting Radiographic Quality

	1. Receptor Exposure	2. Contrast	3. Spatial Resolution	4. Distortion
a. mAs	X			
b. kVp	X	X		
c. OID		X (air gap)	X	X
d. SID	X		X	X
e. focal spot size			X	
f. grids*	X	X		
g. tube filtration	X	X		
h. beam restriction	X	X		
i. motion			X	
j. anode heel effect	X			
k. patient factors (size, pathology)	X	X	X	X
l. angle (tube, part, or receptor)			X	X

*Includes conversion factors for grids.

B. Technique Charts

1. Anatomically Programmed Technique
2. Caliper Measurement
3. Fixed Versus Variable kVp
4. Special Considerations
 - a. casts
 - b. pathologic factors
 - c. age (e.g., pediatric, geriatric)
 - d. body mass index (BMI)
 - e. contrast media

C. Automatic Exposure Control (AEC)

1. Effects of Changing Exposure Factors on Radiographic Quality
2. Detector Selection
3. Anatomic Alignment
4. Exposure Adjustment (e.g., density, +1 or -1)

D. Digital Imaging Characteristics

1. Spatial Resolution (equipment related)
 - a. pixel characteristics (e.g., size, pitch)
 - b. detector element (DEL) (e.g., size, pitch, fill factor)
 - c. matrix size
 - d. sampling frequency
2. Contrast Resolution (equipment related)
 - a. bit depth
 - b. modulation transfer function (MTF)
 - c. detective quantum efficiency (DQE)
3. Image Signal (exposure related)
 - a. dynamic range
 - b. quantum noise (quantum mottle)
 - c. signal-to-noise ratio (SNR)
 - d. contrast-to-noise ratio (CNR)

E. Image Identification

1. Methods (e.g., radiographic, electronic)
2. Legal Considerations (e.g., patient date, examination data)

2. Equipment Operation and Quality Assurance (29 questions)

A. Imaging Equipment

1. Components of Radiographic Unit (fixed or mobile)
 - a. operating console
 - b. x-ray tube construction
 1. electron source
 2. target materials
 3. induction motor
 - c. automatic exposure control (AEC)
 1. radiation detectors
 2. back-up timer
 3. exposure adjustment (e.g., density, +1 or -1)
 4. minimum response time
 - d. manual exposure controls
 - e. beam restriction
2. X-Ray Generator, Transformers, and Rectification System
 - a. basic principles
 - b. phase, pulse, and frequency
 - c. tube loading
3. Components of Fluoroscopic Unit (fixed or mobile)
 - a. image receptors
 1. image intensifier
 2. flat panel
 - b. viewing systems
 - c. recording systems
 - d. automatic brightness control (ABC) or automatic exposure rate control (AERC)

- e. magnification mode
- f. table
- 4. Components of Digital Imaging
 - a. CR components
 - 1. plate (e.g., photo-stimulable phosphor (PSP))
 - 2. plate reader
 - b. DR image receptors
 - 1. flat panel
 - 2. charge coupled device (CCD)
 - 3. complementary metal oxide semiconductor (CMOS)
- 5. Accessories
 - a. stationary grids
 - b. Bucky assembly
 - c. compensating filters

B. Image Processing and Display

- 1. Raw Data (pre-processing)
 - a. analog-to-digital convertor (ADC)
 - b. quantization
 - c. corrections (e.g., rescaling, flat fielding, dead pixel correction)
 - d. histogram
- 2. Corrected Data for Processing
 - a. grayscale
 - b. edge enhancement
 - c. equalization
 - d. smoothing
- 3. Data for Display
 - a. values of interest (VOI)
 - b. look-up table (LUT)
- 4. Postprocessing
 - a. brightness
 - b. contrast
 - c. region of interest (ROI)
 - d. electronic cropping or masking
 - e. stitching
- 5. Display Monitors
 - a. viewing conditions (e.g., viewing angle, ambient lighting)
 - b. spatial resolution (e.g., pixel size, pixel pitch)
 - c. brightness and contrast
- 6. Imaging Informatics
 - a. DICOM
 - b. PACS
 - c. RIS (modality work list)
 - d. HIS
 - e. EMR or EHR

C. Criteria for Image Evaluation of Technical Factors

- 1. Exposure Indicator
- 2. Quantum Noise (quantum mottle)
- 3. Gross Exposure Error (e.g., loss of contrast, saturation)
- 4. Contrast
- 5. Spatial Resolution

- 6. Distortion (e.g., size, shape)
- 7. Identification Markers (e.g., anatomic side, patient, date)
- 8. Image Artifacts
- 9. Radiation Fog

D. Quality Control of Imaging Equipment and Accessories

- 1. Beam Restriction
 - a. light field to radiation field alignment
 - b. central ray alignment
- 2. Recognition and Reporting of Malfunctions
- 3. Digital Imaging Receptor Systems
 - a. maintenance (e.g., detector calibration, plate reader calibration)
 - b. QC tests (e.g., erasure thoroughness, plate uniformity, spatial resolution)
 - c. display monitor quality assurance (e.g., grayscale standard display function, luminance)
- 4. shielding accessories (e.g., lead apron, glove testing)

Procedures (64 questions)

This section addresses imaging procedures for the anatomic regions listed below. Questions cover the following topics:

- 1. Positioning (e.g., topographic landmarks, body positions, path of central ray, immobilization devices, respiration)
- 2. Anatomy (e.g., including physiology, basic pathology, and related medical terminology)
- 3. Procedure adaptation (e.g., body habitus, body mass index, trauma, pathology, age, limited mobility)
- 4. Evaluation of displayed anatomic structures (e.g., patient positioning, tube-part-image receptor alignment)

Head, Spine, and Pelvis Procedures (18 questions)

- A. Head
 - 1. Skull
 - 2. Facial Bones
 - 3. Mandible
 - 4. Zygomatic Arch
 - 5. Temporomandibular Joints
 - 6. Nasal Bones
 - 7. Orbits
 - 8. Paranasal Sinuses
- B. Spine and Pelvis
 - 1. Cervical Spine
 - 2. Thoracic Spine
 - 3. Scoliosis Series
 - 4. Lumbar Spine
 - 5. Sacrum and Coccyx
 - 6. Myelography
 - 7. Sacroiliac Joints
 - 8. Pelvis and Hip
 - 9. Hystersalpingography

2. Thorax and Abdomen Procedures (21 questions)

- A. Thorax
 1. Chest
 2. Ribs
 3. Sternum
 4. Soft Tissue Neck
- B. Abdomen and GI Studies
 1. Abdomen
 2. Esophagus
 3. Swallowing Dysfunction Study
 4. Upper GI Series, Single or Double Contrast
 5. Small Bowel Series
 6. Contrast Enema, Single or Double Contrast
 7. Surgical Cholangiography
 8. ERCP
- C. Urological Studies
 1. Cystography
 2. Cystourethrography
 3. Intravenous Urography
 4. Retrograde Urography

3. Extremity Procedures (25 questions)

- A. Upper Extremities
 1. Fingers
 2. Hand
 3. Wrist
 4. Forearm
 5. Elbow
 6. Humerus
 7. Shoulder
 8. Scapula
 9. Clavicle
 10. Acromioclavicular Joints
- B. Lower Extremities
 1. Toes
 2. Foot
 3. Calcaneus
 4. Ankle
 5. Tibia/Fibula
 6. Knee/Patella
 7. Femur
 8. Long Bone Measurement
- C. Other
 1. Bone Age
 2. Bone Survey (e.g., metastatic, child abuse)
 3. Arthrography

Exam Procedure

Application Process

At the appropriate point in your educational program, your program director will provide you with a printed

or electronic booklet published by the ARRT to apply to take the radiography certification exam. Read everything in the handbook! You should pay close attention to the ARRT Rules and Regulations and the Standards of Ethics and Code of Ethics. Although your program director may highlight and discuss certain portions of the booklet, you are responsible for understanding everything it contains. This may be the most important exam you will have taken so far in your career, so be sure to read the materials provided.

After you read the entire booklet, it is important to fill out the application, providing all of the information requested. Be sure to print legibly and to fill in all information and dates accurately. Pay close attention to the photo requirements. You can submit the application up to 3 months before your anticipated graduation date.

After you have signed the application and your program director has signed it, insert the document along with a check or money order for the application fee into the envelope provided with the application. It is important that you mail the envelope yourself. Do not include it in a large envelope with applications from other members of your class, and do not trust anyone else to mail the application for you. Be sure to send your application as certified mail and to request a return receipt. Although this costs slightly more than regular mail, you will receive verification that your application has been delivered.

Several weeks after receipt of your application, the ARRT will send you exam information and test center admission instructions. When you receive the admission information, you should immediately check it to verify the exam window dates, the exam to be taken, and the personal identification on the form. If any of this information is incorrect or has changed, or if you fail to receive this mailing after an appropriate period, it is your responsibility to contact the ARRT office immediately at (651) 687-0048. Carefully read the process for making an appointment with the test center. Once you have received these documents, put them in a safe place until the day of the exam.

You must have completed all of the educational requirements of your program to take the ARRT exam; this may be particularly significant if your program requires you to make up missed time after graduation. If you need to make up missed time, you will have to fulfill this requirement before taking the exam. Because an associate degree is required, you must also satisfy all general education coursework requirements before being eligible to take the exam. If you are enrolled in a 4-year program, the same general education coursework requirement applies. Near your date of graduation, your program director will receive a form from ARRT indicating you have applied to take the exam and will use the online verification process to verify you have completed the educational program and are eligible to take the exam. This includes verification you have completed all required clinical and didactic competencies.

Test-Taking Skills

Do not fear the winds of adversity. Remember, a kite rises against the wind rather than with it.

Physically and Mentally Preparing for the Exam Day

Although most of your preparation for the exam centers on reviewing your coursework, physical and mental preparation must be taken into account as well. The question of how long before the exam date you discontinue your review has no definite answer. It is an individual decision, based on how lengthy and thorough a review you have done and how comfortable you are with the material. Consulting your instructors or study-skill professionals to clarify your specific needs will prove helpful in answering this question. A brief discussion of the points involved may assist you in deciding how long to study.

If you are the type of student who conducts a well-thought-out, carefully planned review of all of the material, as suggested in this chapter, it is reasonable to expect that studying will taper off within 2 to 3 weeks before the exam. If you use this review book effectively and cover all of the content areas over a period of at least 6 months, you should be well prepared for the exam and can draw your review to a close several weeks before exam day.

If you have not allowed yourself sufficient time to review and are attempting to compress your studying into a few weeks, you may wish to keep on reviewing until a date closer to the exam. Be aware that anxiety, which will tend to increase as the exam approaches, may interfere with learning and recalling even the most basic information as you continue to review. Also, if you have not learned the material over a certain period, there is little that you can learn in the last few weeks. Trying to cram for the exam is futile. If you have waited too long to begin studying, limit your review to the key points in all of the major subject areas.

As you prepare mentally for the day of the test, realize that apprehension about the exam may surface in unexpected ways. It is not unusual for students to report having strange dreams about the exam. The content of these dreams may involve driving for hours but never reaching the test center or starting the exam, falling asleep, and waking up with only 5 minutes left and nearly 200 questions to answer. This is a normal response to your anticipation of a major event. It may also serve as a motivator to continue reviewing and preparing for the exam. You may wish to share your dream experiences with other students in your class. You will come to realize that most of them are having this response and that it is perfectly normal.

Another important aspect of preparation for the exam involves your physical readiness, which means having gathered all of the materials you will need for the test and having prepared your body physically to take an exam of this type. Having the appropriate materials ready well in

advance of the test has been discussed previously. Don't wait until the day before or the day of the exam to get your paperwork in order. Allowing several days to accomplish these tasks will ensure that you are prepared for any emergency that arises.

In preparing your body to take the exam, the basic rule of thumb is to treat exam day much as you would any other day. This phase of your preparation should begin the evening before the test. Intake of alcohol or large amounts of food should be avoided. You should get approximately the same amount of sleep as usual, waking at your usual time.

On the day of the exam, depending on the time of your appointment, use the time before the test to enhance your mental and physical readiness. Start the day by eating a substantial and healthy breakfast. Although you should do this every day, it is particularly important on test day. As the hour of the exam nears, you may feel less like eating. A light snack is a good idea, but avoid high-sugar snacks so that you do not experience a drop in blood sugar as you go in to take the exam.

If you have an exercise regimen that you follow daily, follow it on the test day as well. Exercise helps relieve stress and anxiety for many people. You will probably find that trips to the restroom increase in number on the test day. This is a normal physiologic response to the stress associated with the anticipation of a major event.

Is such physical preparation really necessary? Why should you be attentive to this aspect of test taking? With all of the time and effort expended during your education in medical radiography and during the review process, you want to be certain that fatigue and physical stress do not impede your ability to take the exam.

Your instructors probably gave you a series of review exams in the last few months of the program, and you will have used the online exams that accompany this text. These will have helped you to assess your strengths and weaknesses in the various subject areas. Another reason for these practice exams was to help you become accustomed to sitting for 3 or 4 hours while taking an exam. It is important not to let the physical aspect of test taking hamper your ability to pass the exam.

The writing of this book is grounded in more than 40 years of experience preparing students to take the ARRT exam. Attention to the details in this section will help relieve your anxiety about the exam and allow you to focus on the more important aspects of reviewing and taking the exam.

Materials Needed for the Exam

You should take very few items with you to the exam center. No papers, books, calculators, purses, cell phones, or food or drink of any kind may be taken into the testing room. The items you should bring include your admission ticket, all required photos, and identification materials required by the ARRT. If you wish to use a calculator during the exam, it will be provided by the test center.

Environmental conditions of the test center can vary. The exam room may be warmer or cooler than you would prefer. If being too cool is a concern for you, consider taking a sweater with you. A good way to prepare for a less-than-ideal situation is to study and take practice exams under different conditions. By doing so, you will be able to adapt more easily to the variations in temperature and to the room arrangements you may face when you take the ARRT exam.

Careful reading of ARRT materials will ensure that you have everything you need for the exam. Addressing these issues well ahead of time will free your mind for the more important task—passing the exam.

Strategies for Taking the Exam

Everyone has a preferred system for taking a lengthy, mostly multiple-choice format exam. If you have a method that has worked well in the past, continue to use it. If you seem to lose focus when taking such a test, however, consider the following suggestions for structuring your approach to this exam.

Just getting started may be difficult for some individuals and cause them to experience discomfort. Many graduates have reported that they were uneasy when beginning the test. This is usually the result of the apprehension and stress surrounding this important event. Such an initial response should not be viewed as abnormal, and you can be assured that several of your peers are feeling that same discomfort. If this occurs, close your eyes, breathe deeply several times, and start again. Unless you have severe test anxiety or failed to review and prepare carefully ahead of time, you will be ready to begin answering the questions.

There are 200 test items on the exam, plus approximately 20 additional unscored pilot questions. You will have 3½ hours to answer all of the questions. Additional time is allotted to complete a tutorial before beginning the exam and a survey after the exam. Be sure to take the tutorial at the start and provide feedback to the ARRT at the end of the exam. Questions are asked randomly, not by category. Most test items include the *stem*, or question, and the set of possible answers. The stem will ask a question; only one of the possible answers will be correct. The other choices are called *distracters*. Distracters are choices designed to make you think they are the correct answer. They often consist of the most common incorrect responses. Each question has only one correct answer.

The technologists who construct the exam attempt to include only items for which there is a broad consensus regarding the correct response. Questions about specific departmental routines and information drawn from only one textbook are not used. Information that is proprietary in nature (i.e., specific to a manufacturer or supplier) is avoided. Several sources are consulted when questions for the exam are screened, and only the information common to several sources is used. The ARRT does not officially endorse any textbooks for screening or writing test items,

so you may be assured that you will not be penalized on the exam because you did not use a certain textbook.

Accurate reading is one of the most important skills needed to pass the exam, so read each question carefully. Comprehension of what is being asked is crucial. Do not attempt to read more into the question than is printed. Do not assume that it is a “trick” question. The exam questions are carefully written and well constructed. There should be nothing on the test that you have not seen before in your studies and during your review. Be careful not to read the question the way you want it to be asked. Take the question at face value.

Questions on the ARRT exam are not all A-B-C-D multiple-choice questions. Questions may be asked using one of several different formats. A valuable resource at <http://www.rrt.org> is the *Item Writing Manual*, which describes the various question formats you may encounter on the exam. Examples of question formats follow.

Used on ARRT Exams	Not Used on ARRT Exams
Direct question, multiple choice	True-false
Incomplete statement	Matching
Exhibits (e.g., radiographs, tables, illustrations, graphs)	Comparison
Hot spots or videos	Short answer and essay
Multiselect items	Other (fill-in-the-blank, none of the above, all of the above)
Sorted list items	
Combined response	

The most commonly used format is called the *direct question*. Here you are asked a question and are provided with either three or four choices, as follows:

Which of the following refers to the grayscale present on a radiographic image?

- intensity
- contrast
- spatial resolution
- brightness

The *incomplete statement* format simply gives a statement to complete, as follows:

The degree of blackening seen on a radiographic image is referred to as radiographic:

- intensity
- contrast
- spatial resolution
- brightness

Another format, one you will definitely encounter, is called an *exhibit question*. It is a question or series of questions referring to a diagram, radiograph, table, chart, or drawing. On the ARRT exam, 10% or more of the questions use an image or illustration of some kind. Numerous questions can be asked about exhibits, including using the computer mouse to click on a spot or region of the exhibit

to identify a piece of information. Questions using exhibits are included in the online tests accompanying this text. Examples of exhibits that may be used are:

- Videos
- Medical images
- Anatomic illustrations
- Positioning photographs or diagrams
- Drawings or photographs of equipment and instrumentation
- Models of scientific principles or processes (e.g., x-rays interacting with a molecule, dose-response curves)
- Tables or graphs with technical factors, technique charts, equipment specifications, results of QC tests

In another example, you may see a list of four to eight options that you are required to place in a correct sequence, such as the steps involved in opening a sterile tray. These are called ordering questions. This is done by using the computer mouse to drag and drop the answers into a table in their proper order. Questions using ordering are included in the online tests accompanying this text.

Another format may present you with a question and a list of several answers from which you will choose all of the correct answers. You will receive credit for a correct answer only if you choose all of the correct answers. For example:

Which of the following affects the geometry of the radiographic image? (Select two responses.)

- a. mAs
- b. OID
- c. kVp
- d. SID

The correct answers would be choices b and d. The computer will explain how to indicate your choices. Questions using this format are included in the online tests accompanying this text.

Be aware the Registry is always researching other question formats and may insert them into your exam as pilot questions being tested for future use.

Regardless of the test item format used, after you read the question and all of the choices, the first answer you choose usually is correct. Be careful not to begin second-guessing your choice of an answer. Do not watch for patterns of answers. For example, resist choosing *A* just because you haven't used it in a while, and do not be surprised if a certain answer choice is used for several consecutive questions. Also, all types of question formats may involve clinical scenarios.

There is no guessing penalty on the exam, so if you have no idea what the answer is, guess; however, have a strategy, even when guessing. Do not choose an answer with terms that are unfamiliar to you. Students sometimes reason that such a choice must be the answer because they have never heard of it before. Most often, this is not the case. Make an educated guess by ruling out answers you are sure are wrong. Then choose from among the items containing familiar terminology.

Becoming familiar with the types of items that may be used will help you anticipate what the exam will be like and will assist you in studying and preparing. A variety of question types are used in this book. Most of these types of

questions are commonly used on exams. The certification exam is nothing to fear if you review and prepare properly. Be sure to consider the suggestions and strategies presented here and those identified by your instructors. If you have practiced and studied and prepared your strategy, the exam will be just another quiz.

Exam Results

On completion of the test, you will receive your preliminary exam result on the screen. The result will include a preliminary scaled score and pass/fail status. Remember that a scaled score of at least 75 is required to pass the exam. This on-screen indication of your score still does not provide evidence of certification, and you may not yet legally use the credentials "R.T.(R)" after your name.

Certification becomes official when you receive your ARRT-approved scores and credentials in the mail. Watch for the envelope from the ARRT to arrive. You may also wish to visit the "Check certification and registration status" link at <http://www.arrt.org> (click "Employers and Regulators") to verify whether or not your name has been added to the list of credentialed radiographers.

KEY REVIEW POINTS

The Certification Exam

- Questions on the exam are not confined to A-B-C-D multiple-choice questions; other types of questions may be used.
- Carefully read and safely file *all* materials regarding the exam provided to you by your instructor and the ARRT.
- Taper off reviewing as the test day nears.
- Apprehension about the exam is normal; share your experiences with others.
- Assemble materials needed for test day well ahead of time; learn the route to the test center a few days before to be certain of its location.
- Maintain usual diet and exercise for test day; avoid large intake of food or alcohol.
- Be aware of test item formats used by the Registry: direct question, incomplete statement, negatively worded, combined response, and exhibit.
- Read all test questions and answer choices carefully.

You're on Your Way!

Using this first chapter as a planner, you are now ready to work toward one of the crowning achievements of your educational career. Do all that is expected, and use your time and talents wisely. Do not allow external distractions to send you off course. It is time to plan and work for what is yet to come—passing the radiography exam and moving on to the next phase of your career. You have numerous human and material resources available to assist you, one of which you are reading. Use them all and go for it! Success is a journey, not a destination.

2

Patient Care

BASIC PATIENT CARE TERMINOLOGY

Verbal communication speaking using clear, concise language understood by the patient

Nonverbal communication communicating with facial expressions, eye contact, or body motions

Diversity factors that distinguish humans from one another, including age, gender, race or ethnicity, sexual preference, traditional versus nontraditional families, nuclear versus extended families, marital status, socioeconomic background, political beliefs, religious beliefs, geographic origin or residence, generation, physical or mental disability

Patient education providing the patient with information regarding the procedure being performed, other imaging procedures, or other medical center services

Torts personal injury law

Assault action that causes fear or apprehension in the patient

Battery inappropriate touching or harm done to the patient

False imprisonment unjustified restraint

Invasion of privacy violation of any aspect of patient confidentiality

Libel written defamation of character

Slander spoken defamation of character

Negligence unintentionally omitting reasonable care

Respondeat superior an employer is responsible for the employee's actions

Res ipsa loquitur cause of the negligence is obvious

Implied consent assumes the patient would approve of care if conscious

Informed consent patient provides consent after being fully informed of need, risks, and alternatives

Patient bill of rights establishes rights for patients regarding diagnosis, treatment, privacy, prognosis, and alternatives

Health Insurance Portability and Accountability Act (HIPAA) establishes legal regulations regarding confidentiality of patient records

Do not resuscitate order (DNR) no code

Advance directive document used by patient to provide directives regarding medical care before becoming incapacitated

Durable power of attorney patient provides for another person (personal representative) to make decisions regarding medical care if the patient is unable to communicate

Patient history provides information for the radiographer about the extent of a patient's injury and the range of motion the patient can tolerate

Medical asepsis microorganisms have been eliminated as much as possible

Surgical asepsis complete removal of all organisms from equipment and environment

Standard precautions first tier of transmission-based isolation precautions; uses barriers to prevent contact with blood, all body fluids, nonintact skin, and mucous membranes when there is a chance that infection could be transmitted

Airborne precautions particulate respirator required for individuals entering a patient's room

Droplet precautions mask required for persons coming in close contact with a patient

Contact precautions gloves and gown required for individuals coming in contact with a patient

Direct contact transmission infected person touches susceptible host

Indirect contact transmission inanimate object containing pathogenic organisms is placed in contact with a susceptible person

Airborne transmission droplets and dust

Droplet transmission primarily transmission by coughs, sneezes, or other methods of spraying onto a nearby host

Common vehicle transmission primarily transmission by contaminated items such as food, water, medications, devices, and equipment

Vector-borne transmission an animal contains and transmits an infectious organism to humans

Handwashing most effective method to prevent the spread of infection

Infection control barriers gloves, protective clothing, masks, eye protection

Temperature normal adult oral temperature is 98° F to 99° F

Pulse normal adult pulse is 60 beats per minute

Tachycardia heart rate more than 100 beats per minute

Bradycardia heart rate less than 60 beats per minute

Respiration normal adult rate is 12 to 16 breaths per minute

Blood pressure normal adult blood pressure is 120/80 mm Hg

Sphygmomanometer device used to measure blood pressure

Systolic pressure measurement of the pumping action of the heart

Diastolic pressure measurement of the heart at rest

Oxygen administration usual oxygen flow rate is 3 L to 5 L per minute

Suction unit used to maintain patient's airway

Cardiac arrest cessation of heart function

Crash cart used in cardiac arrest; contains medications, airways, sphygmomanometers, stethoscopes, defibrillators, cardiac monitors

Respiratory arrest cessation of breathing

Shock failure of circulation in which blood pressure is inadequate to oxygenate tissues and remove by-products of metabolism

Hypovolemic shock follows loss of a large amount of blood or plasma

Septic shock occurs when toxins produced during massive infection cause a dramatic decrease in blood pressure

Neurogenic shock causes blood to pool in peripheral vessels

Cardiogenic shock secondary to cardiac failure or other interference with heart function

Allergic shock (anaphylaxis) allergic reaction to foreign proteins after injection of an iodinated contrast agent

Trauma serious and potentially life-threatening injuries

Ventilators mechanical respirators attached to tracheostomies

Nasogastric (NG) tube tube inserted through the nose and down the esophagus into the stomach

Chest tube tube placed to remove fluid or air from the pleural space

Negative contrast agent most commonly used negative contrast agent is air

Positive contrast agent iodine or barium

Aqueous iodine compound water-soluble sterile contrast agent

Iodinated ionic contrast agents salts of organic iodine compounds; composed of positively and negatively charged ions

Iodinated nonionic contrast agents agents that do not ionize into separate positive and negative charges

Anaphylactic reactions flushing, hives, nausea

Cardiovascular reactions hypotension, tachycardia, cardiac arrest

Psychogenic factors may be caused by patient anxiety

Hypodermic needle gauge unit of measurement that indicates diameter; the larger the gauge, the smaller the diameter of the needle opening

Intravenous (IV) catheter combination unit with a needle inside a flexible plastic catheter

Biohazardous materials—possible routes of entry inhalation, swallowing, absorption through the skin or mucous membranes

Material safety data sheets (MSDS) provide direction for handling precautions, safe use of the product, cleanup and disposal of biohazardous materials

PPE personal protective equipment

OSHA Occupational Safety and Health Administration

CDC Centers for Disease Control and Prevention

Communication with the Patient

A. Importance of clear communication

1. Establishes a respectful and professional relationship with the patient
2. Provides an accurate explanation of the examination
3. Helps the patient feel more comfortable to ask questions
4. Shows respect for the patient
5. Demonstrates a professional demeanor on the part of the radiographer

B. Verbal communication

1. Verbal communication must be clear and distinct
2. Terms used must be in a language the patient can understand
3. Care must be taken that a “difficult day” for the radiographer does not enter the tone of verbal communication with the patient; that is, the radiographer should always be aware of the tone of voice being used to communicate
4. Verbal communication implies that the radiographer should also possess excellent listening skills to interpret properly what the patient is saying

C. Nonverbal communication

1. The radiographer must be continually aware of how facial expressions or other body motions may be interpreted
2. Words may be saying one thing, but nonverbal actions may be communicating an entirely different attitude toward the patient
3. The use of touch must be appropriate and never open to uncertainty or miscommunication

4. Nonverbal communication, including eye contact, must be respectful of the patient's age and ethnicity

5. The radiographer must be a good listener

D. Diversity in medical imaging

1. The radiographer must be aware of the extensive diversity of patients
2. Respect for diversity is vital in the performance of medical imaging
3. Diversity may include any of, or any combination of, the following factors:
 - a. Age
 - b. Gender
 - c. Race or ethnicity
 - d. Sexual preference
 - e. Traditional versus nontraditional families
 - f. Nuclear versus extended families
 - g. Marital status
 - h. Socioeconomic background
 - i. Political beliefs
 - j. Religious beliefs
 - k. Geographic origin or residence
 - l. Generation
 - m. Physical or mental disability
 - n. Language
4. The radiographer must be fully aware that the patient population is composed of infinite diversity in infinite combinations

E. Patient education

1. Patient education is part of the radiographer's scope of practice

2. The radiographer must be able to explain to the patient, in words the patient understands, the imaging procedure being performed
 3. Patient education includes answering questions from the patient regarding the procedure
 4. The radiographer should also be able to answer basic questions regarding other imaging modalities, such as the following:
 - a. Mammography
 - b. Nuclear medicine
 - c. Angiography
 - d. CT
 - e. MRI
 - f. Bone densitometry
 - g. Ultrasound
 5. The radiographer should be able to answer basic questions, or provide directions to the patient, regarding other medical center services, such as the following:
 - a. Social services
 - b. Discharge planning
 - c. Pastoral care
 - d. Rehabilitation
 - e. Business office
 - f. Other medical departments
2. Battery
 - a. Unlawful touching or touching without consent
 - b. Harm resulting from physical contact with radiographer
 - c. May also include radiographing the wrong patient or the wrong body part or performing radiography against a patient's will
 3. False imprisonment
 - a. Unjustified restraint of a person
 - b. Care must be taken when using restraint straps or having other individuals assist with holding a patient still
 4. Invasion of privacy
 - a. Violation of confidentiality of information
 - b. Unnecessarily or improperly exposing the patient's body
 - c. Unnecessarily or improperly touching a patient's body
 - d. Photographing patients without their permission
 5. *Libel*: Written information that results in defamation of character or loss of reputation
 6. *Slander*: Orally spreading false information that results in defamation of character or loss of reputation
 7. Manipulation of electronic data that is ethically wrong and legally questionable:
 - a. using the wrong processing algorithm
 - b. altering the exposure indicator
 - c. cropping/masking anatomy postexposure

KEY REVIEW POINTS

Communication with the Patient

- Clear and comfortable communication—establishing this with the patient is of paramount importance
- Verbal communication—must be clear and in a language the patient understands
- Nonverbal communication—conveys the radiographer's attitude and demeanor
- Diversity—the radiographer must be aware of age, gender, race or ethnicity, sexual preference, traditional versus nontraditional families, nuclear versus extended families, marital status, socioeconomic background, political beliefs, religious beliefs, geographic origin or residence, generation, physical or mental disability
- Patient education—the radiographer must understand the role of patient educator and be prepared to answer basic questions regarding mammography, nuclear medicine, angiography, CT, MRI, bone densitometry, ultrasound, social services, discharge planning, pastoral care, rehabilitation, business office, other medical departments

Medicolegal Aspects of Practice

- A. Torts

Violations of civil law

Also known as *personal injury law*

Injured parties have a right to compensation for injury
- B. Intentional misconduct
 1. Assault
 - a. Patient is apprehensive about being injured
 - b. Imprudent conduct of radiographer that causes fear in patient is grounds for an allegation of civil assault
- C. Unintentional misconduct (negligence)
 1. Neglect or omission of reasonable care
 2. Based on doctrine of the reasonably prudent person
 3. *Reasonably prudent person doctrine*: Based on how a reasonable person with similar education and experience would perform under similar circumstances
 4. *Gross negligence*: Acts that show reckless disregard for life or limb
 5. *Contributory negligence*: Instance in which the injured person is a contributing party to the injury
- D. Four conditions needed to establish malpractice
 1. Establishment of standard of care
 2. Demonstration that standard of care was violated by the radiographer
 3. Demonstration that loss or injury was caused by radiographer who is being sued
 4. Demonstration that loss or injury actually occurred and is a result of the negligence
- E. *Respondeat superior*
 1. "Let the master answer"
 2. Legal doctrine stating that an employer is held liable for an employee's negligent act
- F. Rule of personal responsibility: Individuals are responsible for their own actions
- G. *Res ipsa loquitur*
 1. "The thing speaks for itself"
 2. Legal doctrine stating that the cause of the negligence is obvious (e.g., forceps left inside a patient during surgery)

H. Charting

1. Using electronic medical record or writing on the patient's chart by radiographer
2. Varies by institution
3. Radiographer's responsibilities in this regard must be carefully outlined during new employee orientation
4. Write clear statements regarding patient's condition and patient's reaction to contrast agents; write amount of contrast material injected
5. Must be clearly stated on the chart
6. Information must also include the date and time of the occurrence
7. Radiographer must sign chart entries using institutional protocol
8. In case of error, correct electronically or strike over once and rewrite correct entry; never erase or obscure erroneous information

I. Radiographic images

1. Radiographic images are legal documents, whether electronic or on film
2. Images must include the following information:
 - a. Patient identification
 - b. Anatomic markings, including left and right markers
 - c. Carefully placed markings on each radiograph using lead markers
 - d. Date of exposure
 - e. Markings placed on the image following exposure may not be legally admissible
3. Retention of images
 - a. Varies according to state law
 - b. Normally maintained for 5 to 7 years after the date of the last radiographic examination (mammograms and black lung images are kept for the life span of the patient)
 - c. Files on minors are normally retained for 5 to 7 years after the minor reaches age 18 or 21, depending on the state of residence

J. Patient's rights

1. Patient's bill of rights from the American Hospital Association provides for patient consent or refusal of any procedure; the patient has the right to the following:
 - a. Respectful care
 - b. Obtain up-to-date and understandable medical information regarding diagnosis, treatment, and likely outcomes
 - c. Be involved in the decision-making process throughout diagnosis and treatment
 - d. Have an advance directive (living will, health care proxy, durable power of attorney) on file
 - e. Privacy in all aspects of diagnosis and treatment
 - f. Complete confidentiality
 - g. View medical records of the case
 - h. Expect that a hospital will respond to a request for needed care and services
 - i. Be informed of business or educational relationships that may affect treatment and care

- j. Consent to or decline participation in research studies
- k. Continuity of care and other options for care beyond the hospital
 - l. Be informed of hospital policies and procedures related to diagnosis and treatment
 - m. Be informed of all resources available for resolving disputes
 - n. Be informed of charges for services and payment options
2. Implied consent
 - a. Provides for care when patient is unconscious
 - b. Based on assumption that patient would approve care if conscious
3. Valid consent
 - a. Also called *informed consent*
 - b. Patient must be mentally competent
 - c. Consent must be offered voluntarily
 - d. Patient must be adequately informed
 - e. Patient must be of legal age
 - f. Requires that radiographer or radiologist carefully explain all aspects of procedure and risks involved
 - g. Requires that explanation be provided in lay terms the patient understands
4. Health Insurance Portability and Accountability Act (HIPAA)
 - a. Passed by US Congress and enacted under rules and regulations of US Department of Health and Human Services
 - b. Hospitals must put in place policies and procedures regarding the release of patient information
 - c. Patient must provide clear permission for release of any information to outside parties (e.g., medical, financial, employment)
 - d. Patient must be informed in writing of how the released information will be used
 - e. Patient must be allowed to view and copy records and amend records as needed
 - f. Any history of information sharing must be disclosed to the patient
 - g. Patient must freely provide consent for information to be shared
 - h. Patient has the right to restrict sharing of information
 - i. Patient may file a complaint regarding a violation of HIPAA
5. Do not resuscitate order (DNR)
 - a. Also called *no code*
 - b. May be placed on file when the quality of life has seriously declined or the patient's condition is terminal
 - c. Agreement is between the physician and the patient (or the designated person holding power of attorney if the patient is incompetent)
 - d. The agreement or appropriate notation is made on the patient's chart

6. Advance directive
 - a. Patient provides directives regarding medical care before becoming incapacitated
 - b. Patient may do this so that directions are in place should the patient be unable to communicate wishes regarding care
 - c. Copies should be provided to physician, attorney, family member, and medical record
7. Durable power of attorney
 - a. Patient provides for another person (personal representative) to make decisions regarding medical care if the patient is unable to communicate
 - b. This personal representative may sign informed consent forms for the patient
 - c. The patient and personal representative should communicate clearly ahead of time the patient's thoughts regarding extraordinary methods of treatment and end-of-life wishes
- K. American Registry of Radiologic Technologists (ARRT) Mission and Standards of Ethics
 1. The accompanying box contains the ARRT Mission Statement, Standards of Ethics Preamble, and Rules of Ethics
 2. The Standards of Ethics promote the goals of the Mission Statement
 3. The Standards of Ethics are comprised of the Code of Ethics (not listed here) and the Rules of Ethics
 4. The Code of Ethics serves as a guide for what radiologic technologists aspire to become as professionals
 5. The Rules of Ethics are mandatory, enforceable, and carry sanctions for violations
 6. The Standards of Ethics also include a section addressing administrative procedures, not included here (for details, visit <http://www.arrt.org>)

THE AMERICAN REGISTRY OF RADIOLOGIC TECHNOLOGISTS (ARRT) MISSION STATEMENT AND RULES OF ETHICS (NOT INCLUDING CODE OF ETHICS)

Mission

The mission of The American Registry of Radiologic Technologists is to promote high standards of patient care by recognizing qualified individuals in medical imaging, interventional procedures, and radiation therapy.

The ARRT Standards of Ethics

Preamble

The *Standards of Ethics* of the American Registry of Radiologic Technologists® (ARRT) shall apply solely to persons holding certificates from ARRT that are either currently certified and registered by ARRT or that were formerly certified and registered by ARRT (collectively, "Certificate Holders"), and to persons applying for certification and registration by ARRT to become Certificate Holders ("Candidates"). Radiologic Technology is an umbrella term that is inclusive of the disciplines of radiography, nuclear medicine technology, radiation therapy, cardiovascular-interventional radiography, mammography,

computed tomography, magnetic resonance imaging, quality management, sonography, bone densitometry, vascular sonography, cardiac-interventional radiography, vascular-interventional radiography, breast sonography, and radiologist assistant. The *Standards of Ethics* are intended to be consistent with the Mission Statement of ARRT, and to promote the goals set forth in the Mission Statement.

Rules of Ethics

The Rules of Ethics form the second part of the *Standards of Ethics*. They are mandatory standards of minimally acceptable professional conduct for all Certificate Holders and Candidates. Certification and Registration are methods of assuring the medical community and the public that an individual is qualified to practice within the profession. Because the public relies on certificates and registrations issued by ARRT, it is essential that Certificate Holders and Candidates act consistently with these Rules of Ethics. These Rules of Ethics are intended to promote the protection, safety, and comfort of patients. The Rules of Ethics are enforceable. Certificate Holders and Candidates engaging in any of the following conduct or activities, or who permit the occurrence of the following conduct or activities with respect to them, have violated the Rules of Ethics and are subject to sanctions as described hereunder:

1. Employing fraud or deceit in procuring or attempting to procure, maintain, renew, or obtain or reinstate certification and registration as issued by ARRT; employment in radiologic technology; or a state permit, license, or registration certificate to practice radiologic technology. This includes altering in any respect any document issued by the ARRT or any state or federal agency, or by indicating in writing certification and registration with the ARRT when that is not the case.
2. Subverting or attempting to subvert ARRT's examination process, and/or the structured self-assessments that are part of the Continuing Qualifications Requirements (CQR) process. Conduct that subverts or attempts to subvert ARRT's examination and/or CQR assessment process includes, but is not limited to:
 - (i) disclosing examination and/or CQR assessment information using language that is substantially similar to that used in questions and/or answers from ARRT examinations and/or CQR assessments when such information is gained as a direct result of having been an examinee or a participant in a CQR assessment or having communicated with an examinee or a CQR participant; this includes, but is not limited to, disclosures to students in educational programs, graduates of educational programs, educators, anyone else involved in the preparation of Candidates to sit for the examinations, or CQR participants; and/or
 - (ii) soliciting and/or receiving examination and/or CQR assessment information that uses language that is substantially similar to that used in questions and/or answers on ARRT examinations or CQR assessments from an examinee, or a CQR participant, whether requested or not; and/or
 - (iii) copying, publishing, reconstructing (whether by memory or otherwise), reproducing or transmitting any portion of examination and/or CQR assessment materials by any means, verbal or written, electronic or mechanical, without the prior express written permission of ARRT, or using professional, paid or repeat examination takers

THE AMERICAN REGISTRY OF RADIOLOGIC TECHNOLOGISTS (ARRT) MISSION STATEMENT AND RULES OF ETHICS (NOT INCLUDING CODE OF ETHICS)—Cont'd

- and/or CQR assessment participants, or any other individual for the purpose of reconstructing any portion of examination and/or CQR assessment materials; and/or
- iv) using or purporting to use any portion of examination and/or CQR assessment materials that were obtained improperly or without authorization for the purpose of instructing or preparing any Candidate for examination or participant for CQR assessment; and/or
 - v) selling or offering to sell, buying or offering to buy, or distributing or offering to distribute any portion of examination and/or CQR assessment materials without authorization; and/or
 - vi) removing or attempting to remove examination and/or CQR assessment materials from an examination or assessment room; and/or
 - vii) having unauthorized possession of any portion of, or information concerning, a future, current, or previously administered examination or CQR assessment of ARRT; and/or
 - viii) disclosing what purports to be, or what you claim to be, or under all circumstances is likely to be understood by the recipient as, any portion of, or “inside” information concerning any portion of, a future, current, or previously administered examination or CQR assessment of ARRT; and/or
 - ix) communicating with another individual during administration of the examination or CQR assessment for the purpose of giving or receiving help in answering examination or CQR assessment questions, copying another Candidate’s, or CQR participant’s answers, permitting another Candidate or a CQR participant to copy one’s answers, or possessing unauthorized materials including, but not limited to, notes; and/or
 - x) impersonating a Candidate, or a CQR participant, or permitting an impersonator to take or attempt to take the examination or CQR assessment on one’s own behalf; and/or
 - xi) using any other means that potentially alters the results of the examination or CQR assessment such that the results may not accurately represent the professional knowledge base of a Candidate, or a CQR participant.
3. Convictions, criminal proceedings, or military courts-martial as described below:
 - i) conviction of a crime, including a felony, a gross misdemeanor, or a misdemeanor, with the sole exception of speeding and parking violations. All alcohol and/or drug-related violations must be reported; and/or
 - ii) criminal proceeding where a finding or verdict of guilt is made or returned, but the adjudication of guilt is either withheld, deferred, or not entered or the sentence is suspended or stayed; or a criminal proceeding where the individual enters an Alford plea, a plea of guilty or *nolo contendere* (no contest); or where the individual enters into a pre-trial diversion activity; or
 - (iii) military courts-martial related to any offense identified in these Rules of Ethics.
 4. Violating a rule adopted by a state or federal regulatory authority or certification board resulting in the individual’s professional license, permit, registration, or certification being denied, revoked, suspended, placed on probation or a consent agreement or order, voluntarily surrendered, subjected to any conditions, or failing to report to ARRT any of the violations or actions identified in this Rule.
 5. Performing procedures which the individual is not competent to perform through appropriate training and/or education or experience unless assisted or personally supervised by someone who is competent (through training and/or education or experience).
 6. Engaging in unprofessional conduct, including, but not limited to:
 - i) a departure from or failure to conform to applicable federal, state, or local governmental rules regarding radiologic technology practice or scope of practice; or, if no such rule exists, to the minimal standards of acceptable and prevailing radiologic technology practice;
 - ii) any radiologic technology practice that may create unnecessary danger to a patient’s life, health, or safety.

Actual injury to a patient or the public need not be established under this clause.
 7. Delegating or accepting the delegation of a radiologic technology function or any other prescribed healthcare function when the delegation or acceptance could reasonably be expected to create an unnecessary danger to a patient’s life, health, or safety. Actual injury to a patient need not be established under this clause.
 8. Actual or potential inability to practice radiologic technology with reasonable skill and safety to patients by reason of illness; use of alcohol, drugs, chemicals, or any other material; or as a result of any mental or physical condition.
 9. Adjudication as mentally incompetent, mentally ill, chemically dependent, or dangerous to the public, by a court of competent jurisdiction.
 10. Engaging in any unethical conduct, including, but not limited to, conduct likely to deceive, defraud, or harm the public; or demonstrating a willful or careless disregard for the health, welfare, or safety of a patient. Actual injury need not be established under this clause.
 11. Engaging in conduct with a patient that is sexual or may reasonably be interpreted by the patient as sexual, or in any verbal behavior that is seductive or sexually demeaning to a patient; or engaging in sexual exploitation of a patient or former patient. This also applies to any unwanted sexual behavior, verbal or otherwise.
 12. Revealing a privileged communication from or relating to a former or current patient, except when otherwise required or permitted by law, or viewing, using, releasing, or otherwise failing to adequately protect the security or privacy of confidential patient information.
 13. Knowingly engaging or assisting any person to engage in, or otherwise participate in, abusive or fraudulent billing practices, including violations of federal Medicare and Medicaid laws or state medical assistance laws.

THE AMERICAN REGISTRY OF RADIOLOGIC TECHNOLOGISTS (ARRT) MISSION STATEMENT AND RULES OF ETHICS (NOT INCLUDING CODE OF ETHICS)—Cont'd

14. Improper management of patient records, including failure to maintain adequate patient records or to furnish a patient record or report required by law; or making, causing, or permitting anyone to make false, deceptive, or misleading entry in any patient record.
15. Knowingly assisting, advising, or allowing a person without a current and appropriate state permit, license, registration, or an ARRT-registered certificate to engage in the practice of radiologic technology, in a jurisdiction that mandates such requirements.
16. Violating a state or federal narcotics or controlled-substance law.
17. Knowingly providing false or misleading information that is directly related to the care of a former or current patient.
18. Subverting, attempting to subvert, or aiding others to subvert or attempt to subvert ARRT's *Continuing Education (CE) Requirements*, and/or ARRT's *Continuing Qualifications Requirements (CQR)*. Conduct that subverts or attempts to subvert ARRT's CE or CQR Requirements includes, but is not limited to:
 - (i) providing false, inaccurate, altered, or deceptive information related to CE or CQR activities to ARRT or an ARRT-recognized recordkeeper; and/or
 - (ii) assisting others to provide false, inaccurate, altered, or deceptive information related to CE or CQR activities to ARRT or an ARRT-recognized recordkeeper; and/or
 - (iii) conduct that results or could result in a false or deceptive report of CE or CQR completion; and/or
 - (iv) conduct that in any way compromises the integrity of the CE or CQR Requirements, such as sharing answers to the post-tests or self-learning activities, providing or using false certificates of participation, or verifying credits that were not earned.
19. Subverting or attempting to subvert the ARRT certification and registration processes by:
 - (i) making a false statement or knowingly providing false information to ARRT; or
 - (ii) failing to cooperate with any investigation by the ARRT.
20. Engaging in false, fraudulent, deceptive, or misleading communications to any person regarding the individual's education, training, credentials, experience, or qualifications, or the status of the individual's state permit, license, or registration certificate in radiologic technology or certificate of registration with ARRT.
21. Knowing of a violation or a probable violation of any Rule of Ethics by any Certificate Holder or Candidate and failing to promptly report in writing the same to the ARRT.
 - (i) Failing to immediately report to his or her supervisor information concerning an error made in connection with imaging, treating, or caring for a patient. For purposes of this rule, errors include any departure from the standard of care that reasonably may be considered to be potentially harmful, unethical, or improper (commission). Errors also include behavior that is negligent or should have occurred in connection with a patient's care, but did not (omission). The duty to report under this rule exists whether or not the patient suffered any injury.

KEY REVIEW POINTS

Medicolegal Aspects of Practice

- *Torts*: Violations of civil law; personal injury law
- *Intentional misconduct*: Assault (patient is apprehensive about being injured)
- *Intentional misconduct*: Battery (unlawful touching or touching without consent); may also include radiographing the wrong patient or wrong body part or performing radiography against a patient's will
- *Intentional misconduct*: False imprisonment (unjustified restraint of a person)
- *Intentional misconduct*: Invasion of privacy (violation of confidentiality of information; unnecessary or improper exposure or touching of the patient's body)
- *Intentional misconduct*: Libel (written information that results in defamation of character or loss of reputation)
- *Intentional misconduct*: Slander (orally spreading false information that results in defamation of character or loss of reputation)
- *Unintentional misconduct*: Negligence (neglect or omission of reasonable care)
- *Unintentional misconduct*: Based on doctrine of the reasonably prudent person
- *Reasonably prudent person doctrine*: How a reasonable person with similar education and experience would perform under similar circumstances
- *Gross negligence*: Acts that demonstrate reckless disregard for life or limb
- *Four conditions needed to establish malpractice*: (1) Establishment of standard of care; (2) demonstration that standard of care was violated by the radiographer; (3) demonstration that loss or injury was caused by radiographer who is being sued; (4) demonstration that loss or injury actually occurred and is a result of the negligence
- *Respondeat superior ("Let the master answer")*: Legal doctrine stating that an employer is held liable for an employee's negligent act
- *Res ipsa loquitur ("The thing speaks for itself")*: Legal doctrine stating that cause of the negligence is obvious (e.g., forceps left inside a patient during surgery)
- *Charting*: Entering clear statements regarding the patient's condition, reaction to contrast agents, and amount of contrast material injected
- *Radiographic images*: Legal documents; must include patient identification, anatomic markings (including left and right markers), and date of exposure
- Altering electronic data related to radiographic images may be legally challenged
- *Patient's rights*: Patient Bill of Rights provides for patient's consent to, or refusal of, any procedure and access to appropriate medical information; allows for advance directive
- *Implied consent*: Provides for care when patient is unconscious
- *Valid consent*: Patient must be mentally competent; consent must be offered voluntarily; patient must be adequately informed; patient must be of legal age; requires radiographer and radiologist to explain carefully, in lay terms the patient understands, all aspects of procedure and risks involved; also called *informed consent*
- *Health Insurance Portability and Accountability Act (HIPAA)*: Medical facilities must put in place policies and procedures regarding the release of patient information

KEY REVIEW POINTS—Cont'd**Medicolegal Aspects of Practice**

- *Do not resuscitate (DNR) order*: May be placed on file when the quality of life has seriously declined or the patient's condition is terminal; also called *no code*
- *Advance directive*: Patient provides directives regarding medical care before becoming incapacitated
- *Durable power of attorney*: Patient provides for another person (personal representative) to make decisions regarding medical care if the patient is unable to communicate
- ARRT Standards of Ethics includes Code of Ethics (what radiologic technologists aspire to become) and Rules of Ethics (mandatory and enforceable behaviors)

Scheduling of Radiographic Examinations

A. General considerations

1. Schedule in an appropriate and timely sequence to ensure patient comfort and fiscal responsibility
2. Sequence so that examinations do not interfere with one another
3. Schedule barium studies last
4. Schedule several examinations in a single day if the patient is able to tolerate them
5. Seriously ill or weak patients may be able to tolerate only one examination per day or must have a rest between examinations
6. If sedation is used, patient must be given time to recover from sedation before beginning fluoroscopic studies
7. Thyroid assessment must precede any examinations involving iodinated contrast media
8. Schedule radiographic examinations not requiring contrast agents first
9. Total doses of iodinated contrast media should be calculated if they are to be used in a series of examinations
10. Schedule patients who have been held NPO (nothing by mouth) first
11. Schedule pediatric and elderly patients early
12. Schedule diabetic patients early because of their need for insulin

B. Sequence of examinations

1. Fiberoptic (endoscopy) studies are conducted first in a series
2. Radiography of the urinary tract
3. Radiography of the biliary system
4. CT studies should be scheduled before examinations involving the use of barium sulfate
5. Lower gastrointestinal (GI) series (check for residual contrast material from previous examinations before proceeding)
6. Upper GI series

KEY REVIEW POINTS**Scheduling of Radiographic Examinations**

- Schedule so that examinations do not interfere with one another, with barium studies last
- Schedule radiographic examinations not requiring contrast agents first
- Schedule patients who have been held NPO (nothing by mouth) first; schedule pediatric and geriatric patients early; schedule diabetic patients early because of their need for insulin
- *Sequence of examinations*: Fiberoptic (endoscopy) studies; radiography of the urinary tract; radiography of the biliary system; CT studies before examinations involving the use of barium sulfate; lower GI series; upper GI series

Patient Preparation

A. GI system or urinary system

1. Low-residue diet (e.g., low fiber) or clear liquid diet (e.g., tea, gelatin, bouillon)
2. NPO for 8 to 12 hours before procedure
3. Cathartics and enemas are used to cleanse the GI system
4. If scheduled as an outpatient
 - a. Patient must clearly understand the routine for proper preparation
 - b. Patient should be asked to explain the procedure back to the radiographer to verify understanding

B. All procedures

1. Clothing is removed from area to be radiographed and replaced by patient gown when appropriate
2. All radiopaque objects are removed from area of interest

KEY REVIEW POINTS**Patient Preparation**

- *GI system or urinary system*: Low-residue diet; NPO for 8 to 12 hours before the procedure; cathartics and enemas used to cleanse GI system; patient must clearly understand the routine for proper preparation
- *All procedures*: Clothing removed from area to be radiographed; all radiopaque objects removed from area of interest

Patient History

- A. Provides information for the radiographer about the extent of the patient's injury and the range of motion the patient can tolerate
- B. Assists the radiologist during interpretation of the radiographs
- C. History should begin with the radiographer introducing himself or herself and verifying the patient's name

- D. Types of questions asked to obtain a patient's history (depending on type and site of injury)
1. How did your injury occur?
 2. When did your injury occur?
 3. Where is your pain?
 4. Do you have tingling or numbness?
 5. Do you have any weakness?
 6. Were you unconscious after your injury?
 7. Why did your physician order this examination?
 8. Have you experienced shortness of breath or been coughing?
 9. Have you experienced a fever or heart problems?
 10. Have you experienced any nausea, vomiting, or diarrhea?
 11. Have you had previous surgery on this area?
 12. Is there any family history of problems in this area?

KEY REVIEW POINTS

Patient History

- *Purpose:* Provides information for the radiographer; assists the radiologist during interpretation of the images
- *Types of questions asked to obtain a patient's history:* How did your injury occur? When did your injury occur? Where is your pain? Do you have tingling or numbness? Do you have any weakness? Were you unconscious after your injury? Why did your physician order this examination? Have you experienced shortness of breath or been coughing? Have you experienced a fever or heart problems? Have you experienced any nausea, vomiting, or diarrhea?

Patient Transfer

- A. Check identification bracelet to ensure that correct patient is being transferred
- B. Ask patient to state his or her name to double-check identity; ask date of birth as a backup
- C. Explain the transfer procedure to the patient to gain cooperation and alleviate fear
- D. The radiographer must always use proper body mechanics for patient transfer
 1. Keep knees slightly bent
 2. Keep back straight
 3. Use legs, not back, to perform all lifting

Transfer from Wheelchair to X-Ray Table

- A. Wheelchair is parallel to table
- B. Brakes are applied with step stool nearby
- C. Using face-to-face method, assist the patient to a standing position
- D. Have patient place one hand on step stool handle, place the other hand on your shoulder, and step up onto the stool
- E. Patient pivots with back against the table into a sitting position on the edge of the table

- F. Place one arm around patient's shoulder and the other arm under the knees
- G. Assist patient to a supine position

Transfer from X-Ray Table to Wheelchair

- A. Check to see that brakes of wheelchair have been applied
- B. Assist patient to a sitting position
- C. Allow patient to sit up for a short time to regain sense of balance
- D. Ambulatory patient
 1. Assist to a standing position and pivot
 2. Have patient reach back with both hands and grab arms of wheelchair
 3. Assist patient to sit in the wheelchair
- E. Nonambulatory patients
 1. Stand facing the patient
 2. Reach around patient and place your hands on each scapula
 3. Lift patient upward to a standing position with your knees bent
 4. Pivot so that the back of the patient's leg is touching the edge of the wheelchair; ensure the wheels on the wheelchair are locked
 5. Ease patient down to a sitting position with your knees bent
 6. Position foot and leg rests into place
 7. Cover patient's lap with a sheet

Cart Transfer

- A. Place cart near and parallel to the x-ray table, and lock wheels
- B. Do not attempt patient transfer from cart to x-ray table without assistance
- C. One person supports the neck and shoulders at the head of the cart; the second person lifts the pelvis and knees; if available, other individuals support patient at both sides
- D. Transfer sheet or draw sheet should be used under patient; a slide board should be used when available
- E. On signal, all persons involved in transfer move patient in one fluid motion to the x-ray table

Patient Comfort

- A. Taking into account the patient's physical condition, carefully position pillows or radiolucent sponges so that they do not interfere with the examination
- B. Evaluate patient's condition
 1. Ability to breathe
 2. Presence of nausea
 3. Allow patient to remain partially upright when possible
 4. Special care must be given to older patients, who may have decubitus ulcers or particularly sensitive or thin skin

KEY REVIEW POINTS

Patient Transfer

- Check identification bracelet to ensure that correct patient is being transferred
- Explain transfer procedure to patient to gain cooperation and alleviate fear
- Always use proper body mechanics
- Ensure all appropriate brakes are applied
- Make creative use of sheets and helpers when moving patient

Infection Control

Routes of Transmission

- General Concepts
 - Cycle of infection = All factors involved in the spread of disease
 - Infectious organism: Pathogen
 - Reservoir of infection: Place where organisms can thrive
 - Portal of exit: Any avenue available to exit the body
 - Susceptible host: Person at risk for infection
 - Portal of entry: Any avenue available to enter the body
 - Mode of transportation: Route taken by pathogens from reservoir to susceptible host
 - Healthcare Acquired Infections (HAIs)
 - Also called nosocomial infections
 - Approximately 2 million persons acquire HAI per year
 - CDC estimates 90,000 annual deaths because of HAIs
 - Most common route of infection involves urinary catheter
- Direct Contact Transmission:
 - infected person touches susceptible host, allowing the infectious organisms to come in contact with susceptible tissues
 - Fomite: An object that has been in contact with pathogens comes in contact with susceptible tissues
- Airborne transmission: Droplets and dust that are able to remain suspended in air for extended periods of time
- Droplet transmission*: Transmitted primarily by coughs, sneezes, or other methods of spraying onto a nearby host
- Common vehicle transmission*: Transmitted primarily by contaminated items such as food, water, medications, devices, and equipment
- Vector-borne transmission*: Animal or insect contains and transmits infectious organism to humans

Standard Precautions

- First tier of transmission-based isolation precautions
- System that uses barriers to prevent contact with blood, all body fluids, nonintact skin, and mucous membranes, if there is a chance of transmission of infection
- Assumes all body fluids are sources of infection
- Assumes all patients are infected
- Guidelines
 - Always wear gloves when any chance of being in contact with body substances exists
 - Protect clothing by wearing a protective gown or plastic apron, if a chance of coming in contact with body substances exists
 - Masks or eye protection must be worn if a chance of body-substances splashing exists
 - Handwashing is the most effective method to prevent the spread of infection
 - Uncapped needle syringe units and all sharps must be discarded in biohazard containers
 - If any contact is made with body substances, the entire area contacted must be washed completely with bleach
 - Contaminated articles must be disposed of properly
 - Needles should never be recapped but should be placed with the syringe in a sharps container
 - Protective masks or mouthpieces should be used when performing cardiopulmonary resuscitation (CPR), if providing breaths in addition to chest compression.

Medical Asepsis

- Includes proper hand hygiene
 - Use alcohol-based hand sanitizer for 15 seconds
 - Conventional handwashing (duration): 30 to 60 seconds
 - Adjust water temperature
 - Wet hands
 - Lather antimicrobial soap into hands and fingers for at least 20 seconds
 - Rinse clear
 - Dry thoroughly
 - Turn off faucet with paper towel when handles are present
 - No wearing of artificial nails
- Microorganisms have been eliminated as much as possible
- Water and chemicals are used for the disinfection

Surgical Asepsis

- Complete removal of all organisms from equipment and the environment in which patient care is conducted
- Includes complete sterilization of equipment and appropriate skin preparation
 - Chemical sterilization*: Soaking objects in germicidal solution
 - Boiling*: Sterilization with moist heat

3. *Dry heat*: Placing objects in an oven at temperatures greater than 329° F
4. *Gas sterilization*: Items are exposed to a mixture of gases, which do not harm the materials
5. *Autoclaving*: Steam sterilization under pressure; most convenient way to sterilize materials

Sterile Technique

- A. Steps to follow in the opening of sterile packs
 1. Check expiration date
 2. Place pack on a clean surface
 3. Break seal and open pack
 4. Unfold the first corner of the pack away from you
 5. Unfold both sides
 6. Pull front portion of the wrap toward you and drop it
 7. Never touch the inner surface
 8. If there is an inner wrap, open it using the same method
 9. Separately wrapped sterile items may be added to the sterile field by opening the pack and allowing the items to drop onto the sterile field
 10. Never allow the container to touch the sterile field
- B. Pouring liquids into containers in a sterile field
 1. Carefully determine the contents of the container
 2. Pour a small amount into a waste receptacle to cleanse the lip of the bottle
 3. Pour the medium into the receptacle, being careful not to touch the sterile field in the process
- C. Sterile objects or fields touched by unsterile objects or persons are immediately contaminated
- D. Avoid reaching across sterile fields
- E. If you suspect that an object is contaminated, assume that it is contaminated
- F. Always assume that damp items are contaminated
- G. Do not invade the space between a physician and the sterile field
- H. Never abandon a sterile field; it must be under direct observation at all times
- I. Never turn your back on a sterile field
- J. *Remember*: Only from your waist up and in front is sterile

Gloving

- A. Wash hands thoroughly
- B. Open outer package containing gloves
- C. Open inner package, exposing gloves
- D. Approach glove from open end, and touch only inner surface with opposite hand
- E. Put on glove, touching only the folded cuff
- F. Pick up other glove with gloved hand under the cuff
- G. Place second glove on other hand, and unfold cuff
- H. Carefully unfold cuff on both gloves
- I. Always keep hands in front of the body without touching body covering or placing hands under arms

Types of Transmission-Based Precautions

- A. Airborne precautions—in addition to standard precautions
 1. Wash hands before patient care
 2. Workers and visitors entering patient's room must wear particulate respirators
 3. Wash hands after patient care
- B. Droplet precautions—in addition to standard precautions
 1. Wash hands before patient care
 2. Surgical masks required for persons coming in close contact with patient
 3. Wash hands after patient care
- C. Contact precautions—in addition to standard precautions
 1. Wash hands before patient care
 2. gloves, and gowns are indicated for individuals coming in contact with patient
 3. Wash hands after patient care

Isolation Technique

Mobile Radiography

- A. Requires two people, designated “dirty” and “clean”; the “clean” radiographer handles the portable x-ray machine and controls while the first “dirty” radiographer touches only the patient; both must wash hands before and after the procedure
- B. If protective cap is indicated, it should be put on and all hair should be tucked inside
- C. Mask should be put on next, completely covering the nose and mouth
- D. Gown should be put on and tied securely at the back and neck
- E. Gloves should be put on and pulled over the end of the sleeve of the gown
- F. Radiographic IR should be placed in a protective plastic cover
- G. Enter patient's room and follow all isolation guidelines that have been posted
- H. After the radiographic exposure is made
- I. Remove IR from the vicinity of the patient
- J. Open the end of the protective covering
- K. “Clean” radiographer handling the equipment should remove cassette from the open end of the cover
- L. When leaving the patient's isolation room, carefully remove attire and leave it in room
 1. Untie waist belt of protective gown
 2. Remove gloves
 - a. Pull off one glove by grasping the cuff and inverting it as it is pulled off
 - b. Remove second glove by inserting clean fingers inside the cuff and inverting it as it is removed
 3. Untie neck and back strings from gown
 4. Remove mask by using strings only
 5. Remove gown by holding it away from the body as it is removed
 6. Carefully wash hands
 7. Use paper towels to touch faucet handles

- M. After portable x-ray unit is moved safely outside the room, it should be cleaned thoroughly before it is returned to the radiology department

Patients in Radiology Departments

- Identify precaution and follow guidelines
- Isolation patients should never spend time waiting in the hallway
- Carefully cover x-ray table with a sheet
- Work in pairs so that only one radiographer is in contact with the patient (dirty) while the other radiographer manipulates the equipment (clean); both wash hands
- Carefully cover patient with protective sheets and blankets when returning patient to the wheelchair or cart
- All contaminated materials must be placed in an appropriate discard bag
- Carefully clean off x-ray table and any other equipment with which the patient came in contact
- Remove gloves and carefully wash hands

Patients with Neutropenia

- Have a decrease in white blood cell count
- Neutropenia may be caused by chemotherapy, immunotherapy, bone marrow transplant
- Radiographers caring for patients with neutropenia must carefully follow hospital protocol so as not to transmit something to the patient that they cannot resist
- Some institutions continue to use a similar form of isolation called 'reverse isolation'

KEY REVIEW POINTS

Infection Control

- Routes of transmission:* May be direct or indirect
- Direct contact:* Infected person touches susceptible host, allowing infectious organisms to come in contact with susceptible tissues
- Indirect contact:* Object containing pathogenic organisms is placed in contact with susceptible person
- Airborne transmission:* Droplets and dust
- Droplet transmission:* Transmitted primarily by coughs, sneezes, or other methods of spraying onto a nearby host
- Common vehicle transmission:* Transmitted primarily by contaminated items such as food, water, medications, devices, and equipment
- Vector-borne transmission:* Animal contains and transmits an infectious organism to humans
- Standard precautions:* System that uses barriers to prevent contact with blood, all body fluids, nonintact skin, and mucous membranes of all individuals and susceptible persons; assumes all body fluids are sources of infection; assumes all patients are infected
- Gloves:* Should always be worn
- Protective gown:* Wear to protect clothing
- Masks and eye protection:* Must be worn if there is a chance that body substances will be splashed

- Protective masks or mouthpieces:* Wear when performing CPR
- Handwashing:* Most effective method to prevent spread of infection
- Uncapped needle syringe units and all sharps:* Must be discarded in biohazard containers
- Medical asepsis:* Microorganisms have been eliminated as much as possible
- Surgical asepsis:* Complete removal of all organisms
- Chemical sterilization:* Soaking of objects in germicidal solution
- Boiling:* Sterilization with moist heat
- Dry heat:* Placing objects in an oven at temperatures greater than 329° F
- Gas sterilization:* Items are exposed to a mixture of gases, which do not harm the materials
- Autoclaving:* Steam sterilization under pressure; most convenient way to sterilize materials
- Sterile technique:* Several steps required to maintain integrity of sterile field; review each step and be able to place them in order
- Gloving:* Several steps required for proper gloving; review each step and be able to place them in order
- Transmission-based precautions:* Airborne precautions; droplet precautions; contact precautions
- Isolation technique during mobile radiography:* Specific steps are required; know each step and the order in which steps occur
- Isolation technique in the imaging department:* Specific steps are required; know each step and the order in which steps occur

Assessment of Changing Patient Conditions

- Visual observation of patient
- Changes in skin color to cyanotic or waxen pallor
- Patient verbalizations of discomfort or dizziness
- Cyanosis of lips or nail beds
- Patient is cool and diaphoretic to touch

Vital Signs

- Temperature:* Normal oral temperature is 98° F to 99° F
- Pulse*
 - Taken at radial or carotid artery
 - Tachycardia:* More than 100 beats per minute
 - Bradycardia:* Less than 60 beats per minute
- Respiration:* Normal respiratory rate is 12 to 16 breaths per minute
- Blood pressure*
 - Measured with sphygmomanometer
 - Systolic pressure:* Measurement of pumping action of the heart
 - Diastolic pressure:* Measurement of the heart at rest
 - Diastolic pressure greater than 90 mm Hg indicates increasing level of hypertension

5. Diastolic pressure less than 50 mm Hg gives some indication of shock
6. Always expressed as systolic pressure over diastolic pressure (e.g., 120/80 mm Hg)

Medical Emergencies

A. Oxygen administration

1. Generally administered via a mask or nasal cannula
2. Usual oxygen flow rate is 3 to 5 L/minute
3. Care must be taken while radiographing patients who are on portable oxygen support; avoid pinching or kinking oxygen tubing
4. Radiographers must know how to operate oxygen tanks or wall oxygen outlets so that they can administer oxygen to a patient in the event of an emergency

B. Suction unit

1. Used to maintain patient's airway
2. Must be used any time the airway becomes obstructed by fluids
3. If the radiographer is working alone and the patient's airway needs suctioning, the radiographer should call for help before beginning procedure

C. Cardiac arrest

1. Cessation of heart function
2. Specific routine for announcing cardiac arrest must be followed
3. Emergency medical assistance must be called immediately
4. CPR must begin immediately
5. Radiographer must be familiar with location and contents of crash cart
 - a. Medications
 - b. Airways
 - c. Sphygmomanometers
 - d. Stethoscopes
 - e. Defibrillators
 - f. Cardiac monitors

D. Respiratory arrest

1. Cessation of breathing
2. Possible causes of respiratory arrest
 - a. Upper respiratory tract swelling
 - b. Failure of the central nervous system
 - c. Choking
3. Tracheolaryngeal edema
 - a. Tracheolaryngeal edema may follow injection of iodinated contrast material
 - b. May necessitate an emergency tracheotomy
 - c. Radiographer should know location of tracheotomy tray
4. Respiratory arrest caused by central nervous system failure necessitates calling a respiratory arrest code
5. Respiratory arrest secondary to choking necessitates use of suction or the Heimlich maneuver

E. Shock

1. Failure of circulation in which blood pressure is inadequate to oxygenate tissues and remove by-products of metabolism

2. *Hypovolemic shock*: Follows loss of large amount of blood or plasma
3. *Septic shock*: Occurs when toxins produced during massive infection cause a dramatic decrease in blood pressure
4. *Neurogenic shock*: Causes blood to pool in peripheral vessels
5. *Cardiogenic shock*: Results from cardiac failure or other interference with heart function
6. Allergic shock (anaphylaxis)
 - a. Allergic reaction to foreign proteins after injections
 - b. Marked by extremely low pressure, dyspnea, and possible death
 - c. May follow injection of iodinated contrast media
7. Symptoms of shock
 - a. Restlessness; apprehension
 - b. Accelerated pulse
 - c. Pale skin
 - d. Weakness
 - e. Alteration in ability to think
 - f. Cool, clammy skin
 - g. Systolic blood pressure less than 30 mm Hg
8. Radiographer's response to shock
 - a. Stop procedure
 - b. Place patient in recumbent (Trendelenburg) position
 - c. Immediately obtain help, calling a code if necessary
 - d. Determine blood pressure
 - e. Administer oxygen
 - f. Accurately document the time and occurrence of each symptom

F. Trauma

1. Serious, potentially life-threatening injuries
2. Be careful to do no additional harm to the patient
3. Be prepared to work with other health care professionals present in the radiography room
4. Be prepared to perform a cross-table lateral cervical spine examination as soon as possible or transport to CT
5. Regardless of which area of the body is to be radiographed, assume that a serious internal injury is present
6. Patient is at one of four levels of consciousness
 - a. Alert and conscious
 - b. Drowsy
 - c. Unconscious but reactive to stimuli
 - d. Comatose
7. Carefully observe the condition of the patient when first brought to the radiography room
8. Note any changes in patient's condition during the course of radiographic procedures
9. Trauma patients should not be left alone under any circumstances
10. Until otherwise informed by a physician, assume the presence of serious spinal injuries

11. Slight movement of a patient who has spinal injuries may result in paralysis or death
 12. Immobilization devices, such as cervical collars or splints, must never be removed unless permission is granted by a physician
 13. Be prepared to alter routine positions and projections because of the inability to move the anatomic part
 14. Adjust radiographic technique to compensate for the presence of splints, spine boards, and other immobilization devices
 15. Work carefully with patients who have wounds, making certain to wear gloves
 16. Observe condition of wounds when patient is brought for radiography, and immediately notify emergency department personnel of any changes in wounds, including fresh bleeding
 17. Patients who have severe burns require protective isolation
 - a. Patients who have severe burns experience either no sensation at all or extreme pain
 - b. Care must be exercised when working with burn patients under either condition
3. Bag attached to urinary catheters must always be kept below the level of the bladder
 4. Allowing urine to flow retrograde into the urethra and bladder can cause urinary tract infections
 - a. Urinary tract infections are the number one cause of nosocomial infections (infections acquired in the hospital)
- F. Oxygen
1. Oxygen should not be removed during radiographic examinations (but care should be taken to remove tubing away from anatomy being radiographed)
 2. Oxygen may be removed only with a physician's order
 3. Care should be taken to avoid pinching the tubing

Patient Monitoring and Support Equipment

- A. Ventilators
1. Mechanical respirators attached to tracheostomies
 2. Patient who has a ventilator has been intubated (a tube inserted into the trachea)
 3. Care must be taken not to dislodge tubing connected to tracheostomy
- B. Nasogastric (NG) tubes
1. Tube inserted through the nose and down the esophagus into the stomach
 2. Used to feed the patient or to conduct gastric suction
 3. Care must be taken by the radiographer not to pull on the NG tube while moving patient or performing the examination
- C. Chest tube
1. In place to remove fluid or air from pleural space
 2. May be connected to a suction device
 3. Radiographer must be careful not to disturb the chest tube or suction devices or bottles to which tube may be attached
 4. Bottle must never be raised above chest level
 5. Tubing must not be pinched
- D. Venous catheters
1. May be kept in place for patients requiring long-term chemotherapy or nutrition
 2. Must not be disturbed or pulled in any way
- E. Urinary catheters (Foley and suprapubic)
1. Care must be taken during transfer and radiography of patients who have urinary catheters in place
 2. Urinary catheter tubing must not be bent, pinched, or caught on other equipment and pulled out of the bladder

KEY REVIEW POINTS

Assessment of Changing Patient Conditions

The radiographer should be able to observe changes in patient condition and understand the ramifications of each. Review those listed in the outline.

- *Temperature*: Normal oral temperature is 98° F to 99° F
- *Pulse*: Normal is around 60 beats per minute; greater than 100 beats per minute indicates tachycardia; less than 60 beats per minute indicates bradycardia
- *Respiration*: Normal rate of respiration is 12 to 16 breaths per minute
- *Blood pressure*: Always expressed as systolic pressure over diastolic pressure (e.g., 120/80 mm Hg)
- *Systolic pressure*: Measurement of the pumping action of the heart
- *Diastolic pressure*: Measurement of the heart at rest
- *Oxygen administration*: Generally administered using mask or nasal cannula; usual oxygen flow rate is 3 to 5 L/minute
- *Suction unit*: Used to maintain patient's airway
- *Cardiac arrest*: Cessation of heart function; CPR must begin immediately
- *Crash cart*: Medications, airways, sphygmomanometers, stethoscopes, defibrillators, cardiac monitors
- *Respiratory arrest*: Cessation of breathing; CPR must begin immediately
- *Respiratory arrest caused by choking*: Necessitates the use of suction or the Heimlich maneuver
- *Shock*: Failure of circulation in which blood pressure is inadequate to oxygenate tissues and remove by-products of metabolism
- *Hypovolemic shock*: Follows loss of large amount of blood or plasma
- *Septic shock*: Occurs when toxins produced during massive infection cause a dramatic decrease in blood pressure
- *Neurogenic shock*: Causes blood to pool in peripheral vessels
- *Cardiogenic shock*: Caused by cardiac failure or other interference with heart function
- *Allergic shock (anaphylaxis)*: Allergic reaction to foreign proteins after injections
- *Symptoms of shock*: Restlessness; apprehension; accelerated pulse; pale skin; weakness; alteration in ability to think; cool, clammy skin; systolic blood pressure less than 30 mm Hg

- *Radiographer's response to shock:* Stop procedure, place patient in a recumbent (Trendelenburg) position, immediately obtain help, call a code if necessary, determine blood pressure, and administer oxygen
- *Trauma:* Serious, potentially life-threatening injuries; do no additional harm to the patient
- *Four levels of consciousness:* Alert and conscious, drowsy, unconscious but reactive to stimuli, comatose
- *Ventilators:* Mechanical respirators attached to tracheostomies
- *NG tube:* Tube inserted through the nose and down the esophagus into the stomach
- *Chest tube:* In place to remove fluid or air from the pleural space
- *Venous catheters:* May be kept in place for patients requiring long-term chemotherapy or nutrition
- *Urinary catheters (Foley and suprapubic):* Do not bend, pinch, or catch tubing; bag attached to urinary catheters must always be kept below the level of the bladder
- *Urinary tract infections:* Number one cause of health care-acquired infections

Contrast Media

- Negative contrast agent
 - Most commonly used agent is air
 - Requires fewer x-rays and produces a higher density on the image
 - Air may be used in combination with a positive contrast agent on double-contrast studies
 - Most common examination performed using a negative contrast agent is a routine chest radiograph
- Positive contrast agents
 - Examples
 - Iodine (atomic number 53)
 - Barium (atomic number 56)
 - Relatively high atomic numbers
 - Result in greater attenuation of x-rays
 - Provide lower density on radiograph
 - Provide an increase in contrast between structure to be visualized and surrounding structures
- Barium
 - Administered to patient in the form of barium sulfate, an inert salt
 - For upper GI series and esophagogram, barium is most palatable when mixed with very cold water
 - For barium enema, barium powder is mixed with water at a temperature of approximately 100° F
 - For some studies of esophagus, barium sulfate paste, which is much thicker and more difficult to swallow, may be administered
 - Barium tends to absorb water
 - Patients must be given careful instructions regarding fluid intake after barium studies so that the barium does not cause an impaction
 - Barium sulfate escaping into the peritoneal cavity can cause peritonitis
- Aqueous iodine compounds
 - Used for contrast studies of GI tract
 - Used when barium could be a surgical contaminant
 - Perforated ulcers
 - Ruptured appendix
 - Aqueous iodine compounds may also be used in patients at high risk for impactions
 - These compounds may cause significant dehydration
- Iodinated contrast media
 - Ionic contrast agents
 - Salts of organic iodine compounds
 - Composed of positively and negatively charged ions
 - Nonionic contrast agents
 - Similar to ionic contrast agents
 - Do not ionize into separate positive and negative charges, which affords their primary advantage over ionic contrast agents
 - Provide far lower incidence of contrast agent reactions
 - Contraindications to use of iodinated contrast media
 - Previous sensitivity to contrast agents
 - Known sensitivity to iodine
 - Both ionic and nonionic contrast agents are iodinated (i.e., both contain various concentrations of iodine—nonionic does **not** mean **noniodinated**)

Pharmacology

History and Patient Care Preceding Injection of Iodinated Contrast Media

- Determine history of allergies or previous hypersensitivity to contrast media
- Determine extent of patient's medical problems, including medications being taken
- Review possible reactions to contrast medium being used; determine the presence of contraindications
- Verify pertinent laboratory values (blood urea nitrogen (BUN), creatinine, and glomerular filtration rate) per department and contrast agent protocol
- Verify appropriate dosage related to patient weight and age
- Know the location of all emergency equipment
- Obtain informed consent from patient per department protocol
- Carefully observe and evaluate the patient, noting color of skin, tone and pitch of voice, and presence of apprehension or anxiety, so that changes from these baseline observations may be noted after injection

Patient Care Following Injection of Iodinated Contrast Media

- Continue conversation with patient
 - Encourage patient to speak
 - Laryngeal swelling as a contrast agent reaction first manifests as a change in the tone and pitch of the patient's voice

- B. Continue to observe the patient for early signs of urticaria, profuse sweating, or extreme anxiety
- C. If patient becomes overanxious, take patient's pulse to determine whether tachycardia is present
- D. If patient becomes faint, immediately check respirations, pulse, and blood pressure, and observe for signs of cyanosis
- E. Be aware of the location of a physician in the event of an emergency, such as a contrast agent reaction
- F. Remain with the patient (except when at the control panel to make exposures)
 1. Patient should never be left alone after injection or at any time during the procedure
 2. Although most contrast media reactions are noticeable and may even be violent, others are more difficult to observe
 - a. A patient who appears to be resting comfortably or sleeping may have experienced cardiac arrest
 3. Summon help immediately on observing the onset of a contrast agent reaction
 - a. Although a calm response is required to avoid alarming the patient, urgency is important because a mild contrast agent reaction may quickly accelerate into a more serious reaction

Contrast Media Complications and Reactions

- A. *Overdose*: May occur in infants or adults who have renal, cardiac, or hepatic failure
- B. *Anaphylactic reactions*: Flushing, hives, nausea
- C. *Cardiovascular reactions*: Hypotension, tachycardia, cardiac arrest
- D. *Psychogenic factors*: May be caused by patient anxiety or suggested by the possible reactions described during the informed consent process
- E. Other symptoms of contrast agent reactions
 1. Nausea and vomiting
 2. Sneezing
 3. Sensation of heat
 4. Itching
 5. Hoarseness (or change in pitch of voice during conversation)
 6. Coughing
 7. Urticaria
 8. Dyspnea
 9. Loss of consciousness
 10. Convulsions
 11. Cardiac arrest
 12. Paralysis
 13. Any change in level of orientation
- F. Complications may occur at site of injection
 1. Local irritation may occur if contrast material extravasates
 2. Phlebitis may occur in the vein in which contrast material was injected

KEY REVIEW POINTS

Contrast Media

- *Negative contrast agent*: Air
- *Positive contrast agents*: Iodine and barium
- *Barium*: As barium sulfate; in cold water for upper GI, 100° F for lower GI
- *Aqueous iodine compounds*: Used for contrast studies of GI tract when barium could prove to be a surgical contaminant (perforated ulcers, ruptured appendix)
- *Iodinated ionic contrast media*: Contain positively and negatively charged ions
- *Iodinated nonionic contrast agents*: Do not ionize into separate positive and negative charges, which is their primary advantage over ionic contrast agents; far lower incidence of contrast agent reactions
- *Contrast agent reaction*: Anaphylactic (flushing, hives, nausea); cardiovascular reaction (hypotension, tachycardia, cardiac arrest); psychogenic factors (may be caused by patient anxiety)
- *Other symptoms of contrast agent reactions*: Nausea and vomiting, sneezing, sensation of heat, itching, hoarseness (or change in pitch of voice during conversation), coughing, urticaria, dyspnea, loss of consciousness, convulsions, cardiac arrest, paralysis, any change in level of orientation
- Determine patient history of allergies or previous hypersensitivity to contrast media and extent of medical problems
- Continue talking with and observing patient after injection; be prepared to recognize any signs of a reaction

Venipuncture

- A. Use of hypodermic needle
 1. May be used for small injections
 2. Described by gauge
 - a. Unit of measurement that indicates diameter
 - b. The larger the gauge, the smaller the diameter of the needle opening
 - c. Higher gauge needles are useful for intravenous (IV) injection of contrast agents because they make a smaller hole and limit bleeding at the site
 - d. Higher gauge needles limit the rate at which contrast material may be injected and consequently limit the size of the bolus that may be injected
- B. IV catheter
 1. Combination unit with a needle inside a flexible plastic catheter
 2. Combination unit is inserted into the vein, needle first
 3. Once in place, catheter is pushed in over the needle
 4. Afterward, needle is withdrawn
 5. Catheter may be connected to syringe containing contrast medium
 6. Entire system is more flexible than a hypodermic needle or butterfly

7. Also allows attachment to IV tubing leading to bag or bottle, which can be used in the event of a serious contrast agent reaction
- C. Winged infusion set (butterfly)
1. Has a needle and small plastic “butterfly wings” projecting from either side
 2. Wings may be taped to patient’s skin once needle is in place
 3. Short length of tubing connects the butterfly to the syringe so needle does not move if syringe is moved
- D. Procedure for performing venipuncture
1. Wash hands
 2. Always wear gloves
 3. Secure tourniquet in place
 4. Select vein
 5. Thoroughly cleanse the skin using departmental protocol
 6. Push medication or contrast agent through the needle prior to inserting into vein so as to avoid injecting air
 7. Insert needle into vein
 8. Observe blood return into catheter, plastic tubing, or syringe, depending on equipment used; remove tourniquet
 9. Begin injection immediately
 10. If using hypodermic needle, remove needle at conclusion of injection
 - a. Place small piece of gauze or alcohol wipe on puncture site, and bend patient’s arm
 - b. Dispose of needle and syringe correctly; never recap
 11. If using catheter, continue until all contrast medium has been injected, then disconnect syringe, and observe site for swelling
 12. If using butterfly, tape wings to patient’s skin if indicated
 13. Do not discard vial of injected agent until examination is completed and patient has left the area

KEY REVIEW POINTS

Venipuncture

Specific steps and knowledge are required when performing venipuncture; know each step and the order in which it occurs. Review the equipment used and the procedure.

Hazardous Materials

Handling and Disposal of Biohazardous Materials (Figure 2-1)

- A. General chemicals
1. Chemicals may cause harm if taken into the body by any route



• **Figure 2-1** Biohazardous waste container and symbol.

2. Possible routes of entry
 - a. Inhalation
 - b. Swallowing
 - c. Absorption through the skin or mucous membranes
 3. Material safety data sheets (MSDS) must be available, and radiographers should be familiar with their content and warnings
 4. MSDS provide direction for the following:
 - a. Handling precautions
 - b. Safe use of the product
 - c. Cleanup and disposal
 5. Guidelines for handling chemicals
 - a. Use only if container is clearly labeled
 - b. Read container label several times before using the contents to be certain of what is being handled
 - c. Handle carefully to prevent contact with skin, eyes, and mucous membranes
 - d. Wear personal protective equipment (PPE)
 - e. Use chemicals only as directed
 - f. Never mix chemicals unless compatibility can be verified
 - g. Store chemicals only as directed on label
 - h. Never pour toxic chemicals down the drain; this includes irritating or flammable materials
 - i. Clean up spills immediately according to written procedures
 - j. After contact with the skin, rinse immediately with cool water for at least 5 minutes
 - k. After contact with eyes, rinse for at least 15 minutes
 - l. Always notify the supervisor on duty, and follow guidelines for medical follow-up and incident reports
- B. Infectious waste
1. Anything that has the potential to transmit disease
 2. Handle using US Centers for Disease Control and Prevention (CDC) guidelines for standard precautions



• **Figure 2-2** Puncture-proof container for needle and syringe disposal.

3. Place in containers or bags properly labeled with the type of waste therein (e.g., linens, used sharps, disposable items)
 4. Know the facility's procedures for handling, containment, and disposal of all infectious waste
 5. Exposure to infectious waste must be reported for medical follow-up and incident reports
6. Gloves must always be worn in the following activities:
 - a. Handling used needles and syringes
 - b. Handling bandages and dressing
 - c. Assisting patients who use urinals or bedpans
 7. Needles and syringes must be disposed of in special sharps containers (Figure 2-2)
 8. Needles should not be recapped
 9. Used bandages and dressings must be placed into red plastic biohazard bags and sealed
 10. Bedpans and urinals must be emptied immediately and rinsed

KEY REVIEW POINTS

Hazardous Materials

- *Route of entry:* May enter the body by any route— inhalation, swallowing, absorption through skin or mucous membranes
- *MSDS:* Radiographers should be familiar with their content and warnings
- *Handling chemicals:* Know all guidelines and be able to explain each step
- *Infectious waste:* Handle using CDC guidelines for standard precautions; place in containers or bags properly labeled with type of waste therein
- *Gloves:* Must always be worn when handling used needles and syringes; handling bandages and dressing; assisting patients who use urinals or bedpans
- *Needles and syringes:* Must be disposed of in special sharps containers; must not be recapped
- *Used bandages and dressings:* Must be placed into waterproof bags and sealed
- *Bedpans and urinals:* Must be emptied immediately and rinsed

Review Questions

1. Routes of entry of toxic chemicals may include:
 - a. Swallowing and inhalation
 - b. Inhalation only
 - c. Absorption through skin or mucous membranes
 - d. Inhalation, swallowing, or absorption through skin or mucous membranes
2. Written instructions for handling of biohazardous materials, safe use of the product, and cleanup and disposal directions are called:
 - a. Package inserts
 - b. HIPAA
 - c. MSDS
 - d. Biohazardous warning systems
3. Older patients should be scheduled:
 - a. Late in the day to give them time to build their strength
 - b. For one examination at a time
 - c. As early in the day as possible
 - d. Only when no one else is in the department
4. Patients who have been NPO should be scheduled:
 - a. Last
 - b. First
 - c. Just before lunch
 - d. In any way that helps the work flow
5. Patients with diabetes should be scheduled:
 - a. Late in the day to give them time to build their strength
 - b. Only after they have had their insulin
 - c. As early in the day as possible
 - d. Immediately after a full breakfast
6. Endoscopic procedures should be scheduled:
 - a. After ingestion of barium for increased contrast
 - b. First in a series of procedures
 - c. After a series of procedures so as to verify the diagnosis
 - d. Only by the endoscopy department
7. What describes torts?
 - a. Violations of criminal law
 - b. Considered part of personal injury law
 - c. Provide for compensation for injury
 - d. Violations of civil law that are part of personal injury law and provide for compensation for injury
8. Which of the following may be considered as an example of battery?
 - a. Late in the day to give them time to build their strength
 - b. Only after they have had their insulin
 - c. As early in the day as possible
 - d. Immediately after a full breakfast

- a. Violating HIPAA
 - b. Radiographing the wrong patient or body part
 - c. Verbally abusing a patient
 - d. Criticizing a physician's order in front of a patient
9. Assault means:
 - a. Threatening the patient or causing the patient to be apprehensive
 - b. Striking the patient
 - c. Touching the patient without consent
 - d. Performing radiography against the patient's will
 10. Which of the following is an example of invasion of privacy?
 - a. Radiographing the wrong patient
 - b. Unjustified restraint of patient
 - c. Improperly exposing the patient's body
 - d. Radiographing the wrong body part
 11. Unintentional misconduct is also called:
 - a. Negligence
 - b. An accident
 - c. Libel
 - d. Slander
 12. The concept of the reasonably prudent person is interpreted as:
 - a. How a reasonable jury member would perform the act
 - b. How a professional who has similar education, training, and experience would perform the act
 - c. How a prudent attorney would interpret the act
 - d. How a reasonable and prudent judge would rule on the act
 13. *Respondeat superior* means:
 - a. "The thing speaks for itself"
 - b. A radiographer has no need to carry malpractice insurance
 - c. The reasonable and prudent person should make the decision
 - d. "Let the master answer"
 14. Gross negligence is:
 - a. A case that includes the injured person as a contributing party to the injury
 - b. Loss of life or limb
 - c. An act that shows reckless disregard for life or limb
 - d. Found in criminal cases only
 15. Which of the following conditions must be met to prove malpractice?
 - a. The injury actually occurred and is a result of negligence
 - b. The standard of care was violated by the person being sued
 - c. The injury was caused by the person being sued and is a result of negligence
 - d. The standard of care was violated and the injury actually occurred and was caused by the defendant and was a result of negligence
 16. A case involving obvious negligence would be defined by the doctrine of:
 - a. *Respondeat superior*
 - b. Slander
 - c. Libel
 - d. *Res ipsa loquitur*
 17. Which of the following statements are true concerning valid (informed) consent?
 1. Patient must be of legal age
 2. Patient must be given a brochure describing the risks of the procedure in lay terms
 3. Consent must be offered voluntarily
 4. Patient must be mentally competent
 5. Patient must completely understand all aspects of the procedure
 - a. 1, 3, 4
 - b. 1, 2, 3, 4, 5
 - c. 1, 2, 3, 4
 - d. 1, 2, 3, 5
 18. Patient transfers from cart to x-ray table and back to cart should be performed:
 - a. By the radiographer alone if the patient is ambulatory
 - b. By two or more radiographers to ensure patient and radiographer safety
 - c. By the radiographer alone if the department is short staffed
 - d. By the radiographer alone so as not to frighten the patient
 19. A patient history should be taken by the radiographer:
 - a. To assist the radiographer in understanding the patient's injury and to assist the radiologist with interpretation of the images
 - b. To verify patient name and form of payment
 - c. Only on patients from the ED
 - d. Only in the absence of the patient's chart
 20. Direct contact allows an infectious organism to move:
 - a. From the susceptible host directly to the infected person
 - b. From the infected person directly to the susceptible host
 - c. In either direction
 21. MSDS provide directions for:
 - a. Housekeeping only
 - b. Engineering only
 - c. Radiology only
 - d. All persons exposed to hazardous materials
 22. If the radiographer touches hazardous chemicals, what must be done first?
 - a. Rinse immediately with warm water
 - b. Rinse immediately with cool water for at least 5 minutes
 - c. Rinse immediately with cool water for at least 15 minutes
 - d. Rinse with the warmest water that can be tolerated
 23. Vectors may be:
 - a. Insects
 - b. Persons
 - c. Plants
 - d. Objects

24. Common vehicle transmission involves:
 - a. The spread of infection in crowded forms of public transportation, such as jet aircrafts, subways, and trains
 - b. Food, water, medications, and equipment
 - c. Animals
 - d. Plants
25. Airborne transmission of infection may occur as a result of contact with:
 - a. Bird droppings, acid rain, or air pollution
 - b. Droplets and dust
 - c. Animals
 - d. Other humans
26. Indirect contact involves:
 - a. Coughs or sneezes
 - b. An object containing pathogenic organisms
 - c. Plants and animals
 - d. Other humans
27. A system that emphasizes the placement of barriers between the health care worker and the patient is called:
 - a. Universal precautions
 - b. Standard precautions
 - c. Universal safety
 - d. Infection barriers
28. The placement of barriers between the health care worker and the patient assumes that:
 - a. There is always a contagion present
 - b. No one wants to be touched
 - c. Every patient should be in isolation
 - d. Every health care worker is carrying something contagious
29. The most effective method used to prevent the spread of infection is:
 - a. Wearing of gloves
 - b. Wearing of gowns
 - c. Distance
 - d. Handwashing
30. Because barium enemas increase the possibility of contact between body substances and clothing, the radiographer should always wear:
 - a. Disposable gowns or surgical scrubs
 - b. Head covering
 - c. Shoe covering
 - d. A regular hospital uniform
31. A radiographer should wear eye protection:
 - a. Any time blood may be present
 - b. Any time an injection is being made
 - c. Any time there is a possibility of blood splashing
 - d. With nearly all patients
32. Needles should be recapped after use:
 - a. Never
 - b. Always
 - c. In a nonsterile field
 - d. Only during procedures involving a sterile field
33. Any area that is touched by body fluids:
 - a. Must be washed completely
 - b. Must be covered and isolated for the remainder of the day
 - c. Must be evaluated by infection control
 - d. Must be reported to risk management
34. Hands should be washed:
 - a. At least five times during each shift to help stop the spread of infections
 - b. Before and after contact with each patient and before touching equipment
 - c. Every hour regardless of patient contact
 - d. Both with and without gloves
35. The process of eliminating as many organisms as possible by the use of water and chemical disinfectants is called:
 - a. Surgical asepsis
 - b. Sterilization
 - c. Medical asepsis
 - d. Boiling
36. The process of eliminating all organisms from the environment by gas sterilization, use of germicides, or use of dry heat is called:
 - a. Surgical asepsis
 - b. Sterilization
 - c. Medical asepsis
 - d. Autoclaving
37. When putting on gloves for a procedure, which of the following should occur first?
 - a. Carefully open glove package, and avoid touching outside of gloves
 - b. Wash hands
 - c. Place glove package in center of sterile field in preparation for the procedure
 - d. Put on one glove immediately so that one hand is protected and the other is free
38. After a radiographer is gowned and gloved for a procedure, hands may not be placed:
 - a. Anywhere on the body because the gown and gloves are sterile
 - b. Anywhere on the front or sides of the gown
 - c. Anywhere on the table containing the sterile field
 - d. Under the arms or on the sides or back of the gown
39. A radiographer who is assisting with a sterile procedure but is not gloved and gowned:
 - a. Should stand between the physician and the sterile field
 - b. Should carefully place all utensils needed in the center of the sterile field by dropping them after removing them from their packages
 - c. May briefly come in contact with the sterile field to move utensils around
 - d. May not have contact with the sterile field or anyone who is scrubbed in
40. What route of transmission involves touching a susceptible person with a contaminated object (e.g., an IR)?
 - a. Droplet transmission
 - b. Indirect contact
 - c. Direct contact
 - d. Airborne transmission

41. Which of the following transmission-based precautions also require the use of standard precautions?
- Airborne and droplet precautions
 - Only contact precautions
 - Only droplet precautions
 - Droplet, contact, and airborne precautions
42. Which of the following rules must always be followed regardless of the route of transmission of infection?
- Gloves must be worn
 - Gowns must be worn
 - Patient must not have any direct contact with the health care worker
 - Handwashing must be performed
43. Which of the following does not *require* the use of gloves?
- Airborne
 - Droplet
 - Contact
 - 1 only
 - 2 only
 - 1, 2
 - 1, 3
44. Which of the following requires that all equipment and personnel be carefully covered?
- Airborne precautions
 - Contact precautions
 - Droplet precautions
 - Patients with neutropenia
45. What is used for total protection of the health care worker from every method of transmission possible in the work setting?
- Standard precautions
 - Airborne precautions
 - Contact precautions
 - Droplet precautions
46. Used bandages and dressings must be placed:
- Inside contaminated linens so they are not touched
 - Into red plastic biohazard bags and sealed
 - Into sharps containers
 - In a nearby waste container
47. The winged infusion set used for venipuncture is also known as:
- IV catheter
 - Hypodermic needle
 - Butterfly
 - Winged injection set
48. When performing mobile radiography on a patient in isolation, which two radiographers are designated?
- Primary and secondary
 - Clean and contaminated
 - Technologist and student
 - Clean and dirty
49. The most common site of health care-acquired infections (HIA) is:
- Open wound
 - Compound fracture
 - Urinary catheter
 - Surgical sutures
50. The reservoir of infection is located:
- Anywhere organisms can thrive
 - On all surfaces
 - Only on patients in isolation
 - Only on already contaminated surfaces
51. Assessment of changing patient conditions includes observing for:
- Skin that becomes unusually warm
 - Patient expressions of discomfort or dizziness
 - Lips that become jaundiced
 - Skin that becomes diaphoretic, lips and nails that turn cyanotic, and patient complaints of dizziness or discomfort
52. The normal adult body temperature taken orally is:
- 98.6° C
 - 98° C to 99° C
 - 99.6° F
 - 98° F to 99° F
53. Which of the following may be ingested by a patient who has been placed on a clear liquid diet?
- Bouillon
 - Gelatin
 - Tea
 - 1 and 2 only
 - 1 and 3 only
 - 2 and 3 only
 - 1, 2, and 3
54. Barium sulfate is classified as a(n):
- Dissolvable organic salt
 - Inert inorganic salt
 - Nonionic contrast agent
 - Iodinated contrast agent
55. A sphygmomanometer is used to:
- Hear the heartbeat
 - Hear the blood pressure
 - Measure blood pressure
 - Measure body temperature
56. A blood pressure of 120/80 mm Hg reveals that:
- The pressure is 120 mm Hg when the heart is at rest
 - The diastolic pressure is 120 mm Hg
 - The systolic pressure is 80 mm Hg
 - The pressure is 80 mm Hg when the heart is at rest
57. When oxygen is administered, the usual rate is:
- 3 to 5 lb/minute
 - 3 to 5 L/hour
 - 3 to 5 L/minute
 - 5 to 7 L/minute
58. A mechanical method used to clear the patient's airway is called:
- The Heimlich maneuver
 - CPR
 - Suctioning
 - NG tube insertion
59. Which of the following contains all the instruments and medications necessary for dealing with cardiac arrest?
- Crash cart
 - Tackle box

- c. IVP cabinet
d. Code cabinet
60. What condition is caused by loss of a large amount of blood or plasma?
a. Anaphylaxis
b. Cardiogenic shock
c. Hypovolemic shock
d. Septic shock
61. What causes blood to pool in peripheral vessels?
a. Anaphylaxis
b. Cardiogenic shock
c. Hypovolemic shock
d. Neurogenic shock
62. What follows an allergic reaction to foreign proteins?
a. Anaphylaxis
b. Cardiogenic shock
c. Hypovolemic shock
d. Septic shock
63. What is caused by an infection that results in extremely low blood pressure?
a. Anaphylaxis
b. Cardiogenic shock
c. Hypovolemic shock
d. Septic shock
64. What condition occurs secondary to heart failure or interference with heart function?
a. Anaphylaxis
b. Cardiogenic shock
c. Hypovolemic shock
d. Septic shock
65. What condition may occur after injection of an iodinated contrast agent?
a. Anaphylaxis
b. Cardiogenic shock
c. Hypovolemic shock
d. Septic shock
66. Which of the following is a symptom of shock?
a. Accelerated pulse; extremely warm skin
b. Accelerated pulse; cool, clammy, pale skin
c. Systolic pressure less than 50 mm Hg
d. Accelerated pulse; cool, clammy, pale skin; systolic blood pressure less than 30 mm Hg
67. What should the radiographer do first when it is suspected a patient is going into shock?
a. Call for assistance
b. Place patient in Trendelenburg position
c. Take patient's blood pressure to confirm shock status
d. Administer oxygen
68. Which of the following statements apply when radiography is performed on trauma patients?
1. Work quickly and efficiently
2. Patient may be left alone if unconscious
3. Spinal injury may be ruled out if patient is not on a spine board or wearing a cervical collar
4. Observe for changes in wound dressing while performing radiography
5. Document in writing changes in patient's condition
- a. 1, 3, 4
b. 1, 2, 3
c. 1, 4, 5
d. 1, 2, 3, 4, 5
69. Which of the following is used to feed a patient or conduct gastric suction?
a. Urinary catheter
b. Chest tube
c. Ventilator
d. NG tube
70. Which of the following is used to administer nutrition or long-term chemotherapy?
a. Urinary catheter
b. Chest tube
c. Ventilator
d. Venous catheter
71. What is the site of most nosocomial (health care-acquired) infections?
a. Urinary catheter
b. Chest tube
c. NG tube
d. Venous catheter
72. What is another name for a mechanical respirator?
a. Urinary catheter
b. Chest tube
c. Ventilator
d. Venous catheter
73. The most frequently performed examination using a contrast medium is a(n):
a. Small bowel study
b. IVP
c. Barium enema
d. Chest x-ray study
74. Which of the following statements are true concerning positive contrast media? (choose 4)
a. Air is the most commonly used
b. Aqueous iodine compounds may be used if perforations are suspected
c. Barium should be mixed with cold water for retrograde administration
d. Nonionic contrast media are ideal for injection because they do not contain iodine, reducing the risk of reactions
e. Barium is an inert substance
f. Aqueous iodine compounds may cause serious dehydration
g. Barium is a surgical contaminant
75. Which of the following is a legitimate contraindication to the use of iodinated contrast media?
a. Allergy to seafood
b. Known sensitivity to proteins
c. Previous sensitivity to contrast agents
d. Allergy to any medications
76. A reaction at the site of injection of iodinated contrast media may be caused by:
a. Extravasation of contrast agent
b. Allergy to seafood

- c. Anaphylaxis
d. Allergy to certain medications
77. Which of the following is a symptom (are symptoms) of a contrast agent reaction?
a. Hoarseness and sneezing
b. Sneezing only
c. Urticaria is the primary symptom
d. Hoarseness, sneezing, urticaria, and vomiting
78. After injection of iodinated contrast media, the radiographer should:
a. Leave the patient to rest
b. Remain with the patient and have a conversation with the patient, listening for signs of laryngeal swelling
c. Tell the patient a funny story as a means of alleviating anxiety about the procedure
d. Alert a radiologist
79. At the first indication of a contrast agent reaction, the radiographer should:
a. Immediately shout for help
b. Stop the examination and obtain help so as not to alarm the patient
c. Continue with the examination because most reactions turn out to be minor
d. Call a respiratory or cardiac arrest code
80. Hypodermic needles are described by their gauge, which is a:
a. List of the uses of the needle
b. Measure of the length of the needle
c. Measure of the diameter of the needle
d. Measure of the diameter of the needle opening—the larger the gauge, the smaller the diameter
81. Air must not be injected when performing venipuncture because:
a. An air embolus would form and may become fatal to the patient
b. Most examinations requiring injection are not air contrast studies
c. It would interfere with the iodine
d. It would prevent visualization of the iodine
82. A smaller, easier-to-handle injection set that includes plastic projections on both sides of the needle and may be used for venipuncture is called a:
a. Venous catheter
b. Butterfly
c. Hypodermic needle
d. Single-injection needle
83. A venous catheter:
a. Is less flexible and more difficult to use than a needle or butterfly
b. Is a combination unit with a needle inside a flexible plastic catheter; both the needle and the catheter are inserted into the vein, after which the needle is withdrawn
c. Is only used for chemotherapy
84. Place the following steps for performing venipuncture in the proper order.
1. Secure tourniquet in place
 2. Thoroughly cleanse the skin
 3. Wash hands
 4. Select vein
 5. Put on gloves
 6. Perform puncture
 7. Cover wound and compress site
 8. Inject contrast agent
 9. Check wound for swelling
 10. Observe blood return
 - a. 5, 4, 1, 6, 8, 7
 - b. 3, 1, 4, 5, 2, 6, 10, 8, 7, 9
 - c. 3, 5, 1, 4, 2, 6, 10, 8, 7, 9
 - d. 4, 1, 3, 5, 2, 6, 8, 9, 10, 7
85. Venipuncture:
a. May be performed by a radiographer where allowed by state law
b. May be performed by a nurse only
c. Must be performed by a radiology supervisor
d. May be performed by a radiographer under any circumstances
86. A contrast medium overdose:
a. Cannot occur because a contrast medium is not a drug
b. May occur in infants
c. May occur if contrast material was injected during the week before the examination
d. May occur in infants or adults who have renal, cardiac, or hepatic failure
87. If medication needs to be ordered for a patient in the radiology department, a physician *always*:
1. Chooses the drug and the dosage
2. Selects the route of administration
3. Administers the drug
 - a. 1 and 2 only
 - b. 1 and 3 only
 - c. 2 and 3 only
 - d. 1, 2, and 3
88. A patient who has sustained a head injury in a motor vehicle accident arrived in the radiology department alert and well oriented. While radiographing the patient, the radiographer observed that the patient was becoming drowsy, irritable, and less coherent. Which of the following would be the correct action for the radiographer to take?
a. Continue the radiographic examination
b. Ignore the changes in the patient's condition, and place the patient back on the stretcher after completing the examination
c. Notify the department supervisor or the attending physician of the change in the patient's condition
d. Sound an emergency code alert
89. A reaction that causes the patient's skin to turn cyanotic means:
a. The skin is turning yellow
b. The skin is turning white
c. The skin is turning blue
d. The skin is turning red

90. What degree of reaction is vomiting?
- Mild to moderate reaction to contrast agent
 - Severe reaction to contrast agent
 - Not considered a reaction to contrast agent
91. In patient care, the radiographer must be constantly aware of the myriad of variations among people of all backgrounds and experiences. This involves the study and understanding of:
- Nonverbal communication
 - Diversity
 - Verbal communication only
 - Patient preferences
92. What degree of reaction is dyspnea?
- Mild to moderate reaction to contrast agent
 - Severe reaction to contrast agent
 - Not considered a reaction to contrast agent
93. Which of the following is always a part of the radiographer's scope of practice?
- Patient education
 - Administration of medications
 - Serve as a resource person for referring physicians
 - Serving on the hospital's radiation safety committee
94. What degree of reaction is cardiac arrest?
- Mild to moderate reaction to contrast agent
 - Severe reaction to contrast agent
 - Not considered a reaction to contrast agent
95. A document that provides instructions regarding medical care that a patient may prepare before incapacitation is called a(n):
- Preplanning order
 - Advance directive
 - Physician notice
 - Informed consent
96. The formal term for "no code" is a(n):
- Advance directive
 - Right to die
 - Do not resuscitate (DNR) order
 - Euthanasia
97. Which of the following contains points that are enforceable?
- ARRT Mission Statement
 - ARRT Code of Ethics
 - ARRT Examination Content Specifications
 - ARRT Rules of Ethics
98. Which of the following serves as a guide to professional conduct?
- ARRT Mission Statement
 - ARRT Code of Ethics
 - ARRT Examination Content Specifications
 - ARRT Rules of Ethics
99. The patient may be left alone following injection of a contrast agent:
- Never
 - After several minutes have passed and there is no sign of a reaction
 - Immediately since contrast agent reactions are rare
 - If they are of legal age
100. The study of contrast agents, their administration, and possible reactions fall under the category of:
- Nursing
 - Pharmacology
 - Emergency care
 - Respiratory care

3

Safety

BASIC RADIATION PROTECTION TERMINOLOGY

Ionizing radiation radiation that possesses the ability to remove electrons from atoms by a process called ionization

Somatic effects effects of radiation on the body being irradiated

Genetic effects effects of radiation on the genetic code of a cell; affects the next generation

Natural background radiation radiation contained in the unpolluted environment

Artificially produced radiation also called man-made radiation (e.g., medical x-rays)

Primary radiation radiation exiting the x-ray tube

Exit radiation (remnant radiation; image-producing radiation) x-rays that emerge from the patient and strike the image receptor

Attenuation absorption and scatter (loss of intensity) of the x-ray beam as it passes through the patient

Heterogeneous beam x-ray beam that contains photons of many different energies

Photoelectric effect absorption of x-ray photons in the atoms of the body

Compton effect scatter of x-ray photons from the atoms of the body

Air kerma unit of exposure

Gray unit of absorbed dose, measured in joules per kilogram (J/kg); 1 Gy = 1 J/kg

Gray_a unit of radiation absorbed in air

Gray_t unit of radiation absorbed in tissue

Sievert unit of effective dose

Sievert unit of equivalent dose

Becquerel unit of activity

National Academy of Sciences/National Research Council Committee on the Biological Effects of Ionizing Radiation (NAS/NRC-BEIR) organization that studies biological effects of ionizing radiation and publishes resulting data

International Commission on Radiologic Protection (ICRP) organization that publishes international radiation protection guidelines

National Council on Radiation Protection and Measurements (NCRP) organization that publishes radiation protection guidelines for the United States

Nuclear Regulatory Commission (NRC) organization that enforces radiation protection standards at the federal level related to use of radioactive material

NCRP Report #102 makes recommendations on equipment design and protection regarding lead shielding and fluoroscopic and mobile exposure rates

NCRP Report #116 defines annual exposure limits; makes recommendations pertaining to risk–benefit analysis of radiation exposure; states that somatic and genetic effects should be kept to a minimum when radiation is used for diagnostic imaging

Effective dose limit upper boundary dose that can be absorbed, either in a single exposure or annually, with a negligible risk of somatic or genetic damage to the individual; effective dose implies whole-body radiation exposure

Cumulative effective dose lifetime occupational exposure must not exceed the radiographer's age multiplied by 10 mSv

Equivalent dose equal to the effective dose multiplied by the radiation weighting factor

As low as reasonably achievable (ALARA) concept of radiologic practice that encourages radiation users to adopt measures that keep the dose to the patient and themselves at minimal levels

Dose-response curves graphs that illustrate the relationship between radiation dose and the response of the organism to exposure; may be linear or nonlinear, threshold or non-threshold

Probabilistic (stochastic) effects randomly occurring effects of radiation; the probability of such effects is proportional to the dose (increased dose equals increased probability, not severity, of effects)

Deterministic effects effects of radiation that become more severe at high levels of radiation exposure and do not occur below a certain threshold dose

Genetically significant dose (GSD) average annual gonadal dose of radiation to individuals of childbearing age; addresses the relationship of gonadal doses to individuals versus an entire population and the overall effects

Linear energy transfer (LET) amount of energy deposited by radiation per unit length of tissue

Relative biological effectiveness (RBE) ability to produce biological damage; varies with the LET

Direct effect effect that occurs when radiation directly strikes DNA in the cellular nucleus

Indirect effect effect that occurs when radiation strikes the water molecules in the cytoplasm of the cell

Radiolysis of water effect that occurs as radiation energy is deposited in the water of the cell; the result of radiolysis is an ion pair in the cell: a positively charged water molecule (HOH⁺) and a free electron

Mutation erroneous information passed to subsequent generations via cell division

Law of Bergonié and Tribondeau cells are most sensitive to radiation when they are immature, undifferentiated, and rapidly dividing

Early somatic effects of radiation hematopoietic syndrome; gastrointestinal (GI) syndrome; central nervous system syndrome

Late somatic effects of radiation carcinogenesis; cataractogenesis; embryologic effects; thyroid dysfunction; life span shortening

Cardinal principles of radiation protection distance, time, shielding

Distance best protection against radiation exposure

Personnel monitoring devices optically stimulated luminescence (OSL) badge, film badge, thermoluminescent dosimeter (TLD)

Mean marrow dose average dose of radiation to the bone marrow

Units of Radiation Measurement

A. Unit of exposure

1. Air kerma
 - a. Used to define radiation exposure or radiation delivered to a specific point
 - b. Unit of measurement is gray (Gy)—normally expressed as Gy_a (a indicates air)
 - c. 1 Gy = 1 joule/kilogram (J/kg)—described as energy absorption per kilogram of tissue irradiated
 - d. Kerma is an acronym for **kinetic energy released in matter**, **kinetic energy released in material**, **kinetic energy released per unit mass**
2. Coulombs/kilogram
 - a. Sometimes used to measure exposure, though preferred unit is air kerma

B. Unit of absorbed dose

1. Amount of energy absorbed per unit mass of tissue
2. Unit of measurement of tissue is gray (Gy); normally expressed as Gy_t (t indicates tissue)

C. Unit of equivalent dose (dose equivalent)

1. The product of absorbed dose (Gy) times the radiation weighting factor (W_R)
 - a. W_R takes into account the biological impact of the type and energy of the radiation being used
 - b. W_R takes into account linear energy transfer (LET), which is the amount of energy transferred by ionizing radiation per unit length of tissue traveled
 - c. High-ionization radiations such as alpha particles and neutrons have high LET (cause more biological damage)
 - d. Lower ionization radiations such as x-rays and gamma rays have lower LET (cause less biological damage)
2. Unit of measurement tissue is sievert (Sv)
3. Calculated as: Sv = Gy × W_R
4. Since the W_R for x-rays and gamma rays is 1, 1 Sv = 1 Gy when using those two forms of radiation

D. Unit of effective dose

1. Estimates the risk present when various tissues are irradiated
2. Uses a tissue weighting factor (W_T); takes into account the relative radiosensitivity of the irradiated organ or body part
3. Unit of measurement tissue is sievert (Sv)
4. Effective dose is the product of absorbed dose times the radiation weighting factor times the tissue weighting factor (W_T)
5. Calculated as Sv = Gy × W_R × W_T

E. Unit of radioactivity

1. Used to measure the quantity of radioactive material (is *not* used to measure the radiation emitted but rather the number of atoms decaying per second)
2. SI unit is the Becquerel (Bq)
3. Used primarily in nuclear medicine



KEY REVIEW POINTS

Units of Radiation Measurement

- Gray—absorbed dose
- Gray (Gy_a)—air kerma
- Gray (Gy_t)—absorbed dose in tissue
- Sievert (Sv)—unit of effective and equivalent dose
- Becquerel (Bq)—unit of radioactivity

Basic Principles of Radiation Protection

Responsibility for Radiation Protection

- A. Radiographer is primarily responsible for protecting the patient from unnecessary exposure
 1. Best accomplished by avoiding repeat exposures
 2. Should use smallest amount of radiation that produces a diagnostic radiographic image

- B. Radiologist and referring physician assume shared responsibility for radiation safety of the patient
 1. Best accomplished by consultation
 2. Should not order unnecessary exams
- C. Safe use of radiation in diagnostic imaging to determine the extent of disease or injury should outweigh the risk involved from the exposure

Ionizing Radiation

- A. X-radiation exposure involves a transfer of energy through photon–tissue interactions
 1. Possesses the ability to remove electrons from atoms by a process called *ionization*
 2. Results of ionization in human cells
 - a. Unstable atoms
 - b. Free electrons
 - c. Production of low-energy x-rays
 - d. Formation of new molecules harmful to the cell
 - e. Cell damage may be exhibited as abnormal function or loss of function
- B. General types of radiation damage
 1. *Somatic*: Damage to the exposed individual
 2. *Genetic*: Damage to the genetic code of the germ cell contained in the DNA; may be passed to the next generation
- C. Sources of ionizing radiation (though not tested on the ARRT exam, this is presented here to provide a comparison between natural and medical background sources of exposure as part of a course study guide)
 1. Total annual background radiation dose is 6.25 mSv annually (double compared with early 1980s)
 2. Natural background radiation
 - a. Contributes 3.0 mSv annually
 - b. Approximately 48% of total radiation dose
 - c. Largest source of natural background radiation is radon
 - d. Other sources of natural background radiation are terrestrial, internal, and space (cosmic)
 3. Medical background radiation
 - a. Contributes 3.2 mSv (these data assume that medical doses would be spread equally across the entire population)
 - b. Approximately 50% of total radiation dose
 - c. Increase in total exposure is primarily attributed to increased use of computed tomography (CT)
 - d. CT accounts for 24% of total radiation exposure
 4. Other human-made background radiation
 - a. Remaining 2% of effective dose
 - b. Sources—occupational exposure, various consumer products, and other sources

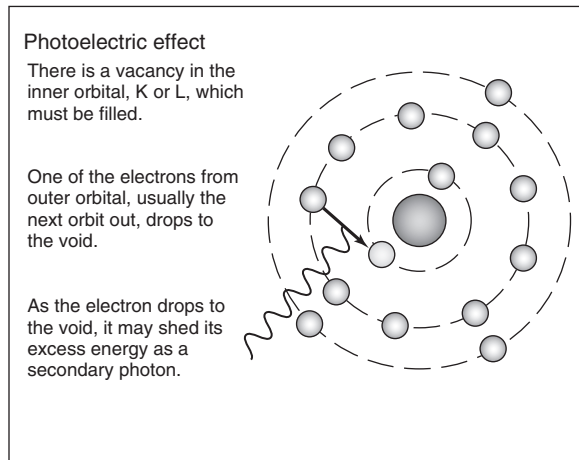
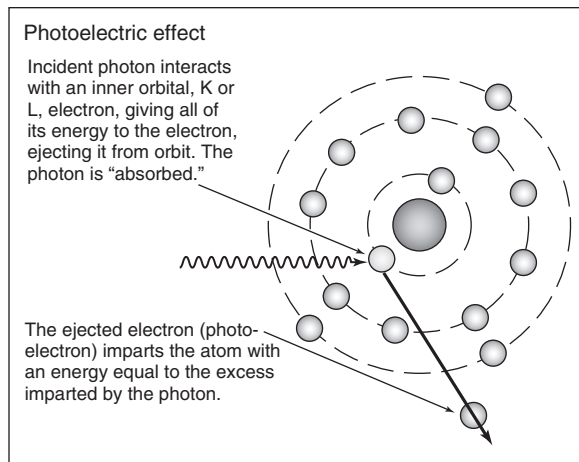
KEY REVIEW POINTS

Ionizing Radiation

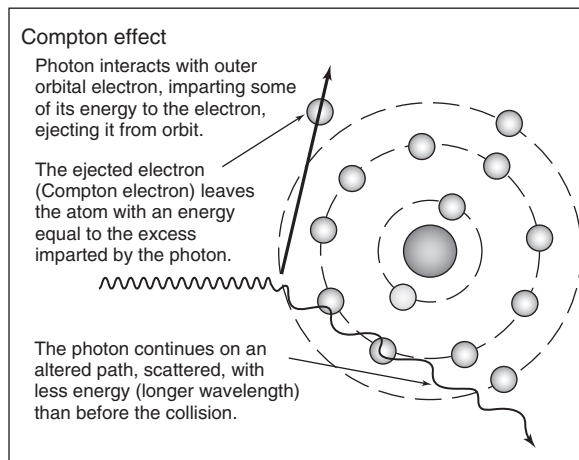
- Ionizing radiation is able to remove electrons from atoms; the process is called *ionization*
- Ionization may cause unstable atoms, free electrons, or formation of new molecules harmful to the cell
- Two types of cell damage may occur: somatic (damage to the cell itself) or genetic (damage to the cell's genetic code)
- Natural background radiation is present in the environment
- The greatest source of natural background exposure to humans is radon
- Human-produced radiation is created by human activities (e.g., medical imaging) or inventions
- CT accounts for the largest increase in total dose and medical dose to the population
- Total radiation dose to the U.S. population has doubled since the 1980s

Photon–Tissue Interactions

- A. *Primary radiation*: Radiation exiting the x-ray tube
- B. *Exit radiation (image-producing radiation)*: X-rays that emerge from the patient and strike the image receptor; composed of primary and scattered photons
- C. *Attenuation*: Absorption and scatter (loss of intensity) of the x-ray beam as it passes through the patient
- D. *Heterogeneous beam*: X-ray beam that contains photons of many different energies
- E. Most common photon–tissue interactions in diagnostic radiography are photoelectric and Compton interactions
 1. Photoelectric interaction ([Figure 3-1](#))
 - a. Photon absorption interaction
 - b. Incoming x-ray photon strikes a *K*-shell electron
 - c. Energy of x-ray photon is transferred to electron
 - d. Electron is ejected from the *K*-shell and is now called a *photoelectron*
 - e. X-ray photon has deposited all of its energy and ceases to exist
 - f. Photon has been completely absorbed
 - g. Photoelectron may ionize or excite other atoms until it has deposited all of its energy
 - h. Hole in *K*-shell is filled by electrons from outer shells, releasing energy that creates low-energy characteristic photons that are locally absorbed
 - i. Photoelectric interaction results in increased dose to the patient
 - j. Photoelectric interaction produces contrast in the radiograph because of the differential absorption of the incoming x-ray photons in the tissues
 2. Compton interaction ([Figure 3-2](#))
 - a. Also called *Compton scattering* or modified scattering
 - b. Incoming x-ray photon strikes a loosely bound, outer-shell electron



• **Figure 3-1** The photoelectric effect is responsible for total absorption of the incoming x-ray photon.



• **Figure 3-2** During the Compton effect, the incoming photon loses energy and changes its direction.

- c. Photon transfers part of its energy to the electron
- d. Electron is removed from orbit as a scattered electron, referred to as a *recoil electron*
- e. Ejected electrons may ionize other atoms or recombine with an ion needing an electron

- f. Photon scatters in another direction with less energy than before because of its encounter with the electron
 - g. Scattered photon may interact with other electrons, causing more ionization, additional scattering events, or photoelectric absorption; or it may exit the patient
 - h. Scattered photons emerging from the patient travel in divergent paths in random directions
 - i. Scattered photons may also be present in the room and expose the radiographer or radiologist
3. Coherent scatter (also known as *classical scatter*)
 - a. Produced by low-energy x-ray photons
 - b. Atomic electrons are not removed but vibrate because of the deposition of energy from the photon
 - c. As the electrons vibrate, they emit energy equal to that of the original photon
 - d. This energy travels in a path slightly different from the path of the original photon
 - e. Ionization has not occurred, although the photon has scattered
 - f. Does not affect image less than 70 kVp
 - g. May have negligible effect on fog greater than 70 kVp
 4. Pair production
 - a. Does not occur in radiography
 - b. Produced at photon energies greater than 1.02 million electron volts
 - c. Involves an interaction between the incoming photon and the atomic nucleus
 5. Photodisintegration—does not occur in diagnostic radiography

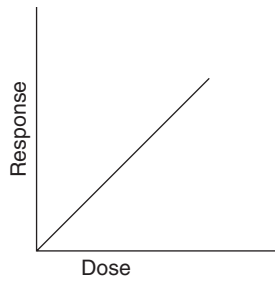
KEY REVIEW POINTS

Photon–Tissue Interactions

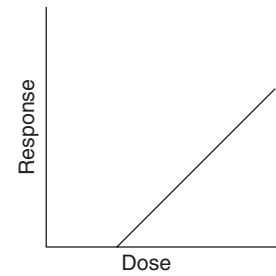
- Attenuation describes changes in the intensity of the x-ray beam as it traverses the patient
- Two primary photon–tissue interactions are significant in diagnostic x-ray procedures—photoelectric and Compton
- Photoelectric interaction results in complete absorption of an incoming x-ray photon; this interaction produces contrast in the radiographic image
- Compton interaction results in scattering of the incoming x-ray photon; scatter produced by this interaction must be removed from the beam before it strikes the image receptor
- Compton scatter is the source of exposure to the radiographer or radiologist during fluoroscopy

Annual Dose Limits

- A. Agencies involved in dose-response evaluations
 1. International Commission on Radiological Protection (ICRP)
 - a. Conducts research and provides recommendations on radiation protection to the worldwide community based on fundamental scientific principles

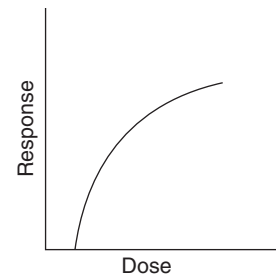


• **Figure 3-3** Linear-nonthreshold relationship.

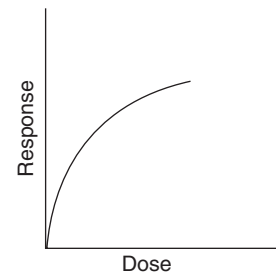


• **Figure 3-4** Linear-threshold relationship.

- b. Has no legal power
- c. Most countries base radiation protection legislation on ICRP recommendations
2. National Council on Radiation Protection and Measurements (NCRP)
 - a. Formulates and publishes scientifically researched recommendations on radiation protection and measurements in the United States
3. Nuclear Regulatory Commission (NRC)
 - a. Enforces radiation protection standards relating to radioactive material at the federal level
- B. Effective dose limit
 1. Upper boundary dose that can be absorbed, either in a single exposure or annually, with a negligible risk of somatic or genetic damage to the individual
 2. *As low as reasonably achievable* (ALARA)
 - a. Concept of radiologic practice that encourages radiation users to adopt measures that keep the dose to the patient and themselves at minimal levels
- C. Dose-response relationships
 1. Linear-nonthreshold relationship (Figure 3-3)
 - a. Indicates that no level of radiation can be considered completely safe
 - b. A response occurs at every dose
 - c. The degree of response to exposure is directly proportional to the amount of radiation received
 2. Linear-threshold relationship (Figure 3-4)
 - a. Indicates that at lower doses of radiation exposure (to the left of the line intersecting the x -axis), no response is expected
 - b. When the threshold dose is exceeded, the response is directly proportional to the dose received
 - c. As an example, cataractogenesis does not occur at low levels of radiation exposure; there is a threshold dose below which cataractogenesis does not occur
 3. Nonlinear-threshold relationship (Figure 3-5)
 - a. Indicates that at lower doses of radiation exposure (to the left of the curve intersecting the x -axis), no response is expected
 - b. When the threshold dose is exceeded, the response is not directly proportional to the dose received and is increasingly effective per unit dose
 4. Nonlinear-nonthreshold relationship (Figure 3-6)
 - a. Indicates that no level of radiation can be considered completely safe
 - b. A response occurs at every dose



• **Figure 3-5** Nonlinear-threshold relationship.



• **Figure 3-6** Nonlinear-nonthreshold relationship.

- c. The degree of the response is not directly proportional to the dose received
- d. The effect is large even with a small increase in dose
5. *Stochastic effects*: Randomly occurring effects of radiation; the probability of such effects is proportional to the dose (increased dose equals increased probability, not severity, of effects)
6. *Deterministic effects*: Effects that become more severe at high levels of radiation exposure and do not occur below a certain threshold dose
- D. NCRP Report #116
 1. Recommends balance between the risk and benefit of using radiation for diagnostic imaging
 2. Recommends that somatic and genetic effects be kept to a minimum when using radiation for diagnostic imaging
 3. Takes into account all human organs that may be vulnerable to radiation damage
 4. Occupational exposure—annual effective dose limit is 50 mSv
 5. Occupational exposure—annual equivalent dose limits for deterministic effects
 - a. Lens of the eye—150 mSv
 - b. Localized areas of skin, hands, feet—500 mSv

6. Cumulative effective dose limit = Age (in years) \times 10 mSv
7. Students (older than age 18)—annual effective dose limit is 50 mSv
8. General public—annual effective dose limit for frequent exposure is 1 mSv
9. General public—annual effective dose limit for infrequent exposure is 5 mSv
10. Embryo-fetus—total equivalent dose for gestation is 5 mSv
11. Embryo-fetus—equivalent dose limit per month is 0.5 mSv
12. Level of negligible risk is 0.01 mSv

KEY REVIEW POINTS

Annual Dose Limits

- Annual dose limits are published by the NCRP
- Effective dose limit is the upper boundary dose that can be absorbed, either in a single exposure or annually, with a negligible risk of somatic or genetic damage to the individual
- The ALARA (*as low as reasonably achievable*) principle means that radiographers do what is possible to keep doses to patients and themselves at minimal levels
- Linear-nonthreshold relationship states that no level of radiation can be considered completely safe, and the degree of response is directly proportional to the amount of radiation received
- Stochastic effects are randomly occurring effects of radiation; the probability of such effects is proportional to the dose (not related to the severity of effects)
- Deterministic effects become more severe at high levels of radiation exposure but do not occur below a certain threshold dose
- NCRP Report #116 contains recommendations for annual dose limits
- Annual effective dose limit for occupational exposure is 50 mSv
- Cumulative effective dose limit = age (in years) \times 10 mSv
- Annual effective dose limit for the general public is 1 mSv for frequent exposure and 5 mSv for infrequent exposure
- Effective dose limit for the embryo or fetus for all of gestation is 5.0 mSv

Review of the Cell

Cell

- A. Contains three main parts
 1. Cell membrane
 2. Cytoplasm
 3. Nucleus
- B. Cell membrane
 1. Protects cell
 2. Holds in water and nucleus
 3. Allows water, nutrients, and waste products to pass into and out of the cell (it is semipermeable)
- C. Cytoplasm
 1. Composed primarily of water
 2. Conducts all cellular metabolism
 3. Contains organelles
 - a. *Centrosomes*: Participate in cell division
 - b. *Ribosomes*: Synthesize protein
 - c. *Lysosomes*: Contain enzymes for intracellular digestive processes
 - d. *Mitochondria*: Produce energy
 - e. *Golgi apparatus*: Combines proteins with carbohydrates
 - f. *Endoplasmic reticulum*: Acts as a transportation system to move food and molecules within the cell
- D. Nucleus
 1. Contains deoxyribonucleic acid (DNA—the master molecule) and the nucleolus (with ribonucleic acid [RNA])
 2. DNA controls cell division
 3. DNA controls all cellular functions
- E. Other cell components
 1. Proteins—15% of cell
 2. Carbohydrates—1% of cell
 3. Lipids—2% of cell
 4. Nucleic acids—1% of cell
 5. Water—80% of cell
 6. Acids, bases, salts (electrolytes)—1% of cell

Capitalize Division- Sv

- A. *Mitosis*: Somatic cells
 1. Interphase
 - a. Cell growth before mitosis
 - b. Consists of three phases: G_1 , S, G_2
 - c. G_1 —pre-DNA synthesis
 - d. S—DNA synthesis
 - e. G_2 —post-DNA synthesis, preparation for mitosis
 2. Four subphases
 - a. Prophase—nucleus enlarges
 - b. Metaphase—nucleus elongates
 - c. Anaphase—two complete sets of chromosomes
 - d. Telophase—separates the two sets of genetic material; division complete; 46 chromosomes in each new somatic cell
- B. *Meiosis*: Cell division of sperm or ovum (germ cells) that halves the number of chromosomes in each cell
 1. Replication division
 - a. G_1
 - b. S
 - c. G_2
 - d. M
 2. Reduction division
 - a. G_1
 - b. No S phase
 - c. G_2
 - d. M
 3. *Note*: Sperm and ovum unite to return the number of chromosomes in each cell of the new individual to 46

Biological Effects of Ionizing Radiation

- A. As LET of radiation increases, so does biological damage
- B. *Relative biologic effectiveness (RBE)*: Ability to produce biological damage; varies with LET
- C. The W_R used to calculate sievert is a measure of the RBE of the radiation being used
- D. Ionizing radiation may change the molecular structure of a cell, affecting its ability to function properly
- E. Somatic cell exposure may result in a disruption in the ability of the organism to function
- F. Reproductive (germ) cell exposure may result in changes, called *mutations*, being passed on to the next generation
- G. Basically, radiation striking a cell deposits energy in either the DNA (a direct effect) or water in the cytoplasm (an indirect effect) if an interaction occurs
- H. Most radiation passes through the body without interacting because atoms are composed mainly of empty space

Direct Effect

- A. Occurs when radiation transfers its energy directly to the DNA (the master molecule) or RNA
- B. As these macromolecules are ionized, cell processes may be disrupted
- C. Some of this damage may be repaired
- D. If the DNA structure incurs sufficient damage, particularly to its nitrogenous bases, a mutation may result
- E. *Mutation*: Erroneous information passed to subsequent generations via cell division
- F. Results of the direct effect
 1. No effect—most common result
 2. Disruption of chemical bonds, causing alteration of cell structure and function
 3. Cell death
 4. Cell line death: Death of the tissues or organs that would have been produced from continued cell division had a cell survived; particularly significant if it results in the failure of a major organ or system to develop
 5. Faulty information passed on in the next cell division; possible results include mutations, cancer, and abnormal formations

Indirect Effect

- A. Because water is the largest constituent of the cell, the probability that it will be struck by radiation is greater
- B. *Radiolysis of water*: Occurs as radiation energy is deposited in the water of the cell
- C. The result of radiolysis is an ion pair in the cell: a positively charged water molecule (HOH^+) and a free electron
- D. Several possibilities exist for chemical reactions at this point; most reactions create further instability in the cell
- E. If the two ions recombine, no damage occurs

- F. Positive and negative water molecules may be formed and then break into smaller molecules such as free radicals
- G. *Free radicals*: Highly reactive ions that have an unpaired electron in the outer shell
- H. Free radicals may cause biological damage by transferring their excess energy to surrounding molecules or disrupting chemical reactions
- I. Some free radicals may chemically combine to form hydrogen peroxide (H_2O_2)
- J. Hydrogen peroxide is a poison that causes further damage to the cell
- K. The DNA in the cell may be affected by the free radicals or H_2O_2
- L. Such action is called *indirect* because the DNA itself is not struck by the radiation
- M. Indirect effect results from ionization or excitation of water molecules
- N. Results of indirect effect
 1. No effect—most common response
 2. Formation of free radicals
 3. Formation of H_2O_2
- O. Most damage to the body occurs as a result of the indirect effect because most of the body is water, and free radicals are readily mobile in water

Target Theory

- A. Each cell has a master molecule (DNA) that directs cell activities
- B. If the DNA is the target of radiation damage and is inactivated, the cell dies
- C. DNA may be inactivated by either direct or indirect effects
- D. All photon–cell interactions occur by chance
- E. Whether a given cell death was the result of direct or indirect effects cannot be determined

Radiosensitivity of Cells

- A. *Law of Bergonié and Tribondeau*: Cells are most sensitive to radiation when they are immature, undifferentiated, and rapidly dividing
- B. If cells are more oxygenated, they are more susceptible to radiation damage (known as the *oxygen enhancement ratio (OER)*)
- C. As cells mature and become specialized, they are less sensitive to radiation
- D. *Blood cells*: Whole-body dose of 25 rads depresses blood count
 1. Caused by irradiation of bone marrow
 2. Lymphocytes are the most radiosensitive blood cells in the body
 3. Stem cells in bone marrow are especially radiosensitive
- E. *Epithelial tissue*: Highly radiosensitive, divides rapidly, lines body tissue
- F. *Muscle*: Relatively insensitive because of high specialization and lack of cell division

- G. *Adult nerve tissue*: Requires very high doses (beyond medical levels) to cause damage, is very specialized, has no cell division, is relatively insensitive to radiation
- H. Reproductive cells
1. *Immature sperm cells*: Very radiosensitive, divide rapidly, unspecialized, require 10 rads or more (which is beyond most commonly used diagnostic levels) to increase chances of mutation
 2. Ova in female fetus and child are very radiosensitive
 3. Ovarian radiosensitivity decreases until near middle age, then increases again

Somatic Effects of Radiation

- A. Somatic effects are evident in the organism being exposed
- B. Doses causing these effects are much higher than the levels of radiation used in diagnostic radiography
- C. Caused when a large dose of radiation is received by a large area of the body (can also be caused by local areas of the body receiving high doses of radiation during radiation therapy)
- D. Examples of early somatic effects of radiation (acute radiation syndrome)
1. *Hematopoietic syndrome*: Decreases total number of all blood cells; can result in death
 2. *GI syndrome*: Causes total disruption of GI tract structure and function and can result in death
 3. *Central nervous system syndrome*: Causes complete failure of nervous system and results in death
- E. Examples of late somatic effects
1. Carcinogenesis: Causes cancer
 2. Cataractogenesis: Causes cataracts to form; follows a nonlinear-threshold dose-response curve
 3. Embryologic effects: Most sensitive during the first trimester of gestation
 4. Thyroid: Very radiosensitive organ; late somatic effect may be cancer or cessation of function
 5. Shortening of life span: Does not occur in modern radiation workers

Genetic Effects of Radiation

- A. Caused by damage to DNA molecule, which is passed to the next generation
- B. Follows a linear-nonthreshold dose-response curve; no such thing as a safe gonadal dose; any exposure can represent a genetic threat
- C. Usually causes recessive mutations, so generally not manifested in the population
- D. *Doubling dose*: Amount of radiation that causes the number of mutations in a population to double (is approximately 1.56 Sv for humans)
- E. Genetic mutations do not cause defects that are not already present in humans from other causes; that is, no defects are unique to radiation exposure

KEY REVIEW POINTS

Cell

- Main parts of the cell are the cell membrane, cytoplasm, and nucleus
- Nucleus contains DNA
- Cytoplasm contains the organelles and water
- *Interphase*: Portion of the cellular life cycle that occurs before mitosis
- *Mitosis*: Somatic cell division; comprises four phases: prophase, metaphase, anaphase, and telophase
- When mitosis is complete, each new cell contains 46 chromosomes
- *Meiosis*: Germ (sperm or ovum) cell division; halves the number of chromosomes in each cell so that the union of two germ cells produces a new cell with 46 chromosomes
- *LET*: Amount of energy deposited per unit length of travel of radiation passing through matter
- An increase in LET results in an increase in the potential for biological damage
- *RBE*: Ability of radiation to produce biological damage; it varies with LET
- *Direct effect*: Occurs when radiation transfers its energy directly to the DNA (the master molecule) or RNA
- *Mutation*: Erroneous information passed to subsequent generations via cell division
- *Indirect effect*: Occurs when radiation transfers its energy to the water in the cytoplasm; may cause radiolysis and produce free radicals or H₂O₂
- *Law of Bergonié and Tribondeau*: Cells are most sensitive to radiation when they are immature, undifferentiated, and rapidly dividing
- *OER*: If cells are more oxygenated, they are more susceptible to radiation damage
- As cells mature and become specialized, they are less sensitive to radiation
- Lymphocytes are the most radiosensitive blood cells in the body
- Stem cells in bone marrow are especially radiosensitive
- *Epithelial tissue*: Highly radiosensitive
- *Muscle*: Relatively insensitive to radiation
- *Adult nerve tissue*: Requires very high doses of radiation (beyond medical levels) to cause damage; is relatively insensitive to radiation
- *Immature sperm cells*: Very radiosensitive
- *Ova in female fetus and child*: Very radiosensitive
- Ova radiosensitivity decreases until near middle age, then increases again
- Somatic effects manifest in the individual being exposed
- *Early somatic effects*: Hematopoietic syndrome, GI syndrome, central nervous system syndrome
- *Late somatic effects*: Carcinogenesis, cataractogenesis, embryologic effects, life span shortening
- *Genetic effects*: Manifest in the next generation because of damage to the DNA; follow a linear-nonthreshold curve
- *Doubling dose*: Amount of radiation that causes the number of mutations in a population to double; estimated to be 1.56 Sv for humans

Patient Exposure and Protection

The heart of radiation protection for the patient lies in the concept of ALARA. It is primarily the radiographer's responsibility to see that ALARA is in practice so that patients are properly protected. Taking adequate histories, communicating clearly, using proper immobilization, and conducting radiographic and fluoroscopic exams calmly and professionally add to the level of safety your patients will encounter while under your care. This section reviews the many technical aspects of the radiographer's practice that contribute to ALARA for the patient.

Beam Limitation

Beam limitation protects the patient by limiting the area of the body and the volume of tissue being irradiated

- A. Collimator
 1. Variable aperture device
 2. Contains two sets of lead shutters placed at right angles to each other
 3. Higher set of lead shutters is placed near the x-ray tube window to absorb off-stem (off-focus) radiation
 4. Lower set of lead shutters is placed near the bottom of the collimator box to restrict the beam further as it exits
 5. Accuracy of the collimator is subject to strict quality control standards (see [Chapter 4](#))
 6. Collimation should be no larger than the size of the image receptor being used
 7. Collimators that automatically restrict the beam to the size of the image receptor have a feature called *positive beam limitation* (PBL), also called *automatic collimation*
 8. PBL responds when an image receptor is placed in the tray containing sensors that measure its size
- B. Cylinder cones
 1. Metal cylinders that attach to the bottom of the collimator
 2. Used to restrict the beam tightly to a small circle
 3. Diameter of the far end of the cone determines field size
 4. Cones may be extended an additional 10 to 12 inches by a telescoping action for even tighter restriction of the beam
 5. Cones may be used for exam of the os calcis, various skull projections, and cone-down views of vertebral bodies
 6. Use of cones results in a restriction of the x-ray beam by cutting out a major portion of the beam
 7. When cones are used, mAs must always be increased to make up for the rays attenuated by the cone
 8. Cylinder cones do not work by focusing the x-ray beam down the cone; x-rays cannot be focused
- C. Aperture diaphragm
 1. Flat piece of lead with a circle or square opening in the middle
 2. Placed as close to the x-ray tube window as possible
 3. Has no moving parts

Filtration

A filter is placed in the x-ray beam to remove long-wavelength (low-energy) x-rays. Low-energy x-rays contribute nothing to the diagnostic image but increase patient dose through the photoelectric effect. As low-energy rays are removed, the beam becomes "harder" (predominantly short-wavelength, high-energy). This process of removing low-energy rays results in a lower patient dose.

- A. Two types of filtration: inherent and added
- B. Inherent filtration
 1. Glass envelope of the x-ray tube
 2. Insulating oil around the tube
 3. Diagonal mirror used for positioning light
- C. Added filtration
 1. Aluminum sheets placed in the path of the beam near the x-ray tube window
 2. Mirror placed in the collimator head
- D. Total filtration
 1. Equals inherent plus added filtration
 2. Must equal at least 2.5-mm aluminum equivalent for x-ray tubes operating at greater than 70 kVp
- E. *Half-value layer*: Amount of filtration that reduces the intensity of the x-ray beam to half of its original value—measured at least annually by a qualified radiation physicist
- F. The radiographer never adjusts added tube filtration; if it is suspected that the filtration has been altered, the x-ray tube must not be used until checked by a radiation physicist

Gonadal Shields

Gonadal shields are used to protect gonads from unnecessary radiation exposure. They should be used whenever they do not obstruct the area of clinical interest.

- A. Gonadal shielding may reduce female gonad dose by up to 50%
- B. Gonadal shielding may reduce male gonad dose by up to 95%
- C. Proper collimation may also greatly reduce gonadal dose and should be used in conjunction with gonadal shields
- D. Most commonly used gonadal shields
 1. *Flat contact shield*: Flat piece of lead or a lead apron placed over the gonads
 2. *Shadow shield*: Suspended from the x-ray tube housing and placed in the x-ray beam light field; requires no contact with the patient; especially useful during procedures requiring sterile technique

Exposure Factors

Exposure technique determines the quantity and quality of x-rays striking the patient

- A. Use optimal kVp for the part being radiographed
- B. Use the lowest possible mAs to reduce the amount of radiation striking the patient

- C. The part being imaged should be measured with calipers
- D. A reliable technique chart should be consulted to determine the proper exposure factors to use
- E. Use of automatic exposure controls (AEC) reduces the number of repeat exposures

Grids

- A. Result in an increase in patient dose because increased mAs are required
- B. Use appropriate type and ratio of grid for part being imaged and exam being performed

Repeat Exposures

- A. Always result in an increase in radiation dose to the patient
- B. Must be kept to a minimum
- C. Should be tracked via a departmental repeat exposure analysis
- D. Reasons for repeat exposures should be documented
- E. In-service education for areas of frequent repeat exposures should be conducted by qualified radiographers or radiologists

Technical Standards for Patient Protection

- A. Minimum source-to-skin distance for portable radiography: at least 12 inches
- B. Fluoroscopy
 - 1. Use of intermittent fluoroscopy (as opposed to a constant beam-on condition)
 - 2. Tight collimation of the beam
 - 3. High kVp
 - 4. Source-to-tabletop distance for fixed fluoroscopes: not less than 15 inches
 - 5. Source-to-tabletop distance for portable fluoroscopes: not less than 12 inches
 - 6. Proper filtration of the beam
 - 7. Fluoroscopy timer that sounds alarm after 5 minutes (300 seconds) of beam-on time
 - 8. Fluoroscopy timer should not be reset before alarm goes off; fluoroscopist must be made aware of time that the patient and other persons in the room were exposed
 - 9. Exposure switch must be dead-man type
 - 10. Limit dose at the tabletop to no more than 100 mGy_a per minute
 - 11. Limit use of high-level-control fluoroscopy (HLCF) during interventional procedures to no more than 200 mGy_a per minute
 - 12. Long exposure times (>30 minutes) can lead to skin effects; the patient should be informed of the possibility of skin injury (e.g., erythema, epilation)
 - 13. Fluoroscopy times should be recorded
 - 14. Pulsed fluoroscopy or low-dose modes should be used when possible to achieve ALARA objectives

- 15. Personnel during fluoroscopy should stand on the image intensifier side of the C-arm during lateral or oblique projections
- 16. When possible, use the C-arm with the x-ray tube below the patient for anteroposterior and postero-anterior projections
- 17. During fluoroscopy, the radiographer should always wear the radiation dosimeter outside of the lead apron at the level of the collar
- 18. Avoid use of electronic magnification modes on the image intensifier when possible because this increases the dose to the patient and other persons in the room
- 19. Air kerma
 - a. Provides an approximate skin dose where the x-ray beam is entering the patient
 - b. Is displayed during a fluoroscopic procedure
 - c. Monitoring air kerma is a way to keep dose to the patient lower, especially during prolonged fluoroscopic procedures
 - d. Expressed as Gy_a (a indicates energy deposited in a mass of air)
- 20. Dose area product (DAP)—the total of air kerma striking the surface of the patient
 - a. May be read on the DAP meter on the fluoroscopic monitor
 - b. Expressed as mGy-cm²
- 21. Last image hold (LIH)
 - a. Provides for keeping the most recently acquired fluoroscopic image displayed on the monitor without continued radiation exposure to the patient
 - b. Using last image hold reduces patient exposure by allowing the fluoroscopist to evaluate an image without continuing to expose the patient
- 22. Automatic brightness control (ABC) or automatic exposure rate control (AERC)
 - a. kVp and mA are automatically adjusted during fluoroscopy, which keeps image brightness level
 - b. The ABC or AERC delivers to the image receptor only the exposure that is required to maintain the necessary image quality

Other Factors Relating to Patient Dose

- A. Measuring patient dose
 - 1. Skin entrance dose
 - 2. *Mean marrow dose (MMD)*: Average dose to active bone marrow
- B. *Genetically significant dose (GSD)*: Radiation dose that, if received by the entire population, would cause the same genetic injury as the total of doses received by the persons actually being exposed; the average gonadal dose to the childbearing-age population
- C. *Pediatrics*: Children need to be carefully protected from unnecessary exposure; high-speed image receptors should be used along with adequate immobilization
- D. Pregnant patients

1. It is the responsibility of the referring physician to determine whether a diagnostic exam involving x-rays is necessary; the benefit should outweigh the risk; if the abdomen or pelvis is involved, the radiologist should communicate the risk of the exam to the referring physician and the patient
2. Most diagnostic x-ray exams have equivalent doses of less than 0.01 mSv
3. Radiation doses of less than 0.01 mSv to the embryo or fetus are considered lower risk

KEY REVIEW POINTS

Patient Exposure and Protection

- Always observe the ALARA principle
- *Beam limiters*: Collimator, cylinder cones, aperture diaphragms
- *PBL*: Positive beam limitation, or automatic collimation
- *Beam filtration*: Removes long-wavelength rays; total filtration must be at least 2.5-mm aluminum equivalent
- *Gonadal shielding*: May reduce female gonad dose by up to 50%; may reduce male gonad dose by up to 95%
- *Exposure factors*: Use optimum kVp for the part; use lowest practical mAs
- Grids remove scatter radiation from exit beam; increase total dose to the patient because of the increased mAs needed
- Maintain a minimum of 12 inches source-to-skin distance for portable radiography
- Use intermittent fluoroscopy
- Maintain a minimum of 15 inches source-to-tabletop distance for fixed fluoroscopes
- Maintain a minimum of 12 inches source-to-tabletop distance for portable fluoroscopes (15 inches preferred)
- Monitor fluoroscopy timer that must sound alarm after 5 minutes (300 seconds) of beam-on time
- Fluoroscopy foot switch must be dead-man type
- Fluoroscopy dose at the tabletop is limited to no more than 100 mGy_a per minute
- *MMD*: Average dose to active bone marrow
- *GSD*: Radiation dose that, if received by the entire population, would cause the same genetic injury as the total of doses received by the persons actually being exposed; the average gonadal dose to the childbearing-age population

Radiation Worker Exposure and Protection

The ALARA concept applies to radiographers as well as to patients. Many of the steps taken to reduce the dose to the patient also reduce the dose to the radiographer. However, additional steps may be taken to protect the radiation worker further. Agency standards also apply to the equipment used by radiographers. This section reviews practices and standards used to protect occupationally exposed individuals. As you study the factors involved in protecting the radiation worker, reexamine the annual effective dose limits covered previously.

Cardinal Principles of Radiation Protection

- Time*: Amount of exposure is directly proportional to duration of exposure
- Distance*: Most effective protection from ionizing radiation
 1. Dose is governed by the inverse square law
 2. The greater the distance from the radiation, the lower the dose
 3. Dose varies inversely according to the square of the distance; for example, if the exposure is 5 mGy_a at a distance of 3 feet, stepping back to a distance of 6 feet causes the exposure to decrease to 1.25 mGy_a
 4. The inverse square law should always be used during fluoroscopy in which close contact with the patient is not required and during mobile radiography and fluoroscopy
- Shielding*: Lead-equivalent shielding absorbs most of the energy of the scatter radiation
 1. A lead apron of at least 0.25-mm lead equivalent *must* be worn (0.5-mm lead equivalent *should* be worn) during exposure to scatter radiation; a thyroid shield of at least 0.5-mm lead equivalent *should* be worn for fluoroscopy
 2. The radiographer should never be exposed to the primary beam
 3. If exposure of the radiographer to the primary beam is unavoidable, the exam should not be performed
 4. Family members of the patient, nonradiology employees, or radiology personnel not routinely exposed should be the first choices to assist with immobilization of the patient for an exam when all other types of immobilization have proved inadequate
 5. The radiographer should be the last person chosen to assist with immobilization during an exposure
 6. Radiographers and student radiographers should not be viewed as quick and easy-to-use immobilization devices
 7. Thickness recommendations for lead devices have been determined by NCRP Report #102

Source of Radiation Exposure to Radiographer

- A. Source of radiation exposure to the radiographer is scatter radiation produced by Compton interactions in the patient
- B. Greatest exposure to the radiographer occurs during fluoroscopy, portable radiography, and surgical radiography
- C. It is vital that lead aprons be worn when fluoroscopy and mobile radiography or fluoroscopy is performed
- D. Photons lose considerable energy after scattering
- E. Scattered beam intensity is about $\frac{1}{1000}$ the intensity of the primary beam at a 90-degree angle at a distance of 1 m from the patient
- F. Beam collimation helps reduce the incidence of Compton interactions, resulting in decreased scatter from the patient

- G. The use of high-speed image receptors may further reduce the amount of scatter produced because of decreased quantity of radiation needed for exposure

Structural Protective Barriers

- A. Primary protective barriers
1. Consist of $\frac{1}{16}$ -inch lead equivalent
 2. Located where primary beam may strike the wall or floor
 3. If in the wall, extend from the floor to a height of 7 feet
- B. Secondary protective barriers
1. Consist of $\frac{1}{32}$ -inch lead equivalent
 2. Extend from where primary protective barrier ends to the ceiling, with $\frac{1}{2}$ -inch overlap
 3. Located wherever leakage or scatter radiation may strike
 4. X-ray control booth is also a secondary protective barrier
 - a. Exposure switch must have a cord short enough that the radiographer has to be behind the secondary protective barrier to operate the switch
 - b. Lead window by control booth is usually 1.5-mm lead equivalent
- C. Determinants of barrier thickness
1. *Distance*: Between the source of radiation and the barrier
 2. *Occupancy*: Who occupies a given area
 - a. *Uncontrolled area*: Areas where personnel are not provided radiation exposure monitors (dosimeters) or radiation safety training should be shielded to ensure an effective dose limit to the general public of 20 μSv per week
 - b. *Controlled area*: Occupied by persons trained in radiation safety and wearing personnel monitoring devices; shielded to keep exposure under 1 mSv per week
 3. *Workload*: Measured in mA minutes per week (mA min/wk); takes into account the volume and types of exams performed in the room
 4. *Use factor*: Amount of time the beam is on and directed at a particular barrier

X-ray Tube Housing

- A. X-rays may leak through the housing during an exposure
- B. Patient and all others present in the room must be protected from excess leakage radiation
- C. Leakage radiation may not exceed 1 mGy_a per hour at a distance of 1 m from the housing

Fluoroscopic Equipment

- A. *Exposure switch*: Must be dead-man type
- B. *Protective curtain*: Minimum 0.25-mm lead equivalent

- C. *Bucky slot shield*: Minimum 0.25-mm lead equivalent
- D. 5-minute timer with audible alarm

Portable Radiographic Equipment and Procedure

- A. Exposure switch must be on a cord at least 6 feet long
- B. Lead aprons must be worn if mobile barriers are unavailable
- C. Least scatter is at a 90-degree angle from patient
- D. Apply the inverse square law to reduce dose by using exposure cord at full length
- E. Radiographer should never hold the image receptor in place for a portable exam because of possible exposure to the primary beam
- F. Commercial image receptor holders, pillows, and sponges should be used to hold the image receptor in place

KEY REVIEW POINTS

Radiation Worker Exposure and Protection

- *Cardinal principles of radiation protection*: Time, distance, shielding; distance is the best protection
- Dose is governed by the inverse square law
- *Lead apron*: Must be at least 0.25-mm lead equivalent; should be at least 0.5-mm lead equivalent
- The radiographer must never be exposed to the primary beam
- Source of radiation exposure to radiographer is scatter radiation produced by Compton interactions in the patient during fluoroscopy, portable radiography, and surgical radiography
- Scattered beam intensity is about $\frac{1}{1000}$ the intensity of the primary beam at a 90-degree angle at a distance of 1 m from the patient
- Beam collimation helps reduce the incidence of Compton interactions, resulting in decreased scatter from the patient
- *Primary protective barriers*: Must be at least $\frac{1}{16}$ -inch lead equivalent and extend from the floor to a height of 7 feet
- *Secondary protective barriers*: Must be at least $\frac{1}{32}$ -inch lead equivalent and extend from the primary protective barrier to the ceiling with a $\frac{1}{2}$ -inch overlap
- *Determinants of barrier thickness*: Distance, occupancy, workload, use
- *Uncontrolled area*: General public areas such as waiting rooms and stairways
- *Controlled area*: Occupied by persons trained in radiation safety and wearing personnel monitoring devices
- *X-ray tube leakage*: May not exceed 1 mGy_a per hour at a distance of 1 m from the housing
- *Fluoroscopic protective curtain*: Minimum 0.25-mm lead equivalent
- *Bucky slot shield*: Minimum 0.25-mm lead equivalent
- Portable x-ray machine exposure switch must be on a cord at least 6 feet long

Monitoring Radiation Exposure

Monitoring Personnel Exposure

- A. Optically stimulated luminescence (OSL) dosimeters
 1. Use aluminum oxide to record dose
 2. Radiation absorbed causes electrons to be trapped
 3. Aluminum oxide layer is stimulated by a laser beam after wear period
 4. Electrons release energy as visible light
 5. Light is in direct proportion to the amount of radiation received
 6. Measures exposures as low as $10 \mu\text{Gy}_a$
 7. Relatively unaffected by temperature and humidity
 8. Can be worn 3 months at a time
 9. Can be reanalyzed multiple times, if necessary
 10. Exposures below $10 \mu\text{Gy}_a$ are reported as minimal
- B. Thermoluminescent dosimeters (TLDs)
 1. Use lithium fluoride crystals instead of film to record dose
 2. Electrons of crystals are excited by radiation exposure and release this energy on heating
 3. Energy released is visible light, which is measured by a photomultiplier tube
 4. Light is in direct proportion to the amount of radiation received
 5. TLDs are used mainly in ring badges worn by nuclear medicine technologists
 6. Measure exposures as low as $50 \mu\text{Gy}_a$
 7. Relatively unaffected by temperature and humidity
 8. Can be worn for longer periods than film badges
 9. TLDs and equipment used to read them are expensive
 10. Exposures below $50 \mu\text{Gy}_a$ are reported as minimal
- C. Film badges—available but not often used today
 1. Consist of plastic case, film, and filters
 2. Plastic case holds film and filters and provides a clip for attaching to clothing
 3. Film used is similar to dental x-ray film
 4. Measure doses as low as $100 \mu\text{Gy}_a$
 5. Doses below $100 \mu\text{Gy}_a$ are reported as minimal
 6. Film is sensitive to extremes in temperature and humidity

7. Filters made of aluminum and copper measure intensity and type of radiation striking the film badge
8. Film badges are usually changed monthly

Monitoring Area Exposure

- A. Handheld ionization chamber
 1. Used to measure radiation in an area (e.g., a fluoroscopic room), storage areas for radioisotopes, doses traveling through barriers, and patients who have radioactive sources within them
 2. Not used to monitor short exposure times
 3. Measures exposure rates as low as $10 \mu\text{Gy}_a$ per hour
 4. Operates on a principle similar to the pocket ionization chamber, with internal gas being ionized when struck by radiation
- B. Geiger-Mueller detector
 1. Used to detect radioactive particles in nuclear medicine facilities
 2. Sounds audible alarm when struck by radiation, with sound increasing as radiation becomes more intense
 3. Meter reads in counts per minute

KEY REVIEW POINTS

Monitoring Radiation Exposure

- *OSL dosimeters:* Aluminum oxide layer stores energy that is released when exposed to a laser; correlate to dose; provide readings as low as $10 \mu\text{Gy}_a$; insensitive to environmental factors
- *TLDs:* Store energy in lithium fluoride crystals that is released when heated; correlate to dose; provide readings as low as $50 \mu\text{Gy}_a$; insensitive to environmental factors
- *Film badges:* Use small piece of x-ray film; provide readings as low as $100 \mu\text{Gy}_a$; sensitive to extremes in temperature and humidity
- *Handheld ionization chamber:* Used to measure radiation in an area; measures doses of $10 \mu\text{Gy}_a$ per hour
- *Geiger-Mueller detector:* Used to detect radioactive particles; meter reads in counts per minute

Review Questions

1. Natural background radiation represents what percentage of humans' radiation exposure?
 - a. 21%
 - b. 50%
 - c. 82%
 - d. 5%
2. The greatest source of natural background radiation exposure is:
 - a. Cosmic rays
 - b. Radioactive materials
 - c. The body itself
 - d. Radon gas
3. Cosmic radiation:
 - a. Is present only in space
 - b. Is a source of exposure only to persons who lie in the sun
 - c. Is of concern only to space travelers
 - d. Is a part of natural background exposure
4. Radon gas:
 - a. Presents a danger when undetected
 - b. Is present in doses proportional to other sources
 - c. Is entirely human-made
 - d. Is the source of 100% of annual background dose

5. X-rays and gamma rays used in diagnostic imaging are:
 - a. Not of concern because the beam is filtered
 - b. Part of the natural background dose
 - c. Part of an artificial background radiation dose
 - d. An insignificant dose to the general population because they are used safely
6. A feature of fluoroscopic x-ray machines that automatically adjusts kVp and mA so as to maintain image brightness for necessary image quality is called:
 - a. Automatic imaging
 - b. Automatic brightness control (ABC)
 - c. Automatic image processing
 - d. Constant exposure output
7. What term best describes the approximate skin dose where the x-ray beam is entering the patient?
 - a. Effective dose
 - b. Nonoccupational dose
 - c. In-air exposure
 - d. Air kerma
8. Sievert is calculated by multiplying gray by
 - a. W_R
 - b. W_a
 - c. W_t
 - d. mAs
9. The total of air kerma over the exposed area of the patient is called:
 - a. Dose area product
 - b. Mean marrow dose
 - c. Genetically significant dose
 - d. Total patient dose
10. Which of the following is also known as *coherent scattering*?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Classical scatter
 - d. Pair production
11. Which of the following photon–tissue interactions does *not* occur in diagnostic radiography?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
12. Which of the following is responsible for creating the conditions for contrast on the image?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
13. Which of the following produces scatter radiation that exits the patient and may fog the image?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
14. Which of the following produces scatter as a result of vibration of orbital electrons?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
15. Which of the following results in total absorption of an incident x-ray photon?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Classic scatter
 - d. Pair production
16. Which of the following is the only photon–tissue interaction that does *not* result in ionization?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
17. Which of the following involves interaction between an incident photon and an atomic nucleus?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
18. Which of the following photon–tissue interactions primarily involves *K*-shell electrons?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
19. Which of the following primarily involves loosely bound outer-shell electrons?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
20. Which of the following results in the production of a photoelectron that is ejected from the atom?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
21. Which of the following photon–tissue interactions necessitates the use of a grid?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
22. Which of the following may result in occupational exposure for a radiographer?
 - a. Photoelectric interaction
 - b. Compton interaction
 - c. Coherent scatter
 - d. Pair production
23. What unit of measurement is used for absorbed dose in tissue?
 - a. Gy_a
 - b. Gy_s
 - c. Gy_b
 - d. Gy_t

24. What unit of measurement is used for effective dose limits?
- Becquerel
 - Gy_t
 - Sievert
 - Gy_a
25. Which of the following units would be used to describe the radiation present in a fluoroscopic room?
- Bq
 - Sv
 - Gy_a
 - Gy_t
26. The amount of energy deposited by radiation per unit length of tissue being traversed is:
- LET, which determines the use of a W_R when the equivalent dose is being calculated
 - Linear energy transfer
 - Higher for wave radiations than for particulate radiations
 - LET, which is expressed as a W_R when absorbed dose is being calculated
27. What agency publishes radiation protection standards based on scientific research?
- Nuclear Regulatory Commission (NRC)
 - American Society of Radiologic Technologists (ASRT)
 - National Council on Radiation Protection and Measurements (NCRP)
 - Bureau of Radiological Health (BRH)
28. The agency that enforces radiation protection standards relating to radioactive material at the federal level is the:
- Nuclear Regulatory Commission (NRC)
 - International Commission on Radiation Protection (ICRP)
 - National Council on Radiation Protection and Measurements (NCRP)
 - Bureau of Radiological Health (BRH)
29. Effective dose limit is defined as the upper boundary dose that:
- Can be absorbed annually with a negligible risk of somatic or genetic damage to the individual
 - Can be absorbed, either in a single exposure or annually, with no risk of damage to the individual
 - Can be absorbed, either in a single exposure or annually, with no risk of somatic or genetic damage to the individual
 - Can be absorbed, either in a single exposure or annually, with a negligible risk of somatic or genetic damage to the individual
30. ALARA is an acronym for:
- As long as reasonably achievable
 - As little as reasonably achievable
 - As long as radiologist allows
 - A radiation protection concept that encourages radiation users to keep the dose to the patient as low as reasonably achievable
31. What are graphs called that show the relationship between dose of radiation received and incidence of effects?
- Nonlinear-nonthreshold effect
 - Linear-nonthreshold effect
 - Radiation-effect curves
 - Dose-response curves
32. Which of the following is the basis for all radiation protection standards?
- Nonlinear-nonthreshold effect
 - Linear-nonthreshold effect
 - Linear-threshold effect
 - Nonlinear-threshold effect
33. Which of the following means there is no safe level of radiation and the response to the radiation is not directly proportional to the dose received?
- Nonlinear-nonthreshold effect
 - Linear-nonthreshold effect
 - Linear-threshold effect
 - Nonlinear-threshold effect
34. Which of the following means there is no safe level of radiation and the response to the radiation is directly proportional to the dose received?
- Nonlinear-nonthreshold effect
 - Linear-nonthreshold effect
 - Linear-threshold effect
 - Nonlinear-threshold effect
35. Which of the following means there is a safe level of radiation for certain effects and those effects are directly proportional to the dose received when the safe level is exceeded?
- Nonlinear-nonthreshold effect
 - Linear-nonthreshold effect
 - Linear-threshold effect
 - Nonlinear-threshold effect
36. Which of the following means there is a safe level of radiation for certain effects and those effects are not directly proportional to the dose received when the safe level is exceeded?
- Nonlinear-nonthreshold effect
 - Linear-nonthreshold effect
 - Linear-threshold effect
 - Nonlinear-threshold effect
37. Effects of radiation where the probability of occurrence, not severity of occurrence, is proportional to the dose are called:
- Stochastic effects
 - Deterministic effects
 - Genetic effects
 - Somatic effects
38. Effects of radiation that become more severe as dose increases are called:
- Dose-response curves
 - Deterministic effects
 - Genetic effects
 - Somatic effects

39. According to NCRP Report #116, what is the embryo or fetus equivalent dose limit per month?
- 0.5 mSv
 - 0.1 mSv
 - 5 mSv
 - 0.05 mSv
40. According to NCRP Report #116, the occupational cumulative effective dose limit = age in years \times what dose?
- 5 mSv
 - 0.1 mSv
 - 0.5 mSv
 - 10 mSv
41. According to NCRP Report #116, the annual occupational effective dose limit is:
- 50 mSv
 - 10 mSv
 - 0.50 mSv
 - 0.05 mSv
42. According to NCRP Report #116, what is the annual effective dose limit for radiography students older than age 18?
- 50 mSv
 - 10 mSv
 - 0.50 mSv
 - 0.05 mSv
43. According to NCRP Report #116, what is the annual effective dose limit for the general public, assuming infrequent exposure?
- 5 mSv
 - 0.1 mSv
 - 10 mSv
 - 0.05 mSv
44. According to NCRP Report #116, what is the embryo or fetus equivalent dose limit for gestation?
- 5 mSv
 - 10 mSv
 - 0.5 mSv
 - 0.05 mSv
45. According to NCRP Report #116, what is the annual effective dose limit for the general public, assuming frequent exposure?
- 5 mSv
 - 1.0 mSv
 - 0.5 mSv
 - 0.05 mSv
46. According to NCRP Report #116, what is the annual effective occupational dose limit for the lens of the eye?
- 1.5 mSv
 - 1.0 mSv
 - 100 mSv
 - 150 mSv
47. The W_R used in calculating sievert takes into account which of the following?
- Meiosis
 - Age
 - LET
 - Pregnancy
48. LET and biological damage are:
- Directly proportional
 - Indirectly proportional
 - Inversely proportional
 - Unrelated
49. The ability of different types of radiation to produce the same biological response in an organism is called:
- LET
 - W_R
 - RBE
 - Doubling dose
50. The phases of the cellular life cycle, in order, are:
- Prophase, metaphase, anaphase, telophase
 - Interphase, prophase, metaphase, anaphase, telophase
 - G_1 , S, G_2 , telophase
 - Interphase (G_1 , S, G_2), prophase, metaphase, anaphase, telophase
51. The process of cell division for germ cells is called:
- Mitosis
 - Spermatogenesis
 - Organogenesis
 - Meiosis
52. Which of the following occurs when radiation transfers its energy to DNA?
- Indirect effect
 - Target theory
 - Direct effect
 - Mutations
53. Which of the following states that each cell has a master molecule that directs all cellular activities and that, if inactivated, results in cellular death?
- Indirect effect
 - Target theory
 - Direct effect
 - Mutations
54. Which of the following describes the amount of radiation required to increase the number of mutations in a population by a factor of 2?
- Indirect effect
 - Target theory
 - Doubling dose
 - Mutations
55. What occurs when radiation transfers its energy to the cellular cytoplasm?
- Indirect effect
 - Target theory
 - Direct effect
 - Doubling dose
56. Which of the following induces radiolysis?
- Indirect effect
 - Target theory
 - Direct effect
 - Doubling dose

57. What is the name for changes in genetic code passed on to the next generation?
- Indirect effect
 - Target theory
 - Direct effect
 - Mutations
58. Which of the following is responsible for producing free radicals?
- Indirect effect
 - Target theory
 - Direct effect
 - Doubling dose
59. What occurs when the master molecule is struck by radiation?
- Indirect effect
 - Target theory
 - Direct effect
 - Doubling dose
60. Which of the following poisons the cell with H_2O_2 ?
- Indirect effect
 - Target theory
 - Direct effect
 - Doubling dose
61. Most of the damage to a cell occurs as a result of:
- Direct effect
 - Mutations
 - Law of Bergonié and Tribondeau
 - Indirect effect
62. Cell radiosensitivity is described by the:
- Inverse square law
 - Law of Bergonié and Tribondeau
 - Reciprocity law
 - Ohm's law
63. The law that states that cells are most sensitive to radiation when they are nonspecialized and rapidly dividing is the:
- Inverse square law
 - Law of Bergonié and Tribondeau
 - Reciprocity law
 - Ohm's law
64. Cells are more radiosensitive when:
- Fully oxygenated
 - Deoxygenated
 - Slowly dividing
 - Near the skin
65. Blood count can be depressed with a whole-body dose of:
- 0.25 Sv
 - 25 Sv
 - 1 Sv
 - 10 Sv
66. The most radiosensitive cells in the body are:
- Lymphocytes
 - Epithelial cells
 - Nerve cells
 - Muscle cells
67. Cells that are least sensitive to radiation exposure include:
- Ova and sperm
 - Epithelial cells
 - Nerve and muscle cells
 - Blood cells
68. Compared with ova in younger and older women, ova in women of reproductive age are:
- More radiosensitive
 - Less radiosensitive
 - About the same
69. Most somatic effects occur:
- At doses delivered during diagnostic radiography
 - At doses beyond doses used during diagnostic radiography
 - In middle age
 - In old age because of an increase in medical care
70. Somatic effects manifest in:
- The person who has been irradiated
 - The next generation
 - Newborns
 - Imaging technologists
71. Which of the following is considered a late somatic effect?
- Carcinogenesis
 - Genetic effect
 - Alzheimer disease
 - Parkinson disease
72. Which of the following is used to limit the area of the patient being irradiated?
- Grid
 - Lead mask
 - Collimator
 - Compensating filter
73. Gonadal shields may reduce exposure to female gonads by up to:
- 50%
 - 95%
 - 10%
 - 75%
74. Which of the following sets of exposure factors would result in the lowest dose to the patient?
- High mAs, low kVp
 - Low mAs, high kVp
 - Low mAs, high kVp, small focal spot
 - Low mAs, high kVp, large focal spot
75. Which of the following is used as part of an effort to practice the ALARA concept?
- Grids
 - Increased mAs
 - Collimation
 - Thinner filtration
76. The cardinal rules of radiation protection include:
- Collimation, gonadal shielding, no repeats
 - Collimation, short exposure time, no repeats
 - Shielding, distance, time
 - Time, distance, collimation

77. Which of the following is used to survey an area for radiation detection and measurement?
- TLD
 - Film badge
 - Handheld ionization chamber
 - Geiger-Mueller detector
78. Which of the following is accurate as low as 100 μGy_a ?
- TLD
 - Film badge
 - OSL
 - Handheld ionization chamber
79. Which of the following includes filters for measurement of radiation energy?
- TLD
 - Film badge
 - OSL
 - Handheld ionization chamber
80. Which of the following may be used to measure in-air exposures in a fluoroscopic room?
- TLD
 - Film badge
 - Handheld ionization chamber
 - Geiger-Mueller detector
81. What detection device sounds an alarm to indicate the presence of radioactivity?
- TLD
 - Film badge
 - Pocket ionization chamber
 - Geiger-Mueller detector
82. Which of the following is accurate as low as 50 μGy_a ?
- TLD
 - Film badge
 - Pocket ionization chamber
 - Handheld ionization chamber
83. Which of the following is a digital monitor that may be used to measure dose in an area?
- TLD
 - Film badge
 - Pocket ionization chamber
 - Handheld ionization chamber
84. Which of the following may be used for 3 months at a time?
- TLD
 - Film badge
 - Pocket ionization chamber
 - Geiger-Mueller detector
85. Which of the following is sensitive to extremes in environment?
- TLD
 - Film badge
 - Pocket ionization chamber
 - Handheld ionization chamber
86. Which of the following is used to represent the mean marrow dose?
- GSD
 - ALARA
 - MMD
 - DMM
87. The radiation dose that would cause the same genetic injury to the population as the sum of doses received by individuals actually being exposed is called:
- GSD
 - ALARA
 - MMD
 - MPD
88. The timer used in fluoroscopy:
- Must be 3 minutes
 - Should always be reset before the alarm sounds so that it does not annoy the radiologist
 - Sounds an alarm after 3 minutes
 - Is used to alert the fluoroscopist after 5 minutes of fluoroscopy scanning have elapsed
89. The most effective protection against radiation exposure for the radiographer is:
- Lead apron
 - Lead gloves
 - Lead glasses
 - Distance
90. If the dose of scatter radiation in fluoroscopy to the radiographer is 10 mGy_a at a distance of 2 feet from the table, where should the radiographer stand to reduce the dose to 2.5 mGy_a ?
- 8 feet from the table
 - 4 feet from the table
 - At the foot of the table
 - Directly behind the fluoroscopist
91. Lead aprons used in fluoroscopy must be at least:
- 0.5-mm lead
 - 0.25-mm lead
 - 0.1-mm lead
 - 0.25-mm lead equivalent
92. Which of the following is true concerning holding of patients for radiographic exams?
- May be performed routinely to obtain a diagnostic exam
 - Should be done only when absolutely necessary, and then the holding should be done by a competent radiographer so that a repeat will not be needed
 - Should be done only when absolutely necessary, and then the holding should be done by a non-pregnant member of the patient's family
 - May be performed using a student radiographer to hold because students are not exposed as often as staff radiographers
93. The factors that must be considered in the design of structural shielding for a radiology room or department include:
- Use, occupancy, workload
 - Time, distance, shielding
 - Occupational and nonoccupational exposure
 - Number of employees and number of students

94. The lowest intensity of scatter radiation from the patient is located:
- At the head of the table
 - At a 90-degree angle from the patient
 - At a 180-degree angle from the patient
 - At the foot of the table
95. Minimal (M) readings on dosimeter reports mean:
- A dose below the sensitivity of the dosimeter has been received
 - A maximum dose has been received
 - A mean (average) dose has been received
 - Much radiation has been received
96. A readout on the fluoroscopic monitor that indicates air kerma striking the surface of the patient is:
- mA meter
 - DAP meter
 - ESD meter
 - kVp meter
97. Which of the following is the most sensitive personnel monitoring device?
- TLD
 - Film badge
 - OSL dosimeter
 - Geiger-Mueller detector
98. Minimum source-to-skin distance for mobile radiography must be:
- 15 inches
 - 12 inches
 - 36 inches
 - 55 inches
99. Positive beam limitation is also known as:
- Use of collimators
 - Beam limitation used for all exams
 - Use of beam restrictors
 - Automatic collimation
100. Added tube filtration should be adjusted by the radiographer:
- To “harden” the x-ray beam
 - To remove the soft rays from the x-ray beam
 - To exercise radiation protection
 - Never

4

Image Production

X-RAY EQUIPMENT OPERATION

Basic Physics Terminology

Matter has form or shape and occupies space

Mass amount of matter in an object; generally considered the same as weight

Energy ability to do work

Potential energy energy of position

Kinetic energy energy of motion

Chemical energy energy resulting from a chemical reaction

Electrical energy energy resulting from movement of electrons

Thermal energy heat energy resulting from movement of atoms or molecules

Nuclear energy energy resulting from the nucleus of an atom

Electromagnetic energy energy that is emitted and transferred through matter

Ionizing radiation electromagnetic radiation that is able to remove an electron from an atom

Ionization removal of an electron from an atom

Measurement Standards

Length meter

Mass kilogram

Time second

SI system meter, kilogram, second

MKS system meter, kilogram, second

CGS system centimeter, gram, second

British system foot, pound, second

Velocity (speed) how fast an object is moving

Acceleration rate of change of speed per unit of time

Work force applied on an object over a distance

Power rate of doing work (measured in watts)

Atomic Structure

Atomic nucleus contains protons (positive charges) and neutrons (no charge); contains most of the mass of an atom

Atomic mass number of protons plus number of neutrons; represented by the letter A

Electron shells contain orbital electrons (negative charges); represented by the letters K, L, M, N, O, P, and Q; in a stable atom, the number of electrons and protons is equal

Atomic number of an atom equals the number of protons in the nucleus; represented by the letter Z; the atomic number

determines the chemical element; all chemical elements are represented in the periodic table of elements

Isotopes atoms with the same number of protons but with a different number of neutrons

Electron-binding energy force that holds electrons in orbit around the nucleus

Octet rule outer shell of an atom may not contain more than eight electrons

Particulate radiation alpha particles (helium nucleus—two protons and two neutrons); beta particles (electronlike particles emitted from the nucleus of a radioactive atom)

Characteristics of Electromagnetic Radiation

Photon smallest amount of any type of electromagnetic radiation; also considered a bundle of energy called a quantum; travels at the speed of light; travels in waves in a straight path

Sine waves waves of electromagnetic radiation; wave height is called amplitude; distance between the peaks of waves is called wavelength; as photon wavelength decreases, photon energy increases

Frequency number of wavelengths passing a given point per unit time; measured in hertz (Hz)

Speed of travel electromagnetic radiation travels at the speed of light (186,000 miles per second); travel at the speed of light is constant, regardless of wavelength or frequency; wavelength and frequency of electromagnetic radiation are inversely proportional

Gamma rays electromagnetic rays produced in the nucleus of radioactive atoms; x-rays and gamma rays differ only in their origin

Wave-particle duality concept that although x-ray photons exist as waves, they exhibit properties of particles

Attenuation partial absorption of the energy of an x-ray beam as it traverses an object

Inverse square law law that governs the intensity of x-radiation; states that the intensity of the x-ray beam is inversely proportional to the square of the distance between the source of the x-rays and the object

Law of conservation of matter matter cannot be created or destroyed, only changed in form

Law of conservation of energy energy cannot be created or destroyed, only changed in form

Principles of Electricity and Magnetism

Electrostatics stationary electrical charges (static electricity)

Electrification movement of electrons between objects

Laws of electrostatics unlike charges attract, and like charges repel; electrostatic charges reside on the outer surface of a conductor and are concentrated at the area of greatest curvature; only negative charges move

Methods of electrification friction, contact, and induction

Conductor material that allows the free flow of electrons

Insulator object that prohibits the flow of electrons

Electrical current movement of electrons along a conductor or pathway (electrical circuit); measured in amperes

Electromotive force (EMF) measured in volts; the force with which electrons move in an electrical circuit

Electrodynamics electrical charges in motion

Semiconductor material that may act as an insulator or conductor under different conditions

Electrical resistance measured in ohms

Ohm's law voltage in the circuit is equal to the current \times resistance

Electrical circuits path along which electrons flow; may be wired as series circuits or parallel circuits

Alternating current (AC) electrical circuit in which the current of electrons oscillates back and forth

Direct current (DC) unidirectional flow of electrons in an electrical conductor

Sine wave representation of electron flow as alternating current

Magnetic field energy field surrounding an electrical charge in motion; can magnetize a ferromagnetic material, such as iron, if the material is placed in the magnetic field

Magnetic poles every magnet has a north pole and a south pole

Laws of magnetics like poles repel, and unlike poles attract; the force of attraction between poles is governed by the inverse square law

Electromagnetism movement of electrons in a conductor produces a magnetic field around the conductor; a coiled conductor (i.e., a wire), through which an electrical current is flowing, has overlapping magnetic fields

Solenoid stacks of wire coil through which electrical current flows, creating overlapping force field lines; a magnetic field is concentrated through the center of the coil

Electromagnet solenoid with an iron core that concentrates the magnetic field

Electromagnetic induction process of causing an electrical current to flow in a conductor when it is placed within the magnetic field of another conductor; two types of electromagnetic induction are self-induction and mutual induction

Self-induction opposing voltage created in a conductor by passing alternating current through it

Mutual induction inducing current flow in a secondary coil by varying the current flow through a primary coil

Electrical generator device that converts mechanical energy to electrical energy; usual output of an electrical generator is alternating current

Single-phase, two-pulse alternating current simplest type of current; voltage (and accompanying current) flows as a sine wave; voltage begins at zero, peaks at full value at the crest of the wave, returns to zero, reverses, and again peaks on the inverse portion of the cycle at the trough

Three-phase alternating current special wiring patterns ("wye," "star," "delta") used to create voltage waveforms that are placed 120 degrees out of phase with one another; these voltage waveforms are called three-phase; three-phase waveforms may have 6 pulses per cycle or 12 pulses per cycle; three-phase, 6-pulse waveforms contain 360 pulses per second; three-phase, 12-pulse waveforms contain 720 pulses per second; high-frequency generators produce high-frequency electricity (thousands of hertz)

Electrical motor device that converts electrical energy to mechanical energy

Transformer changes electrical voltage and current into higher or lower values; the transformer operates on the principle of mutual induction, so it requires alternating current

Step-up transformer transformer that increases voltage from the primary to the secondary coil and decreases current in the same proportion; a step-up transformer has more turns in the secondary than in the primary coil; a step-up transformer is used in the x-ray circuit to increase voltage to the kilovoltage level for x-ray production

Step-down transformer transformer that decreases voltage from the primary to the secondary coil and increases current in the same proportion; a step-down transformer has more turns in the primary than in the secondary coil; a step-down transformer is used in the filament portion of the x-ray circuit to increase current flow to the cathode

Autotransformer transformer that contains an iron core and a single winding of wire; an autotransformer is used in the x-ray circuit to provide a small increase in voltage before the step-up transformer; the kVp settings are made at the autotransformer

Rectification process of changing alternating current to direct current

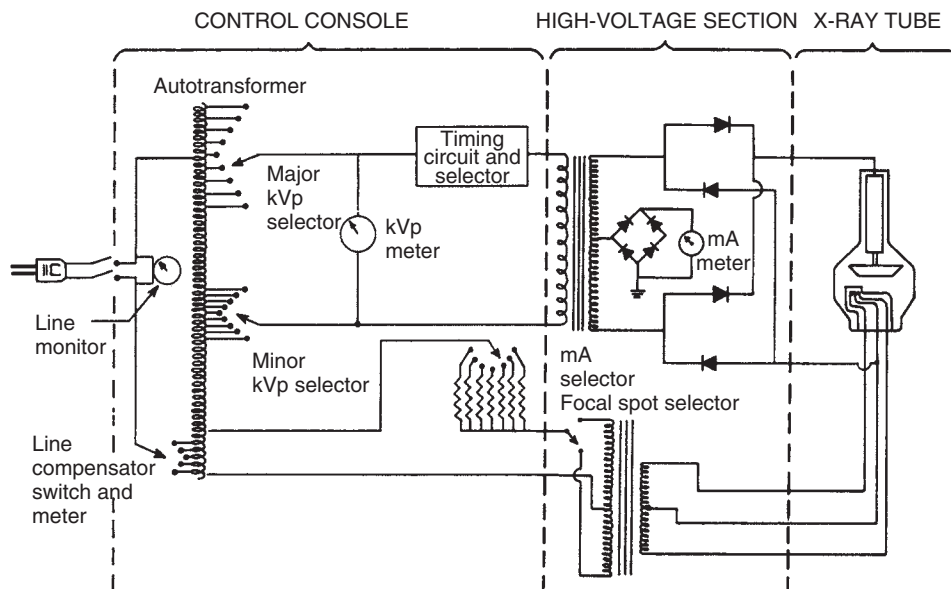
Line voltage compensation x-ray circuit depends on a constant source of power; power coming into the radiology department may vary; line voltage compensator keeps incoming voltage adjusted to proper value; usually operates automatically but may be manually adjusted on older equipment

Conditions Necessary for the Production of X-Rays

- A. Source of electrons
- B. Acceleration of electrons
- C. Sudden stoppage of electrons against target material

Equipment Used in the Production of X-Rays (Figure 4-1)

- A. Autotransformer
 1. Also known as a *variable transformer*
 2. Provides for the variation of voltage flowing in the x-ray circuit and applied to the x-ray tube
 3. Single coil of wire with an iron core
 4. Source for selecting kVp
 5. Operates on the principle of self-induction
 - a. Single winding of wire incorporates both the primary and the secondary coils of the transformer
 6. Primary turns are fed 220 V from the radiology department's incoming line
 7. Secondary turns (secondary taps) are selected by the radiographer using the kVp select control
 8. Voltage is stepped up or stepped down by only a small amount and sent to the primary side of the high-voltage step-up transformer
 9. The high-voltage step-up transformer boosts the voltage to the kVp that was selected
- B. Prereading voltmeter
 1. The voltmeter in the x-ray circuit indicates the voltage that is selected
 2. Called *prereading* because it indicates the kilovoltage that will be flowing through the tube once the exposure is made
3. Placed in the circuit between the autotransformer and the high-voltage transformer
- C. Timer
 1. Used to regulate the duration of x-ray exposure
 2. Wired in the circuit between the autotransformer and the high-voltage transformer
 3. mAs timer
 - a. Provides the safest tube current in the shortest time possible
 - b. Measures total tube current
 - c. Located after the secondary coil of the high-voltage transformer
 - d. Used with falling load generators
 4. Electronic timer
 - a. Microprocessor controlled
 - b. Contained in most radiographic equipment
 - c. Allows exposure times of 1 ms (0.001 second)
 5. Automatic exposure control (AEC)
 - a. Used to provide consistency of radiographic quality
 - b. Relies on excellent positioning skills and extensive knowledge of surface and internal anatomy because the part being imaged must be accurately positioned over ionization sensors
 - c. Requires proper ionization chambers be selected for part being imaged
 - d. Consists of a flat ionization chamber that is located between the patient and the image receptor
 - e. Uses fixed kVp while machine controls mAs
 - f. As radiation passes through the ionization chamber, it ionizes the gas contained inside
 - g. When a predetermined level of ionization is reached (allowing time for a sufficient amount of radiation to pass through to strike the image receptor), the electronics terminate the exposure



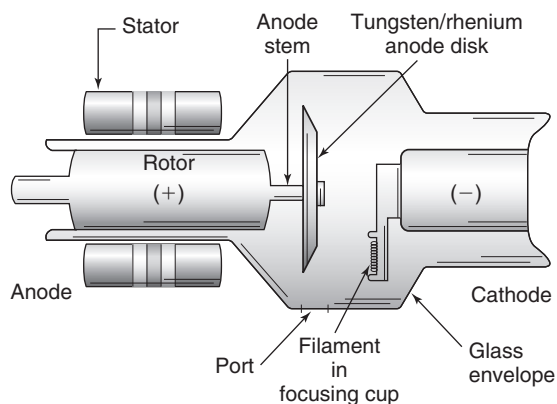
• **Figure 4-1** Simplified electrical circuit diagram for an x-ray machine.

- h. Backup timer must be set to terminate the exposure in the event of a malfunction
 - i. Backup timer protects the patient from overexposure and the x-ray tube from overheating
 - j. Minimum response time: Shortest time possible with an AEC because of the time it takes to operate
 - k. Shortest time with an AEC is 1 ms (0.001 second)
 - l. Varying kVp when using AEC does not alter receptor exposure, although contrast changes
 - m. Varying kVp serves to alter penetrating ability of the beam, resulting in faster or shorter exposure time
 - n. Changing \pm controls on AEC allows exposure to be increased or decreased; each step normally represents a change of 25% in receptor exposure
6. Falling load generator
- a. Modern generator that takes advantage of extremely short time capabilities and tube heat-loading potential
 - b. Radiographer sets mAs and kVp
 - c. Falling load generator calculates the most efficient method of obtaining the required mAs
 - d. X-ray tube current starts at highest level possible for first portion of the exposure
 - e. When the maximum heat load of the tube has been reached for that mA, the generator decreases the mA to the next lower level that the tube can handle
 - f. The exposure continues at progressively lower levels of mA for the shortest times possible until the desired mAs is reached
 - g. Falling load generator always uses the shortest times possible to obtain a given mAs
 - h. *Disadvantages:* Exams in which long exposure times are used (e.g., breathing techniques for lateral thoracic spine); rapid-sequence exposures in which heat buildup in the tube may cause exposure times to increase
- D. Step-up transformer (high-voltage transformer)
- 1. Consists of primary coils and secondary coils
 - 2. Requires alternating current to operate
 - 3. Primary coil receives voltage from the autotransformer
 - a. Operates on principle of mutual induction
 - b. Magnetic field surrounding a wire with electricity flowing through it induces (causes) electricity to flow in a second wire placed within the force field
 - 4. Voltage in the primary coil is boosted to the kilovoltage level (thousands of volts) in the secondary coil
 - a. Number of turns of the wire in the primary coil compared with the number of turns of the wire in the secondary coil is called the *turns ratio*
 - b. Turns ratio determines how much the voltage is stepped up
 - c. The greater the turns ratio, the higher the resulting kilovoltage
 - d. Voltage is being induced in the secondary coil, which has many more wire turns than the primary coil
 - 5. The turns ratio may be 500 to 1000, depending on the machine
 - 6. Voltage is varied at the autotransformer and sent to the high-voltage transformer
 - 7. Turns ratio in the step-up transformer is not varied
- E. Rectifier
- 1. X-ray tube requires direct current to operate properly
 - 2. Rectifier changes alternating current coming from the step-up transformer to direct current
 - 3. Rectifiers are solid-state semiconductor diodes
 - a. Consist of silicon-based n-type and p-type semiconductors
 - 4. Located between the step-up transformer and the x-ray tube
 - 5. Unit with four diodes provides full-wave rectification for single-phase generator
 - a. Full-wave rectification produces pulsating direct current
 - b. Resultant waveform contains two pulses per cycle (120 pulses per second)
 - c. Uses both portions of rectified alternating current
 - d. Results in 100% ripple, with voltage dropping to zero 120 times per second
 - e. X-ray production ceases 120 times per second
 - 6. Unit with 6 or 12 diodes provides full-wave rectification for three-phase equipment
 - a. Because three-phase current is used, voltage never drops to zero during the exposure
 - b. Voltage ripple for three-phase, 6-pulse is approximately 13%; the voltage actually used is about 87% of the kVp set
 - c. Voltage ripple for three-phase, 12-pulse is approximately 4%; the voltage actually used is about 96% of the kVp set
 - d. Voltage ripple for high-frequency generators is approximately 1%; the voltage actually used is about 99% of the kVp set
 - e. High-frequency units result in lower patient dose
 - f. Three-phase, full-wave rectified waveforms produce higher average photon energy (35% higher for three-phase, 6-pulse; 41% higher for three-phase, 12-pulse)
 - g. Three-phase and high-frequency units produce 12% to 16% more x-rays than single-phase units
 - h. kVp values used with single-phase equipment may be decreased 12% to 16% when the same exam is performed on three-phase or high-frequency equipment
- F. Milliammeter (mA meter)
- 1. Measures tube current in milliamperes
 - 2. Wired between the rectifier and x-ray tube
- G. mA control (filament circuit)
- 1. Regulates the number of electrons available at the filament to produce x-rays
 - 2. Voltage is provided by tapping windings of the autotransformer and varying the voltage being sent to the step-down transformer

- a. Step-down transformer reduces voltage and increases current in response to the use of variable resistors (rheostats) manipulated by the radiographer via the mA stations on the control panel
- b. Resultant high current is sent on to heat the filament
- c. A filament ammeter may also be connected

H. X-ray tube (Figure 4-2)

1. **Cathode assembly:** Negative electrode in the x-ray tube
 - a. Contains two filaments—small and large
 - b. Filaments are made of tungsten (because of its high melting point); a small amount of thorium is added to reduce vaporization and prolong tube life
 - c. Filaments are heated slightly when the x-ray machine is turned on; no electrons are ejected at this low level of heating
 - d. During x-ray exposure, one filament is heated to a level that causes electrons to be “boiled off” in preparation for x-ray production (which is known as *thermionic emission*)
 - e. Over time, filaments vaporize and coat the inner surface of the x-ray tube with tungsten, leading to tube failure
 - f. Cathode assembly also includes the focusing cup
 - g. The focusing cup surrounds the filaments on three sides
 - h. The focusing cup has a negative charge applied, which tends to concentrate electrons boiling off the filaments into a narrower stream and repels them toward the anode
 - i. Electron concentration keeps the electrons aimed at a smaller area of the anode
 - j. Some x-ray tubes use the focusing cup as an electronic grid that can turn the tube current on and off rapidly, allowing very short and precise exposure times, such as times needed for rapid serial exposures (referred to as a *grid-controlled tube*)
2. **Anode:** Positive electrode in the x-ray tube
 - a. Consists of a metal target made of a tungsten–rhenium alloy (because of its high melting point and high atomic number) embedded in a disk (or base) of molybdenum with a motor to rotate the target



• **Figure 4-2** Structure of a typical x-ray tube, including the major operational parts.

- b. Must be able to tolerate extremely high levels of heat produced during x-ray production
 - c. Anode rotates from 3300 to 10,000 rpm, depending on tube design
 - d. Rotation is achieved by the use of an induction motor located outside the x-ray tube, which turns a rotor located inside the x-ray tube; the target is attached at the end of the rotor
 - e. Rotation of the target allows greater heat dissipation
 - f. Rotation of the target is stopped by a braking action provided by the induction motor
 - g. X-ray machine should never be shut off immediately after an exposure; machine should not be shut off until the target has stopped rotating
 - h. Without the braking action, the target may spin for 30 minutes, causing great strain on the bearings
 - i. Electrons strike the target on the focal track (sometimes called the *focal spot*)
 - j. The focal track is beveled, producing the target angle
 - k. Target angle allows for a larger actual focal spot (area bombarded by electrons), while producing a smaller effective focal spot (the area seen by the image receptor)
 - l. The larger the actual focal spot, the greater the heat capacity; the smaller the effective focal spot, the greater the radiographic image sharpness
 - m. This effect is called the *line-focus principle*
 - n. Target angle may be 7 to 20 degrees, depending on tube design
 - o. Exposure switch should be activated in one continuous motion, activating the rotor and then the exposure button
 - p. The equipment allows the rotor to come up to speed before making the exposure
 - q. Radiographer does not control this by activating the rotor and waiting to press the exposure button
 - r. Activating the rotor and allowing it to operate by itself results only in unnecessary heating of the filament and wear on the induction motor, shortening tube life
3. **Glass envelope with window**
 - a. Cathode and target are inside the glass envelope; some models use a partial metal envelope
 - b. Glass envelope also contains a vacuum so that electrons from the filament do not collide with atoms of gas
 - c. **Tube window:** Thinner section of glass envelope that allows x-rays to escape
 4. **Tube housing:** Encases the x-ray tube
 - a. Made of aluminum with lead lining
 - b. Supports and protects the tube, restricts leakage radiation during exposure, and provides electrical insulation
 - c. Also contains oil in which the x-ray tube is immersed to assist with cooling and additional electrical insulation

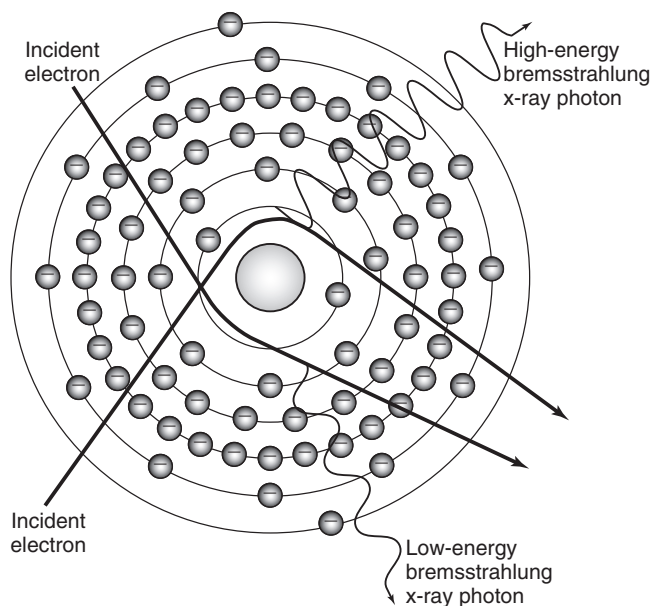
X-Ray Production

A. Making the exposure

1. The x-ray machine is turned on, and a small amount of current is sent to the filament to warm it and ready it for much higher current
2. Radiographer takes equipment through warm-up exposures to warm the filament further and warm the anode
3. Radiographer chooses exposure factors on control console for the exam to be performed with the assistance of technique charts
 - a. Measurement
 1. Part thickness should always be measured using calipers
 2. Caliper measurement is used to consult the technique chart
 - b. Types of technique charts
 1. Fixed kVp–variable mAs
 - a. Assumes optimal kVp for the part being radiographed
 - b. Except for exceptionally large patients, kVp never changes for a given projection
 - c. mAs is varied according to the part thickness as measured with the calipers
 - d. Based on the assumption that thicker parts absorb more rays and more rays must be placed in the primary beam
 2. Variable kVp–fixed mAs
 - a. kVp is varied according to part thickness as measured with the calipers
 - b. Based on the assumption that thicker parts require a beam with shorter wavelength rays that are more penetrating
 3. Variable technique (vary both mAs and kVp)
 - a. Provides for alteration of routine techniques because of pathologic conditions, patient age, ability to cooperate, body mass index, casts, or contrast media
4. Electricity coming into the radiology department is adjusted by the line voltage compensator in the x-ray equipment to maintain it at a constant level
5. When making the exposure, the radiographer presses the rotor switch and exposure switch in one continuous motion
6. The induction motor begins spinning the anode; the filament gets hotter
7. When the exposure switch is closed, the voltage selected by the mA control flows from the autotransformer, through the variable resistors, and into the step-down transformer in the filament circuit
8. The filament heats considerably, boils off electrons (thermionic emission), and creates a space charge or electron cloud around the filament
9. At the same time, the alternating current and voltage the radiographer selects by choosing taps off the autotransformer are sent to the primary coils of the

high-voltage step-up transformer, where they are boosted to kilovoltage levels

10. After leaving the secondary coils of the step-up transformer, the voltage and alternating current are sent through the rectifier, which changes the alternating current to pulsating direct current
 11. The kilovoltage creates a high potential difference in the x-ray circuit, making the anode less negative (relatively positive) and the cathode highly negative
 12. This high potential difference causes the electrons to move at very high speed (approximately half the speed of light) from the cathode to the anode
 13. The collision of these projectile electrons with the atoms of the target material causes a conversion of the kinetic energy of the electrons (100%) to heat (99.8%) and x-rays (0.2%)
 14. Heat is produced when the projectile electrons strike the outer shell electrons of the target material and place them in an excited state, which causes them to emit infrared radiation
 15. The production of x-rays comes from two interactions with the anode
- B. Bremsstrahlung (brems) radiation (Figure 4-3)
1. A projectile electron misses outer shell electrons in the target and moves in close to the nucleus
 2. Because the nucleus is positive and the electron is negative, it is slowed or braked
 3. The reduction in kinetic energy causes the electron to slow and release energy as an x-ray photon
 4. The resultant x-rays are called *bremsstrahlung* (braking) x-rays because they are produced by the slowing (braking) of projectile electrons
 5. At diagnostic levels, most x-rays produced are from brems interaction



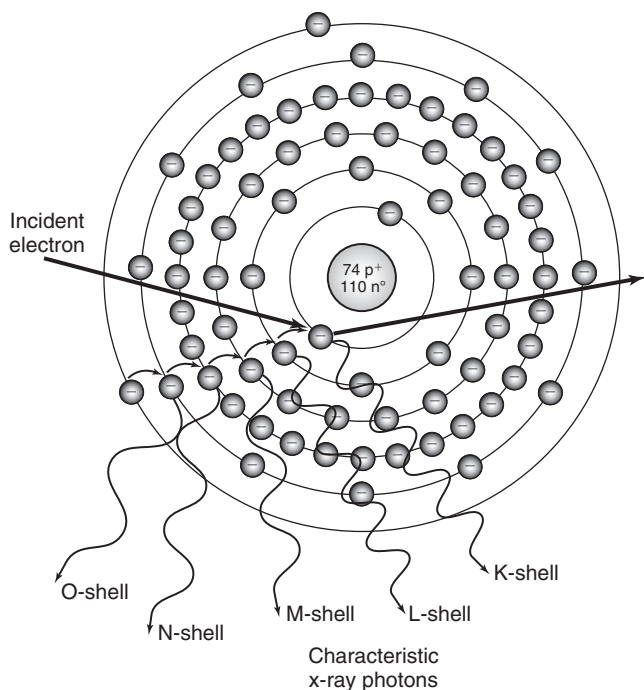
• Figure 4-3 Bremsstrahlung interaction.

C. Characteristic radiation (Figure 4-4)

1. A projectile electron collides with an inner shell electron of a target atom
2. It removes the inner shell electron from orbit and ionizes the atom
3. A hole exists in the inner shell from the vacated electron
4. An electron from an outer shell falls in to fill the hole
5. As the electron falls in, energy is given off in the form of an x-ray photon
6. This creates a hole in its shell of origin, and an electron from the next outer shell falls in to fill this vacancy; this continues until the atom is stable again
7. Each time an electron falls in to fill a hole, an x-ray photon is given off
8. Each x-ray photon has a specific energy, equal to the difference in the binding energies of the two shells involved
9. Only x-rays produced at the *K*-shell are of sufficient energy to be used in diagnostic radiography
10. Because the x-rays possess energy characteristic of the specific binding energies of the atom involved, they are called *characteristic x-rays*
11. Characteristic x-rays are produced at kVp levels greater than 70 but only in small numbers

D. X-ray properties

1. Part of the electromagnetic radiation spectrum
2. Highly penetrating
3. Invisible
4. Travel at the speed of light (186,000 miles per second)



• **Figure 4-4** Characteristic interaction.

5. Travel in straight lines as waves

- a. *Wavelength of diagnostic x-rays*: 0.1 to 0.5 angstroms (Å) ($1 \text{ \AA} \times 10^{-10} \text{ m}$, which is one 10-billionth of a meter)
 - b. Wavelength is the distance from crest to crest or trough to trough, or the distance covered by one complete sine wave
 - c. *Frequency*: The number of waves passing a given point per unit time
 - d. Wavelength and frequency are inversely proportional to one another; as wavelength increases, frequency decreases, and as wavelength decreases, frequency increases
 - e. Short-wavelength rays are more penetrating; long-wavelength rays are less penetrating
6. Invisible to the human eye
 7. Have characteristics of waves and particles; travel in bundles or packets of energy called *photons*
 8. Exist in a wide range of wavelengths and energies
 9. Can ionize matter and gases
 10. Cause fluorescence of phosphors
 11. Unable to be focused by a lens
 12. Liberate a small amount of heat when passing through matter
 13. Electrically neutral
 14. Affect photographic film
 15. Cause biological and chemical changes through excitation and ionization
 16. Scatter and produce secondary radiation
- E. X-ray beam characteristics
1. Because x-rays are produced by brems and characteristic interactions at the anode, the resultant x-ray beam contains many different energies
 2. An x-ray beam containing many different energies is called *heterogeneous*
 3. The collection of all different energies (wavelengths) of x-rays is called the *x-ray emission spectrum*
 4. *Discrete x-ray spectrum*: Produced by characteristic x-rays because energies involved are specific to the target atom and are predictable
 5. *Continuous x-ray spectrum*: Produced by brems radiation because these energies all are different (from the peak electron energy down to zero energy)
 6. The maximum energy an x-ray photon can have corresponds to the kVp that was used
 7. Beam characteristics may be altered by using filtration
 - a. A filter is usually a sheet of aluminum placed in the primary beam just as it exits the x-ray tube and before it reaches the collimator
 - b. The oil and glass envelope of the x-ray tube offer inherent filtration
 - c. Total beam filtration equals inherent filtration plus added filtration
 - d. Total filtration must be at least 2.5-mm aluminum equivalent
 - e. Filtration removes the low-energy (long-wavelength, “soft”) rays from the beam

- f. The result of removing soft rays from the beam is a lower patient skin dose
 - g. Other types of filters that directly affect the radiographic image may be used, known as *compensating filters* (e.g., wedge, boomerang)
 - h. *Half-value layer*: Amount of filtration that reduces the beam intensity by half
- F. Heat units and their management
1. Heat units are a calculation of the total heat produced during an x-ray exposure
 2. Heat units are calculated using the following equations:
 - a. Single-phase, full-wave rectified equipment: $kVp \times mAs$
 - b. Three-phase, 6-pulse, full-wave rectified equipment: $kVp \times mAs \times 1.35$ (Remember: This equipment produces x-ray photons with 35% higher average photon energy)
 - c. Three-phase, 12-pulse, full-wave rectified equipment: $kVp \times mAs \times 1.41$ (Remember: This equipment produces x-ray photons with 41% higher average photon energy)
 3. X-ray tubes and tube housing are constructed to absorb certain levels of heat units
 4. Most modern x-ray equipment automatically prevents the user from making an exposure capable of producing too much heat in the tube; this is indicated on some control panels by the warning “technique overload,” a red light, or a failure to get a green light indicating that the anode is ready
 5. Most modern x-ray equipment prevents overloading of the tube during a series of exposures and does not allow additional exposures until the tube has cooled sufficiently

KEY REVIEW POINTS

Conditions Necessary for the Production of X-Rays

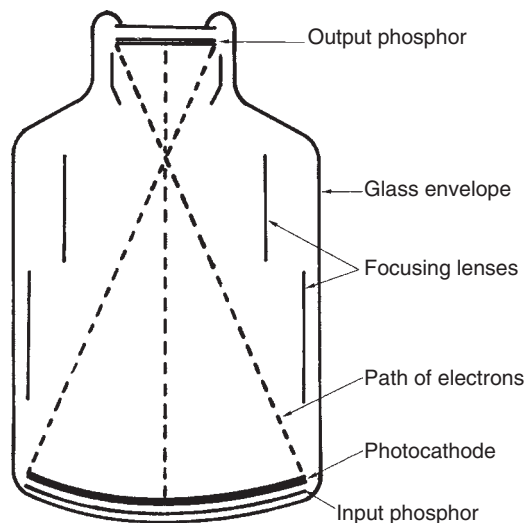
- *Needed for x-ray production*: Source of electrons, acceleration of electrons, sudden stoppage of electrons
- *Autotransformer*: A variable transformer; operates on the principle of self-induction; allows the manipulation of kVp and mA
- *Prereading voltmeter*: Indicates the kVp that will flow through the x-ray tube during exposure
- *Timer*: Regulates duration of x-ray exposure; electronic timer accurate at 1/1000 second
- *AEC*: Ionization chamber that provides consistency of radiographic quality; placed between the patient and the image receptor
- *Falling load generator*: Provides extremely short exposure times by taking advantage of tube heat-loading potential
- *Step-up transformer (high-voltage transformer)*: Operates on principle of mutual induction; steps up voltage, steps down current
- *Rectifier*: Changes AC to DC
- *Milliammeter (mA meter)*: Measures tube current

- *Step-down transformer*: Operates on principle of mutual induction; steps down voltage, steps up current
- *X-ray tube*: Consists of two electrodes—cathode (negative) and anode (positive)
- *Cathode*: Contains filaments, the source of electrons for exposure
- *Focusing cup*: Attempts to narrow the stream of electrons as it leaves the cathode filament
- *Anode*: Metal target where electron energy is converted to x-ray energy and heat energy
- *Focal spot (focal track)*: Area on anode where electrons strike, from where x-rays emanate
- *Exposure switch*: Consists of rotor (begins rotation of the anode and boiling electrons off of filament) and exposure button (closes circuit allowing flow of electrons through the x-ray tube)
- *Leaded glass envelope*: Encircles the anode and cathode and provides a vacuum inside the x-ray tube
- *Tube housing*: Encases the x-ray tube; aluminum lined with lead
- *X-ray production*: Occurs when current inside the x-ray tube flows from the cathode and is suddenly stopped at the anode
- More than 99% of electrons' energy is converted to heat; less than 1% is converted to x-rays
- *Brems*: X-rays produced by slowing of incoming electrons by the target atoms; slowing releases energy in the form of x-rays
- *Characteristic*: X-rays produced when incoming electrons at the anode dislodge orbital electrons from the target material, and outer shell electrons fall in to fill the hole created; this movement releases energy in the form of x-rays
- *X-ray properties*: Highly penetrating; invisible; travel at the speed of light (186,000 miles per second); travel in straight lines as waves; have diagnostic wavelengths of 0.1 to 0.5 Å; travel as bundles of energy called *photons*; can ionize matter; can cause fluorescence; electrically neutral
- *Wavelength*: Distance from crest to crest or trough to trough of a sine wave
- *Frequency*: Number of waves passing a given point per unit time
- Wavelength and frequency are inversely proportional to each other
- Short-wavelength rays are more penetrating; long-wavelength rays are less penetrating
- *X-ray emission spectrum*: Collection of all different energies (wavelengths) of x-rays in a typical x-ray beam
- *Beam filtration*: Removes long-wavelength rays; total filtration must be at least 2.5-mm aluminum equivalent
- *Heat units*: Calculation of the total heat produced during an x-ray exposure

Fluoroscopy

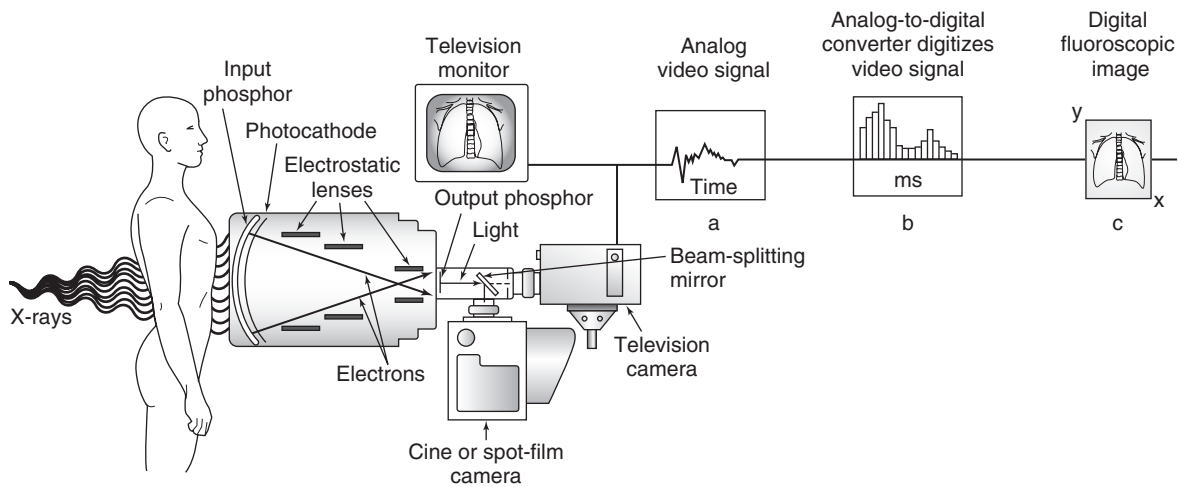
A. Non-digital fluoroscopy

1. Provides dynamic visualization of internal structures
2. Consists of an x-ray table to hold the patient, with x-ray tube inside the table, the spot imaging device and image intensifier (image receptors) over the table, and a monitor nearby



• **Figure 4-5** Diagram of the image intensifier.

3. Spot imaging device allows the fluoroscopist to acquire images of an area of interest as it is seen “live” on the monitor
 4. X-ray tube and image receptors are connected with a C-arm to keep them the appropriate distance apart, regardless of the movement of the equipment
 5. X-ray tube for fluoroscopy is operated at 3 to 5 mA
 6. Regulation of kVp and mA for fluoroscopy depends on the part being examined
 - kVp and mA determine the brightness level of the fluoroscopic image
 - a. kVp and mA are automatically adjusted during fluoroscopy by a process known as *automatic brightness control* (ABC)
 - b. Also called *automatic brightness stabilization*
 - c. Also called *automatic gain control*
 7. Visible image on the monitor is a result of image intensification
 8. Image-intensifier tube converts x-ray energy into visible light and then into an electronic signal that is displayed as an image on the monitor
 9. Image-intensifier tube consists of the following parts (**Figure 4-5**)
 - a. *Input phosphor*: Receives exit rays from the patient and converts them into visible light
 - b. Visible light from input phosphor strikes the photocathode, a thin layer next to the input phosphor; it releases electrons in amounts directly proportional to the visible light striking it
 - c. The electrons are concentrated and directed toward the other end of the image-intensifier tube (anode) by a series of electrostatic lenses and by 25 kVp applied through the tube
 - d. The electrons strike the output phosphor
 - e. The energy of the electrons is converted by the phosphors to visible light in amounts 50 to 75 times greater than at the photocathode
 - f. This increase in brightness caused by acceleration of the electrons is called *flux gain*
 - g. The output phosphor is smaller than the input phosphor, resulting in an increase in brightness called *minification gain*
 - h. Total brightness gain is a product of minification gain and flux gain
 - i. Total brightness gain ranges from 5000 to 20,000 and decreases as the tube ages
 10. Magnification is possible only with dual-focus or trifocus tubes, which result in increased patient dose
 11. Varying the voltage flowing through the image-intensifier tube changes the size of the area on the input phosphor or photocathode being used; this results in the ability to perform magnification during fluoroscopy
 12. A second way of measuring image intensifier efficiency is by using the conversion factor
 13. Conversion factor is measured as the ratio of the luminance of the output phosphor compared with the exposure rate at the input phosphor
 14. Viewing and recording of fluoroscopic image
 - a. Image may be sent to various viewing and recording devices using an image distributor located near the output phosphor
 - b. The signal may be sent to a television monitor for viewing
 - c. The fluoroscopic image may be recorded
- B. Digital fluoroscopy (**Figure 4-6**)
1. X-ray equipment is similar to conventional fluoroscopy
 2. An operating console and computer workstation are added
 3. The image intensifier may be replaced by a flat panel image receptor similar to DR technology
 4. Flat panel image intensifier
 - a. Uses flat panel image receptor technology similar to DR plates in place of conventional image intensifier
 - b. Provides better resolution of smaller anatomy
 - c. Allows for more variety in postprocessing
 - d. Some panels increase the size of the imaged area of the patient
 - e. May reduce patient dose in magnification mode compared with image intensifier tubes
 - f. Images are distortion-free
 - g. Image remains constant across the entire panel
 5. The x-ray beam is pulsed to keep patient dose and heat units at a minimum
 6. The analog signal is sent through an analog-to-digital converter to convert information into numerical digital data
 7. Viewing should take place on a high-resolution flat panel monitor to take advantage of the digital capabilities
 8. Postprocessing manipulation of the image is possible because the image is in digital format (subtraction is an especially useful postprocessing technique, whereby bone and soft tissue are removed from the image)
 9. “Overhead” postfluoroscopy images are usually eliminated with digital fluoroscopy



• **Figure 4-6** Analog and digital signals in fluoroscopy. The video signal from the television camera is analog, wherein the voltage signal varies continuously. This analog signal is sampled (a), producing a stepped representation of the analog video signal (b). The numerical values of each step are stored (c), producing a matrix of digital image data. (Courtesy Eastman Kodak Company.)

KEY REVIEW POINTS

Fluoroscopy

- *Fluoroscopy*: Provides dynamic visualization of internal structures
- X-ray tube for fluoroscopy is operated at 3 to 5 mA
- *ABC*: In fluoroscopy, adjustment of mA and kVp to provide optimal image
- *Image-intensifier tube*: Consists of input phosphor, photocathode, electrostatic lenses, output phosphor
- *Input phosphor*: Converts x-ray energy to light energy
- *Photocathode*: Converts light energy to electron energy
- *Electrostatic lenses*: Keep electron beam narrowed as it travels toward output phosphor
- *Output phosphor*: Converts electron energy to light energy for viewing
- *Total brightness gain*: Product of flux gain and minification gain
- *Flux gain*: Gain in brightness caused by acceleration of electronic beam inside image-intensifier tube
- *Minification gain*: Gain in brightness caused by minification of the image at the output phosphor compared with the input phosphor
- Flat panel plate similar to DR technology may be used in place of an image intensifier
- *Digital fluoroscopy*: Fluoroscopic signal is sent through an analog-to-digital converter enabling images to be manipulated and postprocessed; generally eliminates “overhead” images

Mobile Radiographic and Fluoroscopic Units

- A. Mobile radiographic units allow radiography to be performed under almost any conditions
1. Mobile radiographic units operate on rechargeable battery packs

2. These batteries are recharged by plugging the machine into an outlet
 3. The batteries provide power to propel the unit and operate the x-ray tube
 4. High-frequency mobile radiographic units are smaller and provide ripple-free output
- B. Mobile fluoroscopic units are usually called *C-arms*
1. X-ray tube and image intensifier are located on opposite cusps of the “C” just as in stationary fluoroscopy
 2. Mobile units are capable of providing stationary images (using a last-image-hold feature) and dynamic images
 3. Mobile units are used primarily in surgery

KEY REVIEW POINTS

- Mobile units
- Mobile radiographic units are powered by rechargeable battery packs; x-ray output is similar to that with nonmobile units
- Mobile fluoroscopic units are generally called C-arms; normally used in surgery

Quality Control of X-Ray-Producing Equipment

- A. Quality control and assurance—not all tests listed here are on the certification exam; these are presented for use as a course study guide
1. *Quality assurance*: Complete program in a radiology department that addresses all aspects of quality, including customer service, image interpretation, accuracy of diagnosis, and distribution of radiologists’ reports

2. *Quality control*: Program that specifically addresses the safe and reliable operation of equipment
3. A quality control program is required by The Joint Commission
4. A quality control program is the responsibility of radiologists, radiology managers, radiation physicists, quality control technologists (sometimes a separate position and sometimes a staff radiographer's duties; this depends on the size of the radiology department)
5. Many different tests may be performed as part of a quality control program
6. *Filtration-beam quality*: Tested using a digital dosimeter; half-value layer measurement is required
7. *Collimator/light field to radiation field alignment*: Must be accurate to within 2% of the source-to-image receptor distance (SID)
8. *Effective focal-spot size*: Should be within 50% of size stated in equipment specifications
9. *kVp*: Must be accurate to within 10% of the kVp indicated; some sources indicate $\pm 3\text{-}5$ kVp
10. *Timer*: Should be within 5% of the time chosen for exposures over 10 ms
11. *Exposure linearity*: Adjacent mA stations should be within 10% of one another
12. *Exposure reproducibility*: Radiation intensity of sequential exposures should not vary more than 5%
13. *AEC*: Tested to verify reproducibility of exposure using phantoms to simulate variations in patient thickness
14. *Fluoroscopy exposure rate*: Tested with a digital dosimeter; dose should not be more than 100 mGy_a per minute
15. *ABC on image intensifier*: Checked to ensure that radiation dose hitting the input phosphor is constant

- *Exposure linearity*: Adjacent mA stations should be within 10% of one another
- *Exposure reproducibility*: Radiation intensity of sequential exposures should not vary more than 5%
- *AECs*: Tested to verify reproducibility of exposure, with phantoms used to simulate variations in patient thickness
- *Fluoroscopy exposure rate*: Entrance skin dose should not be more than 100 mGy_a per minute
- *ABC on image intensifier*: Checked to ensure that radiation dose hitting the input phosphor is constant

Digital Image Acquisition

Accept the challenges so that you may feel the exhilaration of victory.

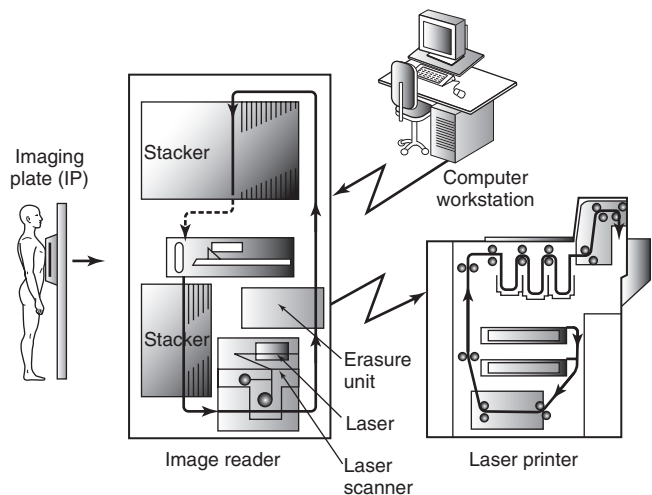
Digital Imaging Equipment

- A. Computed radiography (CR) (Figure 4-7)
 1. Radiographer selects exposure factors
 2. Accurate positioning remains critical
 3. Image receptor is an imaging plate (IP)
 - a. Coated with a photostimulable phosphor (PSP) that is applied to a semirigid support layer
 - b. PSP is struck by the remnant rays exiting the patient
 - c. Remnant rays transfer their energy to electrons in the phosphors, placing the electrons in a higher level conductive layer, where they are trapped until placed in the reader
 - d. IP can store the image for several hours; after that, the energy slowly dissipates and the latent image fades; plates should be processed within 8 hours
 - e. The x-ray exposure must fall within a range that allows the appropriate number of x-ray photons to strike the CR plate

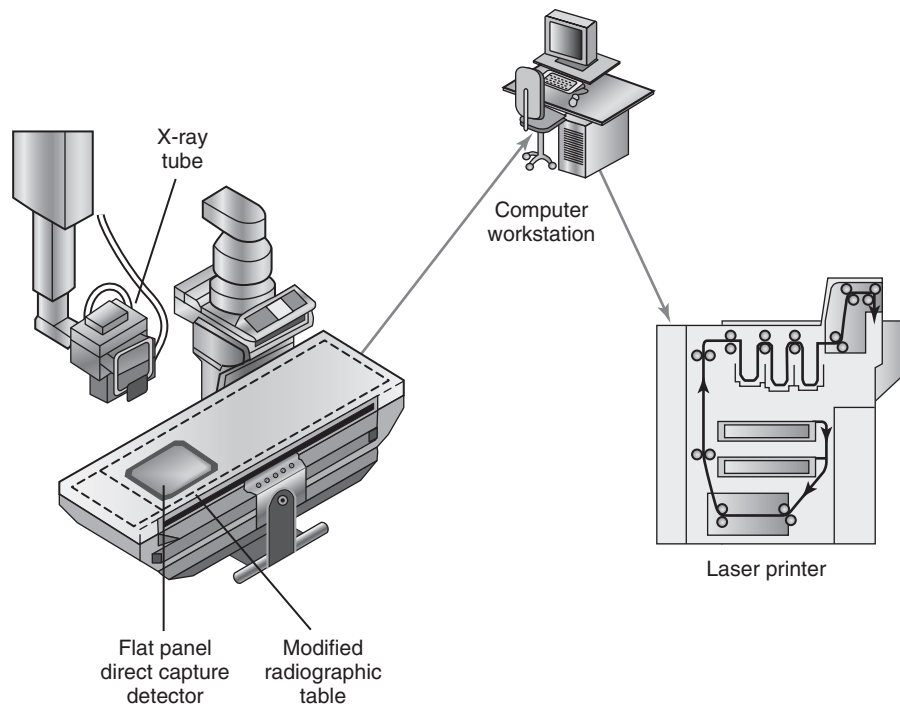
KEY REVIEW POINTS

Quality Control of X-Ray-Producing Equipment

- *Quality assurance*: Complete program in a radiology department that addresses all aspects of quality, including customer service, image interpretation, accuracy of diagnosis, and distribution of radiologists' reports
- *Quality control*: Program that specifically addresses the safe and reliable operation of equipment
- *Filtration-beam quality*: Tested using a digital dosimeter; half-value layer measurement is required
- *Collimator/light field to radiation field alignment*: Must be accurate to within 2% of SID
- *Effective focal-spot size*: Should be within 50% of size stated in equipment specifications
- *kVp*: Must be accurate to within 10% of that chosen
- *Timer*: Should be within 5% of the time chosen for exposures over 10 ms



• **Figure 4-7** The exposed IP is placed in a reader unit to release the stored image, convert the analog image to a digital image, and send the data to a computer monitor or laser printer. The reader unit also erases the exposed IP in preparation for the next exposure. (Courtesy Fuji Medical Systems.)



• **Figure 4-8** Flat panel digital detector fixed in a modified x-ray table.

4. Reader unit accepts the cassette and removes the IP so that it may be scanned with a laser
 - a. Laser beam scans PSPs
 - b. Laser scanning allows the electrons to relax into lower energy levels in the phosphors
 - c. As the electrons relax into lower energy levels, a visible blue light is emitted
 - d. Blue light energy is amplified by a photomultiplier and then converted from analog to digital form and sent to the computer for processing
 5. The radiographer must be very familiar with the equipment being used, especially the manufacturer's terminology for exposure indicator
 6. Viewing of the digital image takes place on a computer monitor, normally a flat panel liquid crystal display (LCD) screen
- B. Digital radiography (DR) (Figure 4-8)
1. Differs from CR by using flat panel detectors that communicate directly with a computer workstation
 2. The flat panel DR systems produce an image more quickly than CR
 3. Patient throughput generally is higher than with CR
 4. Flat panel DR system may use either direct or indirect detectors
 - a. Direct detectors convert exit radiation energy directly into electrical charges, speeding image construction
 - b. Indirect detectors convert exit radiation energy first to visible light via a phosphor layer and then to electrical charges
 5. Electrical signals from either direct or indirect detectors are converted from analog to digital
 6. Viewing of the digital image takes place on a computer monitor, normally a flat panel LCD screen
- C. Workstation monitors
1. Most monitors are flat panel LCD screens that are designed to reduce the effect of ambient lighting on the image
 2. Monitors at the technologist workstation are normally lower resolution, used to review acquired images for exposure and positioning before they are sent to the radiologist
 3. Monitors at the radiologist workstation are high resolution for maximum detail and better contrast resolution
 4. Monitors control the brightness of the image, defined as the intensity of light representing the various pixels comprising the image
 5. Brightness: The measurement of luminance of an area of a radiographic image displayed on a monitor
- D. Imaging informatics
1. CR and DR are part of an integrated system of images and written data
 - a. Picture archiving and communications system (PACS)
 1. Comprises systems for image acquisition, display, network, storage
 - b. Digital imaging and communications in medicine (DICOM)—a standard protocol used for blending PACS and various imaging modalities
 - c. HIS (hospital information system)—blends patient care information, reporting, and billing
 - d. RIS (radiology information system)—used for ordering procedures and reporting results

TABLE
4-1

American Registry of Radiologic Technologists (ARRT) Standard Definitions*

Term	<i>Digital Radiography</i> includes both computed radiography and direct radiography <i>Computed Radiography (CR)</i> systems use storage phosphors to temporarily store energy representing the image signal. The phosphor then undergoes a process to extract the latent image. <i>Direct Radiography (DR)</i> systems have detectors that directly capture and read out an electronic image signal.
Spatial Resolution	The sharpness of the structural edges recorded in the image.
Receptor Exposure	The amount of radiation striking the image receptor.
Brightness	<i>Brightness</i> is the measurement of the luminance of an area in a radiographic image displayed on a monitor. It is calibrated in units of candela (cd) per square meter.
Contrast	<i>Contrast</i> is the visible difference between any two selected areas of brightness levels within the displayed radiographic image. It is determined by the processing algorithm (mathematical codes used by the software to provide the desired image appearance). The default algorithm determines the initial processing codes applied to the image data. <i>Grayscale</i> refers to the number of brightness levels (or gray shades) visible on an image and is linked to the bit depth of the system. <i>Long Scale</i> is the term used when slight differences between gray shades are present (low contrast) but the total number of gray shades is great. <i>Short Scale</i> is the term used when considerable or major differences between gray shades are present (high contrast) but the total number of gray shades is small.
Dynamic Range	The range of exposures that may be captured by a detector.
Receptor Contrast	The fixed characteristic of the receptor. Most digital receptors have an essentially linear response to exposure. This is impacted by <i>contrast resolution</i> (the smallest exposure change or signal difference that can be detected). Ultimately, contrast resolution is limited by the <i>quantization</i> (number of bits per pixel) of the analog-to-digital converter.
Exposure Latitude	The range of exposures that produces quality images at appropriate patient dose.
Subject Contrast	The magnitude of the signal difference in the remnant beam as a result of the different absorption characteristics of the tissues and structures making up that part.

*From American Registry of Radiologic Technologists: *Radiography examination content specifications*, St. Paul, MN, 2015, ARRT. Implementation date January 2017.

- e. EMR (electronic medical record), in some cases referred to as her (electronic health record)—comprehensive collection of patient information stored in a digital format; may be shared across networks; data may include history, medications, allergies, all types of test results including diagnostic images, vital signs

Quality Control of Digital Equipment

- A. Initial acceptance testing: Verify equipment matches specifications
- B. CR plate maintenance
 1. Inspect and clean IP regularly
 2. Plate erasure at least every 48 hours
- C. Uniformity of processing codes: Verify codes across the facility
- D. CR reader: Calibrate annually
- E. DR plate maintenance
 1. Inspect and clean regularly
- F. Monitors
 1. Clean as needed
 2. Use QC monitor test pattern to verify image quality, resolution, presence of geometric distortion
 3. Measure luminance with a luminance meter
 4. Determine presence of reflections and their sources

KEY REVIEW POINTS

Digital Imaging Equipment

- Digital image produced when the analog signal is sent through an analog-to-digital converter to convert information into numerical data
- *CR*: Uses an IP made of a PSP; absorbs energy exiting the patient; IP is scanned with a laser; energy released is converted from analog to digital for postprocessing
- With *CR*, x-ray exposure must fall within a range that allows the appropriate number of x-ray photons to strike the IP
- *Direct DR*: Uses wired or wireless flat panel detectors that communicate directly with a computer workstation
- *DR* flat panel systems produce an image more quickly than *CR*
- Flat panel *DR* systems may use either direct or indirect detectors
- *DR direct detectors*: Convert exit radiation directly into electrical charges, speeding image construction
- *DR indirect detectors*: Convert exit radiation first to visible light and then to electrical charges; uses *CCD* (charge coupled device) or *CMOS* (complementary metal oxide semiconductor)
- Electrical signals from either direct or indirect detectors are converted from analog to digital; viewed on a monitor

Continued

KEY REVIEW POINTS—cont'd

Digital Imaging Equipment

- Monitors may be lower resolution (technologist workstation) or higher resolution (radiologist workstation)
- Monitors determine the brightness of the image
- *Brightness*: The measurement of luminance of an area of a radiographic image displayed on a monitor
- Imaging informatics may include PACS, DICOM, HIS, RIS, EMR
- Digital equipment has its own unique set of quality control tests

Overview of CR and DR Image Characteristics

- Wide exposure latitude; range of exposure techniques that will result in an acceptable image
- Exhibit good visualization of soft tissue and bone
- Digital image is composed of numerical values indicating the variety of tissue thicknesses, densities, and atomic numbers through which the x-ray photons are attenuated
- Digital image is composed of rows and columns called a matrix
 - Matrix size equals the total number of pixels in the image
 - Smallest component of the matrix is the pixel (picture element)
 - Each pixel corresponds to a shade of gray representing an area in the patient called a voxel (volume element)
 - Pixel density—number of pixels/mm in the image; determined by pixel pitch
 - Pixel pitch—space from the center of one pixel to the center of an adjacent pixel
- A histogram (graphic display) is constructed to show the radiographer the distribution of pixel values (indicating low, proper, or high exposure)
- The correct processing algorithm (mathematical formula) must be chosen so that the computer can reconstruct the image specific to the exam that was performed
- As a digital image, the information can be manipulated through various postprocessing steps (subtraction, edge enhancement, contrast enhancement, and black/white reversal)
 - Subtraction*: Removal of superimposed or unwanted structures from the image
 - Contrast enhancement*: Altering of image to display varying brightnesses
 - Edge enhancement*: Improves visibility of small, high-contrast areas
 - Black/white reversal*: Reversal of the gray scale in the image
- Postprocessing can compensate for overexposures or underexposures of considerable degree (–100% to +500%)
 - Because radiographers comply with the *as low as reasonably achievable* (ALARA) concept, patients should never be overexposed with the intention of correcting the resultant images in the postprocessing mode (dose creep)
- Image may be printed onto film with a laser camera
- Resolution is finer with DR than with CR because DR involves less conversion of the information
- In both CR and DR, visibility of the resolution depends on the monitor being used to display the image
- Changing the window level (midpoint of densities) adjusts the image brightness (lighter or darker) throughout the range of densities in postprocessing mode; this is a direct relationship
 - As window level increases, image brightness increases
 - As window level decreases, image brightness decreases
- Changing the window width adjusts the radiographic contrast in postprocessing mode
 - As window width narrows, contrast increases
 - As window width widens, contrast decreases
- Spatial frequency resolution*: Level of detail or sharpness on the CR image
- Look-up table (LUT)*: Histogram of pixel values from image acquisition that can be used to correct or enhance luminance values
- Beam-part-receptor alignment latitude—crucial so that the software can detect collimated edges
- Quantum mottle (“grainy” or “noisy” image)
 - Is a source of noise in the image
 - Caused by too few x-ray photons hitting the image receptor (normally from too low kVp)
- Artifacts may be present in digital radiography
 - Artifacts related to the image receptor
 - Any object on the surface of the image receptor (e.g., hair, dust, adhesive) may result in a light area on the image the shape of the object; may also be caused by dust on the CR plate reader rollers
 - Mishandling of the image receptor may result in bending or cracks in the plate that may cause areas of dead pixels or a row of dead pixels; dead pixels are unable to display the information deposited in their region of the image; dead pixel correction software may provide some correction
 - Inadequate erasure of an image receptor, or incorrect erasure settings, may result in “ghosting,” the appearance of anatomy imaged on the previous exposure (also called image lag)
 - This can occur more often with DR plates as opposed to CR cassettes since there is usually a shorter time period between exposures using DR
 - Excessive backscatter radiation may result in the electronics of the DR plate being imaged and visualized, even with additional lead foil backing on the plate
 - Malfunctioning rollers in the CR plate reader may result in vertical or horizontal lines across the image
 - A CR imaging plate that “stutters” or pauses while in the reader may result in wavy lines across the image

- g. Incorrectly oriented grids may cause a moiré pattern on the image; seen more often with low ratio grids
 - h. Digital imaging plates are extremely sensitive to scatter radiation; control of scatter is critical
2. Artifacts related to software
 - a. Overprocessing the digital image may lead to loss of information
 - b. Overcompression of the image may result in a loss of information in the image
 3. Artifacts related to technical errors
 - a. Improper collimation may lead to exposure field recognition error and histogram analysis errors; the image may appear too light, too dark, or too noisy
 - b. Misalignment of the exposure field may lead to exposure field recognition error and histogram analysis errors; the image may appear too light, too dark, or too noisy

KEY REVIEW POINTS

CR and DR Image Characteristics with Related Definitions

- Wide exposure latitude; better visualization of soft tissue and bone
- *Digital image*: Composed of rows and columns called a matrix
- Pixel: Picture element; smaller part of a digital image; is a shade of gray representing a voxel
- Pixel density: Number of pixels/mm in the image; determined by pixel pitch
- Voxel: Volume element; an area of tissue in the patient
- Histogram (graphic display): Shows the radiographer the distribution of pixel values (indicating low, proper, or high exposure)
- Processing algorithm (mathematical formula): Used by the computer to reconstruct the image specific to the exam that was performed
- Postprocessing: Subtraction, edge enhancement, contrast enhancement, black/white reversal
- Subtraction: Removal of superimposed or unwanted structures from the image
- Contrast enhancement: Altering of image to display varying brightnesses
- Edge enhancement: Improves visibility of small, high-contrast areas
- Black/white reversal: Reversal of the gray scale in the image
- Window level (midpoint of the image densities): Adjusts the image brightness throughout the range of densities; this is a direct relationship
- Window width: Adjusts the image contrast (gray scale) in postprocessing mode; this is an inverse relationship
- Spatial frequency resolution: Level of detail or sharpness on the CR image
- LUT: Histogram of brightness level values from image acquisition that can be used to correct or enhance luminance values
- Quantum mottle (“grainy” or “noisy” image): Source of noise in the image; caused by too few x-ray photons hitting the image receptor
- Signal-to-noise ratio (SNR): Comparison of the useful signal to the presence of noise; high SNR results in a higher quality image

- Detective quantum efficiency (DQE): The efficiency with which the digital system converts an x-ray signal to a useful diagnostic image
- Digital image artifacts: May be related to image receptor issues, software, or technical errors
- Dynamic range: Image receptor’s ability to acquire the chosen exposure
- Detector element (DEL): Smallest resolvable area of the image receptor
- Modulation transfer function: Ability of the digital system to accurately record spatial frequencies
- Automatic rescaling (Auto Ranging, rescaling, scaling, normalization): Software ability to produce images with consistent brightness and contrast
- Detector size (field of view): Area of the imaging device that is used to acquire the useful image
- Quantization: Ability to assign a value to each pixel corresponding to the gray shade determined by its bit depth
- Stitching: Use of software to connect multiple images into one image
- Region of interest: Identifying a specific anatomic area on a digital image
- Dead pixel correction: Assigning a value to a dead pixel based on the values of adjacent pixels
- Flat fielding: Preprocessing calibration techniques used to make the response of the image receptor uniform

Properties of the Digital Image Receptor Exposure

Controlling and Influencing Factors

- A. mAs
 1. Controls the number of electrons passing from cathode to anode in the x-ray tube
 2. Controls the quantity of x-rays produced at the anode
 3. Controls the amount of radiation exiting the x-ray tube
 - a. This is a directly proportional relationship
 - b. As mAs is increased, receptor exposure increases in the same amount
 - c. As mAs is decreased, receptor exposure decreases in the same amount
 4. Directly controls the number of x-ray photons that emerge from the patient as exit rays
 5. Directly controls the number of x-rays that eventually strike the image receptor as exit rays
- B. kVp
 1. Directly controls the energy or quality of the x-rays produced
 - a. As the kVp increases, a greater potential difference exists between the cathode and the anode
 - b. As the potential difference increases, the electrons from the cathode strike the anode in greater numbers and with greater energy
 - c. This results in an increased level of production of short-wavelength, high-energy radiation
 2. Directly affects receptor exposure, although not in a directly proportional relationship
 - a. As kVp increases, receptor exposure increases
 - b. As kVp decreases, receptor exposure decreases

- c. Governed by the 15% rule (an increase in kVp of 15% doubles receptor exposure; a decrease in kVp of 15% halves receptor exposure)
 3. Determines the penetrating ability of the x-ray beam
 - a. As kVp is increased, wavelength decreases, and x-rays become more penetrating
 - b. As kVp is decreased, wavelength increases, and x-rays become less penetrating
 4. Penetrating ability of the x-rays also determines the number of x-rays exiting the patient to strike the image receptor
- C. Distance
1. Inverse square law
 - a. Beam intensity (and ultimately receptor exposure, which is a function of beam intensity) is governed by the inverse square law
 - b. *Inverse square law*: Intensity of the x-ray beam is inversely proportional to the square of the distance between the source of x-rays and the image receptor
 - c. Expressed as: $\text{old intensity/new intensity} = \text{new SID}^2/\text{old SID}^2$
 - d. This equation describes changes in beam intensity (and receptor exposure, which is a function of beam intensity) when SID is changed and no changes are made in exposure technique
 - e. If SID is doubled, intensity (receptor exposure) decreases four times; if distance is halved, intensity (receptor exposure) increases four times
 - f. Variation in intensity is the result of the divergence of the x-ray beam as it travels through space
 2. Exposure maintenance formula
 - a. Expressed as: $\text{old mAs/new mAs} = \text{old SID}^2/\text{new SID}^2$
 - b. Used to calculate changes in mAs needed to maintain receptor exposure when dealing with a change in SID
 - c. If SID is doubled, mAs must be increased four times to maintain the same receptor exposure as that of an image taken at the old distance; if distance is halved, mAs must be decreased four times to maintain the same receptor exposure as that of a radiograph taken at the old distance
- D. Grids
1. Decrease the amount of scatter radiation striking the image receptor
 2. Receptor exposure decreases when grids are used, unless mAs is increased to compensate for the loss of scatter fog
- E. Beam restriction
1. Decreases receptor exposure by limiting the size of the x-ray beam, unless mAs are increased to compensate
 2. Decreases receptor exposure by limiting the area of the patient being struck by x-rays
 3. Reduces the amount of scatter radiation being produced, reducing receptor exposure caused by fog; necessary for proper image processing with digital imaging
- F. Anatomy and pathology
1. Anatomy affects receptor exposure through its variation of atomic number, tissue thickness, and tissue density
 2. Pathologic changes affect receptor exposure by altering tissue integrity, atomic number, tissue density, and tissue thickness (see [Chapter 5](#) for specific pathologic conditions and their effects on radiographic technique)
- G. Anode heel effect
1. X-ray intensity varies along the longitudinal axis of the x-ray beam
 - a. Receptor exposure is greater near the cathode end of the x-ray beam
 - b. Receptor exposure is less near the anode end of the x-ray beam because x-rays are absorbed by the “heel” of the anode
 2. Thicker anatomy should be placed under the cathode side of the x-ray tube to take advantage of the anode heel effect
- H. Filtration
1. Negligible effect on receptor exposure; its purpose is primarily for radiation protection
 2. Radiation protection is due to the reduction in the number of soft, long-wavelength rays being absorbed in the patient
 3. Has an impact on contrast because the average wavelength of the filtered beam is shorter than the nonfiltered beam
 4. Compensating filters even out density of irregular anatomy

KEY REVIEW POINTS

Receptor Exposure

- *Receptor exposure*: The intensity of radiation striking the image receptor; it directly determines the quality of the digital image
- Receptor exposure is directly controlled by mAs—mAs controls the current through the x-ray tube and, consequently, the number of x-rays produced at the anode
- *kVp*: Controls the energy of x-rays produced; also has a direct impact on receptor exposure, although not proportional; governed by the 15% rule
- *SID*: Affects receptor exposure through the inverse square law
- *Grids*: Absorb scatter radiation; this has an impact on the receptor exposure
- *Beam restriction*: Limits the size of the x-ray beam; affects receptor exposure by reducing the amount of scatter produced
- *Anatomy and pathology*: Affect receptor exposure through variations of atomic number, tissue thickness, and tissue density
- *Anode heel effect*: Has some effect on receptor exposure when a large field is being exposed

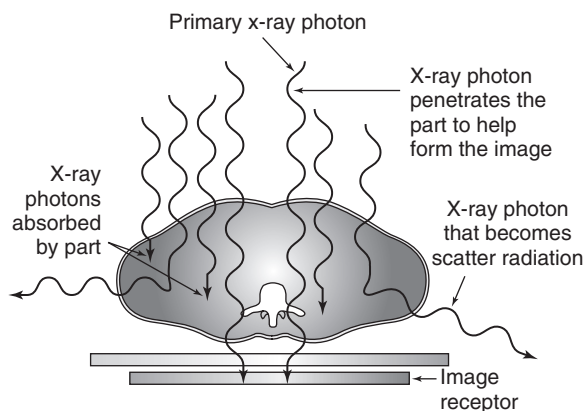
Contrast

Contrast Overview

- A. Contrast is the visible difference between two selected areas of brightness in the displayed radiographic image
- B. Gray scale is the number of gray shades, or brightness levels, visible on an image
- C. Long-scale contrast indicates small differences between gray shades; large number of gray shades present
- D. Short-scale contrast indicates much difference between gray shades, few gray tones present, more black-and-white image
- E. Subject contrast—refers to the differences in the remnant beam secondary to the differential absorption of the x-ray beam by the structures in the body
- F. Contrast resolution—the smallest change in signal that can be detected by the receptor

Controlling and Influencing Factors

- A. Subject contrast
 1. kVp directly controls the differential absorption of the x-ray beam in the body (Figure 4-9)
 - a. As kVp is increased, the shorter-wavelength rays more uniformly penetrate anatomic parts to become part of the remnant beam striking the image receptor
 - b. As kVp is decreased, there is greater absorption of lower energy rays by the anatomic parts due to photoelectric interaction, changing the remnant beam striking the image receptor
 2. Anatomy and pathology: Controls contrast with variations in the following:
 - a. *Atomic number*: Higher atomic number indicates increase in contrast owing to photoelectric effect
 - b. *Tissue density*: As tissue density increases, contrast decreases owing to Compton interaction
- B. Contrast resolution
 1. Ability of the imaging system to distinguish the smallest change in exposure or signal
 2. Provides visibility of small objects having similar shades of gray
 3. Controlled by bit depth, the number of bits per pixel (the larger the bit depth, the greater the number of levels of gray possible in an image)
- C. Grids
 1. Reduce the amount of scatter reaching the image receptor
 2. Less scatter fog results in fewer gray tones, which increases contrast
- D. Beam restriction
 1. Limits area being irradiated
 2. Produces less scatter by reducing the number of Compton interactions taking place
 3. Less scatter fog reduces the number of gray tones on the radiograph, increasing contrast
- E. Filtration (Figure 4-10)
 1. As filtration is increased, beam becomes harder (average photon striking the patient has shorter wavelength)
 2. Contrast decreases as filtration increases

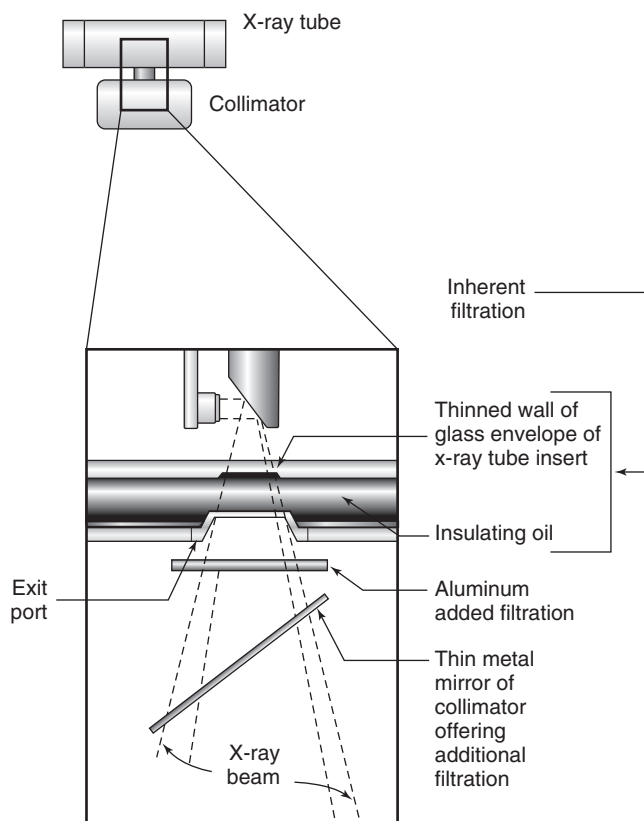


• **Figure 4-9** As the primary beam interacts with the anatomic part, photons are absorbed, scattered, and transmitted. The differences in the absorption characteristics of the anatomic part create an image that structurally represents the anatomic part.

KEY REVIEW POINTS

Contrast

- Contrast is the visible difference between two selected areas of brightness in the displayed radiographic image
- Contrast resolution is the ability of the imaging system to distinguish the smallest change in exposure or signal; controlled by bit depth, the number of bits per pixel (the larger the bit depth, the greater the number of levels of gray possible in an image)
- *High contrast*: Few gray tones, mainly black-and-white image; may also be referred to as *short-scale contrast*; produced at lower kVp
- *Low contrast*: Many gray tones on image; may also be referred to as *long-scale contrast*; produced at higher kVp
- Subject contrast is controlled by kVp—kVp controls differential absorption of the x-ray beam by the body because of its control of x-ray beam energy; also controlled by anatomy and pathology through variations of atomic number, tissue thickness, and tissue density; produced by photoelectric effect
- *Grids*: Reduce the amount of scatter reaching the image receptor, increasing contrast
- *Beam restriction*: Limits area being irradiated, so less scatter is produced, and contrast is increased



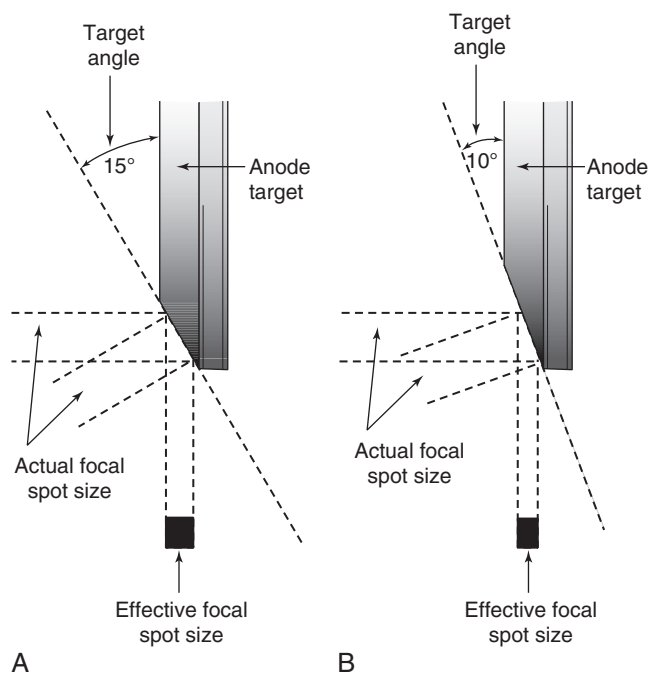
• **Figure 4-10** Aluminum added filtration is shown at the port of the x-ray tube. The inherent filtration of the glass envelope and the oil and the collimator mirror are shown.

Spatial Resolution

- Sharpness of the structural edges in the image; smallest detail that can be detected
- May be described as the geometric representation of the part being imaged
- May also be referred to as *detail sharpness*, *definition*, *image resolution*
- Nyquist frequency*: The highest spatial resolution that can be recorded; controlled by pixel pitch

Controlling and Influencing Factors

- Pixel size—smaller pixels provide greater spatial resolution
- Pixel pitch—space between pixels; less space between pixels provides greater spatial resolution
- Object-to-image receptor distance (OID)
 - Distance from the anatomic part being imaged to the image receptor
 - Shortest possible OID should be used
 - Increased OID causes magnification of the image, resulting in loss of recorded detail
- Source-to-image receptor distance (SID)
 - Distance from the source of radiation to the image receptor
 - Longest practical SID should be used
 - Shorter SID causes magnification of the image, resulting in loss of sharpness



• **Figure 4-11** The line focus principle states that a large target angle produces a large effective focal spot size (A) and that a small target angle produces a small effective focal spot size (B). Both actual focal spot sizes are the same, meaning they can withstand the same heat loading from the same exposure factors.

E. Focal-spot size (Figure 4-11)

- Focal-spot size is most often chosen by the x-ray machine itself; it is not usually controlled by the radiographer
- If size is controllable, use small focal spot when possible
- Use of large focal spot decreases sharpness in the image as a result of x-rays emanating from a larger area of the anode; adds to image blur

F. Motion

- Any motion results in image blur and subsequent loss of recorded detail
- Motion may be caused by the following
 - Patient motion (voluntary and involuntary)
 - X-ray tube motion
 - Excessive motion from reciprocating grid

KEY REVIEW POINTS

Spatial Resolution

- Spatial resolution*: sharpness of the structural edges in the image; smallest detail that can be detected
- May also be referred to as detail sharpness, definition, image resolution
- Controlled by pixel size and pixel pitch
- Influenced by SID, OID, focal-spot size, motion

Distortion

- A. Any geometric misrepresentation of an anatomic structure on an image receptor
- B. Two types of distortion: size and shape

Factors Controlling Distortion

- A. Size
 1. Magnification
 2. Caused by excessive OID
 3. Caused by insufficient SID
 4. Causes anatomic structure to appear larger on the image than in reality
- B. Shape (Figure 4-12)
 1. Elongation
 - a. Causes anatomic structure to appear longer than in reality
 - b. Caused by improper tube, part, or image receptor angulation or alignment
 - c. Caused by angulation along the long axis of the part
 2. Foreshortening
 - a. Causes anatomic structure to appear shorter than in reality
 - b. Caused by improper tube, part, or image receptor angulation
 - c. Caused by angulation against the main axis of the part



• **Figure 4-12** A, No distortion. B, Foreshortened. C, Elongated.

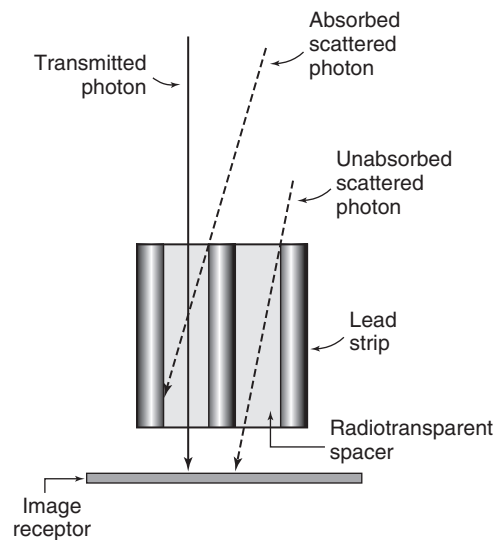
KEY REVIEW POINTS

Distortion

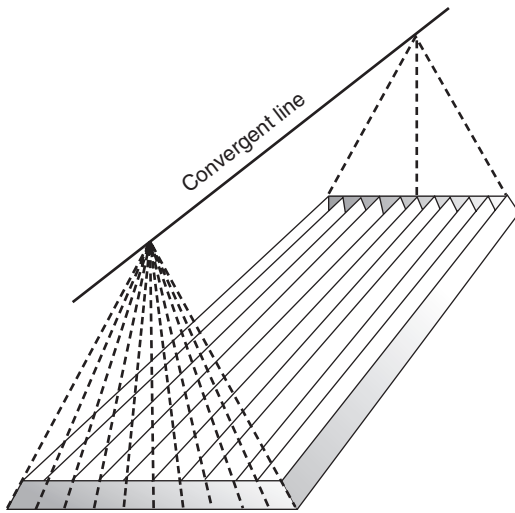
- *Distortion*: Any misrepresentation of an anatomic structure on an image receptor that alters its size and/or shape
- *Size distortion*: Magnification; caused by excessive object-to-image distance (OID) or insufficient source-to-image distance (SID)
- *Shape distortion*: Elongation or foreshortening
- *Elongation*: Causes anatomic structure to appear longer than in reality; caused by improper tube, part, or film angulation or alignment, with angulation along the long axis of the part
- *Foreshortening*: Causes anatomic structure to appear shorter than in reality; caused by improper tube, part, or film angulation or alignment, with angulation against the main axis of the part

Grids

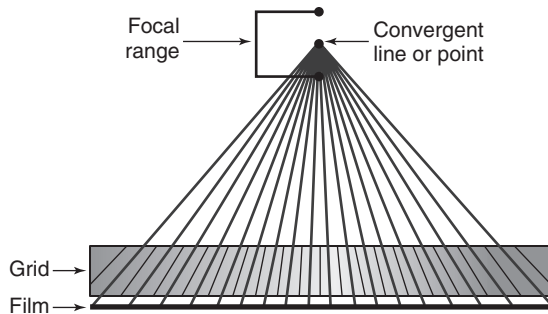
- A. Use
 1. Reduce the amount of scatter radiation reaching the image receptor
 - a. Scatter travels in divergent paths compared with image-producing rays (Figure 4-13)
 - b. More likely to be absorbed in the grid
- B. Construction
 1. Lead strips separated by aluminum interspacers
 2. Grid ratio
 - a. Grid ratio is the height of the lead strips divided by the distance between the lead strips: grid ratio = H/D
 - b. Ratios range from 4:1 to 16:1



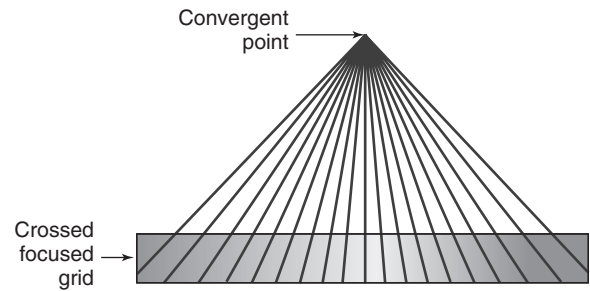
• **Figure 4-13** Ideally, grids would absorb all scattered radiation and allow all transmitted photons to reach the image receptor. In reality, however, some scattered photons are allowed to pass through to the IR, and some transmitted photons are absorbed.



• **Figure 4-14** Imaginary lines drawn above a linear focused grid from each lead line meet to form a convergent line.



• **Figure 4-15** The convergent line of a focused grid falls within a focal range.



• **Figure 4-16** Imaginary lines drawn above a crossed focused grid from each lead line meet to form a convergent point.

3. Grid frequency
 - a. Number of lead strips per inch (or centimeter)
 - b. As grid frequency increases, lead strip thickness decreases and becomes less visible
 - c. Ranges from 60 to 150 lines per inch
- C. Grid types
 1. Linear
 - a. Lead strips are parallel to one another
 - b. X-ray tube may be angled along the length of the grid without cutoff
 - c. *Grid cutoff*: Decreased density along the periphery of the image caused by absorption of image-forming rays
 - d. Used primarily with large SID or small field
 2. Focused grids (Figures 4-14 and 4-15)
 - a. Lead strips are angled to coincide with divergence of x-ray beam
 - b. Used within specific ranges of SID
 - c. *Grid radius*: Distance at which focused grid may be used (also called *focal distance* or *focal range*)
 - d. Focal range is wide for low-ratio grids
 - e. Focal range is narrow for high-ratio grids

- f. Focal range is stated on the front of the grid
3. Crossed grids (Figure 4-16)
 - a. Also called *crosshatch grids*
 - b. Consist of two linear grids placed perpendicular to each other
 - c. Superior scatter cleanup
 - d. Allow no angulation of x-ray beam
 - e. Require perfect positioning and centering
- D. Grid characteristics
 1. Contrast improvement factor
 - a. Measure of ability of a grid to increase contrast
 - b. Expressed as the ratio of the contrast with a grid to the contrast without a grid
 2. Grid selectivity
 - a. Expressed as the ratio of primary radiation transmitted through the grid to secondary radiation transmitted through the grid
 - b. The higher the grid frequency and grid ratio, the more selective the grid
 - c. High selectivity indicates high efficiency of scatter cleanup
 3. Grid conversion factor (GCF)
 - a. Also called *Bucky factor*
 - b. Amount of exposure increase necessary to compensate for the absorption of image-forming rays and scatter in the cleanup process
 - c. Used to indicate the increase in mAs needed when converting from nongrid to grid status (multiply mAs by GCF)
 - d. Used to indicate the decrease in mAs when converting from grid to nongrid status (divide mAs by GCF)
 - e. Factors used at 120 kVp—5:1 grid, 2; 6:1 grid, 3; 8:1 grid, 4; 12:1 grid, 5; 16:1 grid, 6
- E. Grid motion
 1. Stationary grids
 - a. Do not move during the exposure
 - b. Grid lines may be seen
 2. Moving grids
 - a. Reciprocate (move back and forth) during exposure
 - b. Eliminate the visibility of grid lines

- c. Grid must begin moving just before the exposure and continue until just after the exposure to blur grid lines.
- F. *Grid errors: Focused grids*
- Upside down
 - Result is normal density in the middle of the radiograph with decreased density on the sides
 - Focused grid must be placed with labeled tube side facing x-ray tube
 - Off-level
 - Result is image-forming rays absorbed all across the radiographic field, with cutoff (decreased density) visible over the entire radiograph
 - Grid must be perpendicular to the central ray
 - Lateral decentering
 - Central ray does not strike the grid in the center
 - Cutoff visible, more to one side of the radiograph
 - Grid-focus decentering
 - Violation of the grid radius when a focused grid is used
 - Normal density in the middle of the radiograph with cutoff visible on the sides
- G. Air gap technique
- Uses increased OID
 - Increased OID allows scatter (which travels in widely divergent paths) to exit the patient and miss the image receptor
 - Example:* Lateral cervical spine
 - Distance from spine to shoulder causes gap
 - Eliminates need for grid (gap is similar to using a 10:1 grid)
 - Use of grid with air gap increases patient dose and is unnecessary
- H. Radiographic quality and grids
- Produce higher contrast by absorbing Compton scatter rays, which produce fog if they strike the image receptor

- Grid ratio:* The height of the lead strips divided by the distance between the lead strips: $\text{grid ratio} = H/D$
- Grid frequency:* Number of lead strips per inch (or centimeter)
- Linear grids:* Lead strips are parallel to one another
- Focused grids:* Lead strips are angled to coincide with divergence of the x-ray beam
- Grid cutoff:* Decreased density along the periphery of the film caused by absorption of image-forming rays
- Grid radius:* Distance at which focused grid may be used (also called *focal distance* or *focal range*)
- Contrast improvement factor:* Measure of grid's ability to enhance contrast
- Grid selectivity:* Expressed as the ratio of primary radiation transmitted through the grid to secondary radiation transmitted through the grid
- GCF:* Amount of mAs exposure increase necessary to compensate for the absorption of image-forming rays and scatter in the cleanup process (also called *Bucky factor*)
- GCFs:* At 120 kVp—5:1 grid, 2; 6:1 grid, 3; 8:1 grid, 4; 12:1 grid, 5; 16:1 grid, 6
- Stationary grids:* Do not move during the exposure
- Moving grids:* Reciprocate (move back and forth) during exposure; eliminate the visibility of grid lines
- Upside-down grid:* Result is normal density in the middle of the radiograph with decreased density on the sides
- Off-level grid:* Result is image-forming rays absorbed all across the radiographic field, with cutoff (decreased density) visible over the entire radiograph
- Lateral decentering:* Cutoff visible, more to one side of the radiograph
- Grid-focus decentering:* Normal density in the middle of the radiograph with cutoff visible on the sides

KEY REVIEW POINTS

Grids

- Use of grids reduces the amount of scatter radiation reaching the film
- Construction:* Lead strips separated by aluminum interspacers

TABLE 4-2 Variables and Their Effects on Photographic and Geometric Properties of the Radiographic Image

Radiographic Variables	Photographic Properties		Geometric Properties	
	Receptor Exposure	Contrast	Spatial Resolution	Distortion
↑ mAs*	↑	0	0	0
↓ mAs	↓	0	0	0
↑ kVp	↑	↓	0	0
↓ kVp	↓	↑	0	0
↑ SID	↓	0	↑	↓
↓ SID	↑	0	↓	↑
↑ OID†	↓	↑	↓	↑
↓ OID	↑	↓	↑	↓
↑ Grid ratio	↓	↑	0	0
↓ Grid ratio	↑	↓	0	0
↑ Collimation	↓	↑	0	0
↓ Collimation	↑	↓	0	0
↑ Focal-spot size	0	0	↓	0
↓ Focal-spot size	0	0	↑	0
↑ Central ray angle	↑	0	↓	↑

↑, Increased effect; ↓, decreased effect; 0, no effect; *OID*, object-to-image receptor distance; *SID*, source-to-image receptor distance.

*The mAs has no significant effect on contrast as long as densities remain within diagnostic range.

†The amount of OID needed to affect contrast depends on the type of anatomic part being imaged.

From Fauber TL: *Radiographic imaging and exposure*, ed 4, St. Louis, 2012, Mosby.

Because this chapter covers two very large topics, 100 review questions on each topic are presented here:

Review Questions

Review Questions for X-ray Equipment Operation

- In many cases, digital fluoroscopy eliminates which of the following?
 - The need for a radiographer
 - Postprocedure “overhead” images
 - Image acquisition
 - Accurate positioning
- What is the smallest particle of an element that retains the characteristics of the element?
 - Mole
 - Atom
 - Molecule
 - Quark
- In digital fluoroscopy, the image must be turned into digital form by what device?
 - Digital-to-analog converter
 - Flux capacitor
 - Analog-to-digital converter
 - DVD-ROM
- X-rays travel as bundles of energy called:
 - Energy waves
 - Phasers
 - Electromagnetic bursts
 - Photons
- What is atomic mass?
 - The number of protons plus the number of neutrons
 - The number of photons
 - The number of electrons
 - The number of protons plus the number of electrons
- What device may be used to ensure consistency of radiographic quality from one exposure to the next?
 - Electronic timer
 - Step-up transformer
 - Automatic exposure control
 - High-frequency generator
- When a predetermined level of ionization is reached in the ionization chamber, what does the machine do?
 - The unit shuts off as a result of a malfunction
 - The maximum allowable time has been reached
 - The highest allowable dose to the patient has been reached
 - The exposure is terminated

8. What type of x-ray machine uses a continually decreasing mA for the shortest times possible?
 - a. Ionization chamber
 - b. Portable
 - c. C-arm
 - d. Falling load generator
9. What type of current is required for proper operation of the x-ray tube?
 - a. Direct
 - b. Falling load
 - c. Alternating
 - d. Fluctuating
10. The law stating that the outer shell of an atom can contain no more than eight electrons is called:
 - a. Ohm's law
 - b. Octet rule
 - c. Octagon rule
 - d. Electron binding energy
11. Examples of particulate radiation are:
 - a. X-rays, gamma rays, and cosmic rays
 - b. Helium nuclei and beta particles
 - c. Electrons, protons, and meteorites
 - d. X-rays and quarks
12. Electromagnetic radiation travels:
 - a. In waves along a straight path
 - b. In circles
 - c. Back and forth
 - d. As electrons in waves along a straight path
13. The latest digital fluoroscopic units use:
 - a. Nonionizing radiation
 - b. CR cassettes
 - c. Conventional image intensifiers
 - d. Flat panel plates similar to DR
14. At what speed do x-rays travel?
 - a. The speed of light—186,000 miles per hour
 - b. The speed of the incident electrons—93,000 miles per second
 - c. The speed of light—186,000 miles per second
 - d. Infinite speed
15. Waves of radiation are called:
 - a. Sine waves
 - b. Strong waves
 - c. Signal waves
 - d. Current waves
16. Wavelength is defined as the distance from:
 - a. The x-ray tube to the patient
 - b. The cathode to the anode
 - c. The bottom of a wave to the top
 - d. Peak to peak of the wave
17. Frequency is defined as:
 - a. Synonymous with wavelength
 - b. The number of waves passing a point per unit time
 - c. The number of waves striking the patient
 - d. The number of exposures needed during an exam
18. The speed of x-rays is based on:
 - a. mAs
 - b. kVp
 - c. Size of the patient
 - d. The fact that they are a form of electromagnetic radiation
19. Wavelength and frequency are:
 - a. Directly proportional to each other
 - b. Inversely proportional to each other
 - c. Inversely proportional to the square of their distance
 - d. Unrelated to each other
20. The x-ray beam changes as it travels through the patient by a process called:
 - a. Filtration
 - b. Attenuation
 - c. Electrification
 - d. Annihilation
21. The intensity of radiation is inversely proportional to the square of the distance between the source of radiation and the person receiving it. This describes the:
 - a. Square law
 - b. Reciprocity law
 - c. Inverse square law
 - d. Octet law
22. As radiation strikes matter:
 - a. The energy of the rays is destroyed
 - b. The energy of the rays is increased as they acquire the energy of the atoms
 - c. The energy is transferred to the atoms according to the law of conservation of energy
 - d. The energy is converted to matter according to Einstein's theory
23. Choose all of the following statements that are accurate regarding electrostatic charges.
 - a. Electrostatics is the study of electric charges at rest
 - b. The movement of electrons from one object to another is called *ionization*
 - c. Like charges attract, and unlike charges repel
 - d. Electrostatic charges concentrate on a conductor in the area of greatest curvature
 - e. Friction, contact, and induction are methods of ionization
24. Choose all of the following that are accurate (choose 6):
 - a. A magnetic field always surrounds an electrical charge in motion
 - b. Current flows back and forth in AC
 - c. Current flows in one direction in DC
 - d. The volt is the unit of electrical current
 - e. A conductor allows the flow of electrons
 - f. The ampere is the unit of electromotive force
 - g. The volt is the unit of potential difference
 - h. The path of electrical current is called the *circuit*
25. Electromagnetic induction is the process of causing an electrical current to flow in a conductor:
 - a. When it is placed in contact with another conductor
 - b. When it is placed in contact with an insulator
 - c. When it is placed in contact with a superconductor
 - d. When it is placed in the magnetic field of another conductor

26. The two types of electromagnetic induction are:
- Autoinduction and mutual induction
 - Self-induction and mutual induction
 - Generated induction and self-induction
 - Current induction and voltage induction
27. Self-induction is used in the operation of what device?
- Step-up transformer
 - Autotransformer
 - Step-down transformer
 - Electronic timer
28. The strength of the magnetic fields in a transformer is increased by:
- Coiling the wires and placing them in adjoining machines
 - Coiling the wires and letting their magnetic fields overlap
 - Keeping the wires very straight, increasing their effectiveness
 - Replacing the wires with diodes
29. Electricity is supplied to the imaging department by a:
- Motor
 - Rectifier
 - Generator
 - Voltmeter
30. The electricity provided to the radiology department is:
- 110 Hz or 220 Hz DC
 - 110 Hz or 220 Hz AC
 - 60 Hz AC
 - 60 Hz DC
31. The electricity provided to the radiology department operates at:
- 120 pulses per second
 - 60 pulses per second
 - 110 pulses per second
 - 220 pulses per second
32. High-frequency power:
- Is less effective than single-phase power
 - Has almost no ripple
 - Has more ripple than three-phase power
 - Is yet unproved
33. The primary advantage of three-phase power is that:
- Voltage drops to zero only 6 times per second
 - Voltage drops to zero only 12 times per second
 - Voltage never drops to zero
 - Voltage is always at peak value
34. A variable transformer that is used to select kVp for the x-ray circuit is the:
- Step-up transformer
 - Autotransformer
 - Step-down transformer
 - Rectifier
35. A transformer that has more turns in the secondary coil than in the primary coil is called a:
- Step-up transformer
 - Solenoid
 - Step-down transformer
 - Filament transformer
36. What is the transformer used to boost voltage to kilovoltage levels called?
- Autotransformer
 - Step-down transformer
 - Step-up transformer
 - Low-voltage transformer
37. Voltage coming to the x-ray machine is kept constant through the use of a(n):
- Autotransformer
 - Step-down transformer
 - Rectifier
 - Line voltage compensator
38. A step-down transformer:
- Steps down voltage
 - Steps down current
 - Steps up voltage
 - Steps up resistance
39. Where does thermionic emission occur?
- Step-down transformer
 - Rectifier
 - Cathode
 - Timer
40. Which of the following devices is prereading?
- Step-down transformer
 - Rectifier
 - Timer
 - kVp meter
41. Which device reduces voltage and provides current to produce an electron cloud or space charge at the filament?
- Step-down transformer
 - Rectifier
 - Cathode
 - Timer
42. Which device is electronic, with a setting as low as 0.001?
- Step-down transformer
 - Rectifier
 - Cathode
 - Timer
43. What changes AC to DC?
- Step-down transformer
 - Rectifier
 - Cathode
 - Timer
44. Which of the following is surrounded by a negatively charged focusing cup?
- Step-down transformer
 - Rectifier
 - Filament
 - Timer
45. Which of the following is composed of solid-state silicon-based diodes?
- Step-down transformer
 - Rectifier

- c. Cathode
d. Timer
46. What regulates the duration of x-ray production?
a. Step-down transformer
b. Rectifier
c. Cathode
d. Timer
47. What is located in the x-ray circuit between the high-voltage transformer and the x-ray tube?
a. Step-down transformer
b. Rectifier
c. Cathode
d. Timer
48. Which of the following measures tube current?
a. Anode
b. mA meter
c. Ionization chamber
d. Falling load generator
49. What device spins at 10,000-12,000 rpm?
a. Anode
b. mA meter
c. Ionization chamber
d. Step-up transformer
50. What device uses maximum heat storage ability of the tube to deliver mAs?
a. Anode
b. mA meter
c. Ionization chamber
d. Falling load generator
51. What is the source of bremsstrahlung and characteristic rays?
a. Anode
b. mA meter
c. Falling load generator
d. Step-up transformer
52. What device increases voltage approximately 500 times?
a. Anode
b. mA meter
c. Ionization chamber
d. Step-up transformer
53. What is the most commonly used AEC?
a. Phototimer
b. mA meter
c. Ionization chamber
d. Falling load generator
54. What device always delivers the shortest exposure time possible?
a. Anode
b. mA meter
c. Ionization chamber
d. Falling load generator
55. What device is turned by a rotor?
a. Anode
b. mA meter
c. Ionization chamber
d. Step-up transformer
56. Which of the following is located between the patient and the image receptor?
a. Anode
b. mA meter
c. Ionization chamber
d. Falling load generator
57. The filament is kept warm by:
a. A standby current from the time the x-ray machine is turned on
b. Insulating oil
c. Lead housing
d. Current produced only during exposures
58. Activating the rotor:
a. Accelerates a procedure
b. Reduces tube life
c. Keeps it oiled
d. Keeps the cooling fan activated
59. When making an exposure, the radiographer should:
a. Hold the rotor for several seconds before pressing "expose"
b. Activate the rotor and exposure switch in one continuous motion
c. Begin the rotor while a student is still positioning the patient
d. Activate the rotor while estimating how fast the anode is spinning
60. The process of thermionic emission causes:
a. Electrons to boil off the anode
b. The anode to spin
c. The cathode to cool quickly
d. Electrons to boil off the filament
61. The force with which the electron stream passes from cathode to anode is a result of _____ passing through the x-ray tube.
a. Current
b. Kilovoltage
c. Tungsten
d. Heat
62. Heat is produced in the x-ray tube as:
a. Electrons break apart while striking the anode
b. Electrons interact with the target material
c. The anode stops spinning
d. The rectifier operates
63. Most of the energy conversion in the x-ray tube produces:
a. X-rays
b. Light
c. Heat
d. Current
64. X-rays are produced as incident electrons are slowed going past the nuclei of target atoms by a process called:
a. Classical
b. Photoelectric
c. Bremsstrahlung
d. Compton

65. X-rays are produced as incident electrons collide with inner shell electrons in target atoms by a process called:
- Characteristic
 - Photoelectric
 - Bremsstrahlung
 - Compton
66. What percentage of energy in the x-ray tube is converted to x-rays?
- 99%
 - 75%
 - 1%
 - 100%
67. Choose all that are properties of x-rays (choose 6):
- Electrically negative
 - Affect film emulsion
 - Scatter and produce secondary radiation
 - Invisible to the human eye
 - Travel at the speed of light (186,000 miles per hour)
 - Possess wavelengths between 1 Å and 5 Å
 - Travel in bundles of energy called *photons*
 - Can ionize matter and gases
 - Can be focused by collimators
 - Cause phosphors to fluoresce
68. The x-ray beam is:
- Heterogeneous—all rays possess the same energy
 - Homogeneous—all rays possess the same energy
 - Monoenergetic—all energies correspond to the kVp
 - Heterogeneous or polyenergetic—consisting of many different energies (wavelengths)
69. The x-ray emission spectrum consists of:
- Brems and characteristic rays
 - Discrete spectrum (produced by brems rays) and continuous spectrum (produced by characteristic rays)
 - Discrete spectrum (produced by characteristic rays) and continuous spectrum (produced by brems rays)
 - X-rays and electrons, both part of the electromagnetic spectrum
70. The *primary* purpose of filtration is:
- Radiation protection
 - Removal of short-wavelength (soft) rays
 - Hardening the beam for imaging
 - Removal of long-wavelength (hard) rays
71. The amount of material needed to reduce the intensity of the beam by 1/10 is called:
- Half-value layer
 - Tenth-value layer
 - Total filtration
 - Inherent filtration
72. Which of the following statements regarding filtration is true?
- Total filtration must not be less than 2-mm aluminum equivalent
 - Total filtration must remove all soft rays from the beam
 - Total filtration (added + compensating) must not be less than 2.5-mm aluminum equivalent
 - Total filtration (not less than 2.5-mm aluminum equivalent) = inherent filtration (glass envelope, tube housing, oil) + added filtration (aluminum)
73. Calculating heat units for three-phase, 12-pulse equipment requires the use of _____ as a constant; calculating heat units for single-phase equipment requires the use of _____ as a constant; calculating heat units for three-phase, 6-pulse equipment requires the use of _____ as a constant.
- 1.0, 1.35, 1.41
 - 1.35, 1.0, 1.41
 - Calculating heat units does not require the use of a constant because all x-rays possess the same ionizing potential
 - 1.41, 1.0, 1.35
74. When a quality control test is performed to ensure that the penetrating ability of the x-ray beam is accurate, the result must be within what amount of the control panel setting?
- 2% of SID
 - 4%
 - 10%
 - 50%
75. The primary type of grid used in diagnostic imaging is:
- Crosshatch
 - Parallel
 - Rhombic
 - Focused
76. The portion of the image-intensifier tube that converts electron energy to visible light is the:
- Output phosphor
 - Photocathode
 - Input phosphor
 - Detector element
77. The portion of the image-intensifier tube that converts visible light to electrons is the:
- Output phosphor
 - Photocathode
 - Input phosphor
 - Anode
78. The input phosphor of the image-intensifier tube converts:
- Electron energy to x-ray energy
 - X-rays and heat to visible light
 - X-ray energy to visible light
 - X-ray energy to an electronic image
79. Total brightness gain achieved using an image intensifier equals:
- Flux gain times minification gain
 - Diameter of input phosphor times diameter of output phosphor

- c. Intensification factor—brightness without an image intensifier divided by brightness with an image intensifier
- d. Total light emitted at the photocathode
80. Single-phase, full-wave rectification produces:
- Direct current
 - Pulsating direct current
 - Pulsating direct current with 120 pulses per second
 - Pulsating direct current with 120 pulses per second and 100% ripple
81. Three-phase, 6-pulse full-wave rectification produces:
- Direct current with 13% ripple
 - Direct current with 4% ripple
 - Direct current with 100% ripple
 - Alternating current with 13% ripple
82. Three-phase, 12-pulse full-wave rectification produces:
- Direct current with 13% ripple
 - Direct current with 4% ripple
 - Direct current with 100% ripple
 - Alternating current with 13% ripple
83. The increase in average photon energy when using three-phase, 6-pulse equipment compared with single-phase equipment is:
- 1.35%
 - 41%
 - 1.41%
 - 35%
84. The increase in average photon energy when using three-phase, 12-pulse equipment compared with single-phase equipment is:
- 1.35%
 - 41%
 - 1.41%
 - 35%
85. Programs that deal with the safe and reliable operation of equipment and programs that address all aspects of the delivery of radiology services are called, respectively:
- Quality assurance and quality control
 - Total quality improvement
 - Quality control and quality assurance
 - Total quality management
86. An image intensifier's conversion factor is expressed as the ratio of:
- The flux gain to the minification gain
 - The luminance of the output phosphor to the exposure rate at the input phosphor
 - The exposure rate at the output phosphor to the exposure rate at the input phosphor
 - The size of the input phosphor to the size of the output phosphor
87. The collimator must be accurate to a level of:
- $\pm 4\%$ of SID
 - $\pm 5\%$ of SID
 - $\pm 2\%$ of SID
 - $\pm 10\%$ of SID
88. kVp must be accurate to within:
- 1 of the amount on the control panel setting
 - 5% of the control panel setting
 - 2% of SID
 - 10% of the control panel setting
89. Exposure linearity must be accurate to within:
- 4
 - 5%
 - 2% of SID
 - 10%
90. Exposure reproducibility must be accurate to within:
- 4
 - 5%
 - 2% of SID
 - 10%
91. Fluoroscopy exposure rate may not exceed:
- 10 mGy_a per minute
 - 100 mGy_a per minute
 - 5 mGy_a per minute
 - 1 mGy_a minute
92. The feature that automatically adjusts kVp and mA during fluoroscopy is called:
- AEC
 - ABC
 - DQE
 - SNR
93. The test that measures the accuracy of adjacent mA stations is:
- Exposure reproducibility
 - Spinning top test
 - Pinhole camera
 - Exposure linearity
94. The test that measures the accuracy of successive exposures is:
- Exposure reproducibility
 - Spinning top test
 - Pinhole camera
 - Exposure linearity
95. The accuracy of the timer must be within:
- 10% of the time chosen for exposures over 10 ms
 - 5% of the time chosen for exposures over 10 ms
 - 5% of the time chosen for exposures under 10 ms
 - 10% of the time chosen for exposures under 10 ms
96. Resolution of the television system may be measured using the following tool(s):
- Wire mesh test
 - Line pairs/millimeter resolution tool along with a kVp meter
 - Resolution test pattern
 - Resolution test pattern, wire mesh test, or line pairs/millimeter resolution tool
97. AECs may be tested using:
- Phantoms
 - Images of real patients
 - Analog meters
 - Fluoroscopic screens

98. The number of mAs used for analog fluoroscopy is:
- 300 to 500
 - 3 to 5
 - 10 to 12
 - 100 to 300
99. Marks on the focal track of the anode resulting from bombardment of electrons are called:
- Melts
 - Bullet marks
 - Pitting
 - Cracks
100. Effective quality control and quality assurance programs are required for accreditation by:
- The Joint Commission
 - Joint Review Committee on Education in Radiologic Technology
 - American Healthcare Radiology Administrators
 - American Registry of Radiologic Technologists

Review Questions for Digital Image Acquisition

- Receptor exposure may be defined as:
 - Amount of remnant radiation striking the image receptor
 - Dose area product
 - DQE
 - Differences in dark areas on a radiographic image
- The radiographic image is formed by:
 - Exit rays striking the image receptor
 - Laser light
 - Cosmic rays
 - Electrons and heat
- The primary controlling factors of receptor exposure are:
 - kVp and mAs
 - mAs and SID
 - SID and OID
 - SID, OID, FSS
- Which of the following describes the relationship between mAs and receptor exposure?
 - Receptor exposure is directly proportional to mAs
 - Receptor exposure is inversely proportional to mAs
 - Receptor exposure is directly proportional to mAs²
 - mAs controls the number of electrons boiled off the anode and the number of x-rays produced
- The number of electrons boiled off the cathode and consequently the number of x-rays produced are controlled by:
 - kVp
 - SID
 - mAs
 - OID
- Receptor exposure was formerly called:
 - Contrast
 - Detail
 - Density
 - Distortion
- The active portion(s) of a CR IP is (are):
 - ABC
 - PSP
 - DQE
 - SNR
- mAs directly control:
 - The energy of the x-ray emission spectrum
 - The quality and quantity of x-rays produced at the cathode
 - The quality and quantity of x-rays produced at the anode
 - The quantity of x-rays produced at the anode
- Visible differences in adjacent structures on a radiographic image describe:
 - Receptor exposure
 - Spatial resolution
 - Signal loss
 - Contrast resolution
- The primary controlling factor(s) of contrast is (are):
 - mAs, which control the energy of the x-rays produced
 - kVp, which primarily controls the quantity of x-rays produced at the target
 - Focal-spot size, which controls the quantity and quality of x-rays produced
 - kVp and bit depth
- The relationship between kVp and receptor exposure may be described as:
 - Directly proportional
 - Direct, although not proportional
 - Governed by the 15-50 rule
 - Controlled by x-ray tube current
- The 15% rule states that:
 - Receptor exposure may be halved by decreasing kVp by 15%
 - kVp should be 15% of the mAs selected
 - Receptor exposure may be halved by increasing kVp by 15%
 - At least a 15% change in mAs is required to make a change visible
- Choose all of the following statements that are accurate pertaining to the role of kVp in radiographic image production (choose 3):
 - As kVp is increased, penetrating ability of the x-rays increases
 - As kVp is increased, more x-rays exit the patient to strike the image receptor
 - As kVp is decreased, wavelength decreases
 - As kVp increases, receptor exposure increases
 - As kVp decreases, receptor exposure remains constant because mAs controls receptor exposure
- Given an original technique of 30 mAs and 80 kVp, which of the following would produce an image with double the receptor exposure?
 - 60 mAs, 90 kVp
 - 30 mAs, 92 kVp

- c. 15 mAs, 80 kVp
d. 30 mAs, 70 kVp
15. Which of the following governs the relationship between SID and receptor exposure?
a. Reciprocity law
b. 15% rule
c. Inverse square law
d. Ohm's law
16. If SID is doubled, what may be said about receptor exposure?
a. Receptor exposure doubles
b. Receptor exposure is reduced by one half
c. Receptor exposure is reduced by new mAs²
d. Receptor exposure is reduced to one fourth
17. If SID is reduced by one half, what must be done to mAs to maintain a constant receptor exposure?
a. Reduce mAs to one fourth its original value
b. Reduce mAs to one half its original value
c. Increase mAs by four times its original value
d. Increase mAs by two times its original value
18. Choose all factors below that result in poor spatial resolution (choose 4):
a. Long SID
b. Long OID
c. Large focal spot
d. Small focal spot
e. Patient motion
f. Magnification
19. In digital fluoroscopy, what equipment should be used to view the image?
a. Conventional view box
b. High-resolution monitor capable of displaying millions of pixels
c. High-definition television
d. Plasma television required
20. A primary advantage to digital fluoroscopy is:
a. Postprocessing manipulation of the image
b. Radiation dose to the patient is substantially lower
c. No radiologist is needed
d. Lower cost
21. Which of the following describes the relationship between receptor exposure and the use of grids?
a. Grids always reduce receptor exposure
b. Grids reduce receptor exposure unless mAs are increased to compensate
c. Grids reduce receptor exposure by only absorbing scatter radiation
d. Receptor exposure increases as grid ratio increases
22. The use of filtration:
a. Greatly reduces receptor exposure because of the absorption of short-wavelength x-rays
b. Greatly reduces radiographic receptor exposure because of the absorption of high-energy x-rays
c. Increases radiographic receptor exposure by removing long-wavelength x-rays
d. Has little effect on receptor exposure because x-rays removed from beam are not image-producing rays
23. As beam restriction increases (becomes tighter):
a. Receptor exposure increases
b. Receptor exposure increases as a result of focusing of x-rays
c. Receptor exposure decreases
d. Receptor exposure is not affected
24. Which of the following affects receptor exposure?
a. Atomic mass of the x-ray tube anode
b. X-ray tube angle
c. Atomic number of the cathode filament
25. The variation of x-ray intensity along the longitudinal axis of the x-ray beam describes:
a. Beam collimation
b. Positive beam limitation
c. Anode heel effect
d. X-ray emission spectrum
26. The thicker part of anatomy should be placed under which aspect of the x-ray tube?
a. Central ray
b. Cathode
c. Anode
d. Collimator
27. The function of contrast is to:
a. Make the image appear sharper
b. Compensate for uneven anatomic structures
c. Brighten the image
d. Make detail visible
28. A radiographic image with few gray tones, primarily exhibiting black and white, would be described as having what type of contrast?
1. Long scale
2. Short scale
3. Low
4. High
a. 2 and 4
b. 1 and 3
c. 1 and 4
d. 2
29. Lower spatial resolution may be caused by which of the following factors?
a. Short OID
b. Long SID
c. Small focal spot
d. Wide pixel pitch
30. Choose all that describe the outcome of using high kVp (choose 3):
a. High contrast
b. Few gray tones
c. Long-scale contrast
d. Short-scale contrast
e. Low contrast
f. Many gray tones
31. Choose all that describe the outcome of using low kVp (choose 3):
a. High contrast
b. Few gray tones
c. Long-scale contrast

- d. Short-scale contrast
e. Low contrast
f. Many gray tones
32. More uniform penetration of anatomic structures occurs when what level of kVp is used?
a. Low
b. High
c. kVp does not affect penetration
d. Level at which photoelectric interaction predominates
33. Differential absorption of the x-ray beam is a function of:
a. Compton interaction
b. Atomic mass of anatomic structures
c. mAs
d. Photoelectric interaction
34. What effect does beam restriction have on contrast?
a. Decreases contrast by focusing the x-ray beam
b. Decreases contrast because of higher kVp level used
c. Increases contrast by focusing the x-ray beam
d. Increases contrast because of reduction in the number of Compton interactions that occur
35. The adjustment in technical factors required when using beam restriction is:
a. Increase kVp
b. Decrease kVp to reduce the number of Compton interactions taking place
c. Decrease mAs to reduce the number of Compton interactions taking place
d. Increase mAs to compensate for the number of rays removed from the primary beam
36. What effect does the use of radiographic grids have on contrast?
a. Decreases contrast
b. Increases contrast
c. No effect on contrast
d. Increases contrast by absorbing scatter radiation
37. As the amount of beam filtration is increased:
a. Contrast increases
b. There is no effect on contrast
c. Contrast decreases
d. Contrast increases because the beam is harder
38. The portion of contrast that is caused by variations in the anatomy or that is secondary to pathologic changes is called:
a. Radiographic contrast
b. Anatomic contrast
c. Pathologic contrast
d. Subject contrast
39. Spatial resolution is:
a. Photographic representation of the part being radiographed
b. Controlled by kVp
c. Controlled by mAs
d. Geometric representation of the part being radiographed
40. Choose all that will result in higher spatial resolution (choose 3):
a. Long SID
b. Long OID
c. Short SID
d. Short OID
e. Large focal spot
f. Small focal spot
41. Optimal spatial resolution may be created using which of the following factors?
a. Large focal spot
b. Narrow pixel pitch
c. Long OID
d. Short SID
42. Improper use of grids may result in an image artifact known as:
a. SNR
b. Moiré pattern
c. Elongation
d. Foreshortening
43. Distortion may be described as:
a. Misrepresentation of an anatomic structure on the image
b. Foreshortening
c. Elongation
d. Magnification
44. Elongation and foreshortening are examples of:
a. Size distortion
b. Shape distortion
c. Motion
d. Distortion caused by short SID and long OID
45. Magnification is caused by:
1. Short SID
2. Long SID
3. Short OID
4. Long OID
a. 2, 3
b. 1, 4
c. 1, 3
d. 1 only
46. Distortion that occurs when the x-ray beam is angled against the long axis of a part is:
a. Elongation
b. Magnification
c. Minification
d. Foreshortening
47. Distortion that occurs when the x-ray beam is angled along the long axis of a part is:
a. Elongation
b. Magnification
c. Minification
d. Misrepresentation
48. The actual patient dose as measured by a meter embedded in the collimator is:
a. RAD—radiation absorbed dose
b. DAP—dose area product
c. REM—radiation equivalent man
d. Doubling dose

49. Quality assurance and maintenance of CR cassettes include cleaning and inspecting the plates at least:
 - a. Daily
 - b. Every 48 hours
 - c. Every 3 months
 - d. Weekly
50. Quality assurance and maintenance of CR cassettes include erasing plates at least:
 - a. Daily
 - b. Every 48 hours
 - c. Every 3 months
 - d. Weekly
51. Quality assurance of digital imaging requires the uniformity of processing codes to ensure:
 - a. Image appearance consistency
 - b. Faster throughput
 - c. Less heat loading on the anode
 - d. Smoother integration into PACS
52. A software function that evens the brightness displayed in the image is called:
 - a. Smoothing
 - b. Equalization
 - c. Postprocessing
 - d. Subtraction
53. Beam-part-receptor alignment latitude describes:
 - a. The latitude of collimation that still allows the software to detect collimated edges
 - b. The alignment that maintains ALARA requirements
 - c. Exposure latitude
 - d. Acceptable distortion of the image
54. To reduce patient dose, exposure technique in digital imaging should be adjusted by:
 - a. Lowering kVp
 - b. Increasing mAs
 - c. Shortening SID
 - d. Increasing kVp
55. Digital image receptors are more sensitive to:
 - a. Scatter and background radiation
 - b. Fluorescent lights
 - c. Free electrons
 - d. Free radicals
56. In digital radiography inappropriate collimation causes:
 - a. A fogged image
 - b. Pixel unresponsiveness
 - c. DICOM incompatibility
 - d. Histogram analysis error
57. The appearance of digital images on technologists' monitors is:
 - a. The same as on radiologists' monitors
 - b. Substantially better than on radiologists' monitors
 - c. Not as good as on radiologists' monitors
58. Digital imaging is driven by:
 - a. kVp
 - b. mAs
 - c. IR speed class
 - d. Exposure
59. Digital systems operate at what speed class?
 - a. 200
 - b. 400
 - c. 100
 - d. The speed class chosen by the radiographer
60. An artificial increase in display contrast at an edge of the image is:
 - a. Smoothing
 - b. Edge enhancement
 - c. Contrast resolution
 - d. Spatial resolution
61. As speed class increases:
 - a. The likelihood of noise increases
 - b. The likelihood of noise decreases
 - c. Patient exposure increases
 - d. Sharpness increases
62. As speed class decreases:
 - a. The likelihood of noise increases
 - b. Noise is unaffected
 - c. Patient exposure increases
 - d. Sharpness decreases
63. Smoothing software may result in:
 - a. Enhanced fine detail
 - b. Less distortion
 - c. Loss of fine detail
 - d. Increased distortion
64. Excessive processing of the digital image may:
 - a. Degrade visibility of anatomy
 - b. Provide additional anatomic information
 - c. Enhance visibility of desired anatomy
 - d. Increase patient dose
65. A high SNR provides an image with:
 - a. Poor spatial resolution
 - b. Higher spatial resolution
 - c. Poor contrast
 - d. Higher distortion
66. Quantum noise limits ability to see:
 - a. Detail
 - b. Contrast
 - c. Fatty tissue
 - d. Additive pathologies
67. If the exposure field is not accurately recognized, the histogram will contain data:
 - a. Outside the exposure field, narrowing the histogram
 - b. Inside the exposure field, widening the histogram
 - c. Outside the exposure field, widening the histogram
 - d. Inside the exposure field, narrowing the histogram
68. Grid ratio is defined as:
 - a. The ratio of the lead strips to the space between them
 - b. The thickness of the lead strips divided by the thickness of the aluminum interspacers
 - c. The ratio of the height of the lead strips over the distance between the lead strips
 - d. The ratio of the distance between the lead strips over the height of the lead strips

69. Grid frequency is defined as:
- The same as grid ratio
 - The amount of lead in the grid (expressed in terms of focusing distance)
 - How often a grid is used
 - The amount of lead in the grid (expressed as the number of lead strips per inch)
70. Choose all that are true concerning grids (choose 3):
- Contrast improvement factor is the measure of the ability of a grid to enhance contrast
 - Grid selectivity is the ratio of primary radiation transmitted through the grid to secondary radiation transmitted through the grid
 - Grids are used when part thickness is less than 10 cm
 - GCF is the amount of increase in kVp necessary when converting from nongrid to grid technique
 - The primary purpose of grids is radiation protection
 - The main function of grids is to prevent Compton scatter from reaching the IR
 - Grids prevent the production of scatter
71. A grid with lead strips and aluminum interspacers that are angled to coincide with the divergence of the x-ray beam is called a:
- Parallel grid
 - Focused grid
 - Crosshatch grid
 - Rhombic grid
72. The range of SIDs that may be used with a focused grid is called:
- Grid ratio
 - Objective plane
 - Anticutoff distances
 - Grid radius
73. The best scatter cleanup is achieved with the use of:
- Air gap technique
 - Focused grids
 - Crosshatch grids
 - Parallel grids
74. Grid cutoff may be described as:
- Decreased density in the middle of the radiograph caused by the use of a parallel grid inserted upside down
 - Decreased density on a radiograph as a result of absorption of image-forming rays
 - Increased density in the center of a radiograph caused by the use of a focused grid inserted upside down
 - Decreased density on the edges of a radiograph only
75. When a nongrid technique using 10 mAs and 75 kVp is changed to a 12:1 grid using 75 kVp, what new mAs must be used to create the same image?
- 50 mAs
 - 2 mAs
 - 40 mAs
 - 120 mAs
76. Use of the air gap technique:
- Works because x-rays are absorbed in the air between the patient and the film
 - Should occur when possible
 - May cause some magnification because of decreased OID
 - Works because scatter radiation travels in divergent paths and misses the IR as a result of increased OID
77. Use of technique charts:
- Is unnecessary for any exam because of AECs
 - Does not require that the part thickness be measured with calipers
 - Is usually based on fixed mAs and variable kVp
 - Is helpful when manual techniques are used
78. When AEC is used, increasing the kVp:
- increases the exposure time
 - increases the image contrast
 - decreases the exposure time
 - has no effect on image quality
79. The CR reader unit scans the IP with a(n):
- Infrared light
 - Laser
 - Sonar
 - Visible white light
80. Which of the following maintains image brightness over a wide range of exposures?
- AEC
 - Bit depth
 - Automatic rescaling
 - Detector size
81. The available gray scale of an imaging system is determined by:
- Pixel pitch
 - Bit depth
 - Exposure latitude
 - Image latitude
82. The smallest exposure change able to be captured by a detector is called:
- Spatial resolution
 - Exposure latitude
 - Pixel
 - Contrast resolution
83. An indicator of the dose level needed to acquire an optimal image is:
- Detective quantum efficiency
 - Dose area product
 - Field of view
 - Dynamic range
84. The useful image acquisition area of an image receptor is:
- Detector element
 - Detector size
 - TFT size
 - Dynamic range
85. The smallest resolvable area in a digital imaging device is:
- Detector size
 - Detector element

- c. Matrix size
d. Focal-spot size
86. What allows more anatomic structures to be captured during an exposure?
a. Contrast resolution
b. Spatial resolution
c. Dynamic range
d. MTF
87. The range of receptor exposures that provides a quality image is called:
a. Detector latitude
b. Exposure latitude
c. Histogram
d. Dynamic range
88. Which of the following is a graphical representation of pixel values?
a. Dynamic range
b. Luminance
c. Look-up table
d. Histogram
89. Undesirable fluctuations in brightness are called:
a. MTF
b. Image noise
c. Quantization
d. Scintillation
90. The number of pixels making up the digital image is the:
a. Pixel depth
b. Matrix size
c. Pixel pitch
d. Field of view
91. The expression of image quality provided by a detector is called:
a. MTF
b. Matrix size
c. SNR
d. Nyquist frequency
92. Which of the following terms describes the highest spatial frequency that can be recorded by a digital detector?
a. Spatial resolution
b. Contrast resolution
c. MTF
d. Nyquist frequency
93. What converts light into a charge?
a. Diode
b. Cathode
c. AC to DC converter
d. Photodiode
94. The smallest area represented in a digital image is the:
a. Image matrix
b. Pixel
c. Voxel
d. Bit
95. The number of pixels/mm in an image is called:
a. Pixel density
b. Bit depth
c. Pixel pitch
d. Matrix depth
96. The space from the center of a pixel to the center of the adjacent pixel is called:
a. Pixel density
b. Bit depth
c. Pixel pitch
d. Matrix depth
97. Mathematical codes used to generate the digital image are called:
a. Binary codes
b. Algorithms
c. Binary digits
d. Bytes
98. The process of assigning a value to each pixel to represent a gray tone is called:
a. Quantization
b. Scintillating
c. Nyquist frequency
d. Sampling
99. A material that absorbs x-ray energy and emits part of that energy as visible light is called:
a. Diode
b. Scintillator
c. TFT
d. Cathode
100. Bit depth is equal to:
a. 2^n (n equals the number of bits)
b. 4096 shades of gray
c. Pixel pitch
d. Bits times bytes

5

Procedures

BASIC PROCEDURES AND POSITIONING TERMINOLOGY

Anterior or ventral forward or front

Caudal inferior, away from the head

Central mid-area

Cranial cephalic, superior, toward the head

Distal farthest from the origin or point of reference

Lateral away from the median plane of the body or the middle of a part

Medial toward the median plane of the body or the middle of a part

Posterior dorsal; back of a part (not used to describe the foot)

Proximal nearer origin or point of reference

Dorsal recumbent supine, lying on back

Ventral recumbent prone, lying face down

Right lateral recumbent lying on right side

Left lateral recumbent lying on left side

Projection path of the central ray

Position placement of the body or part

View image as seen by the image receptor (opposite of projection)

Oblique body rotated from supine, prone, or lateral

Right anterior oblique (RAO) angle that places right anterior portion of the body closest to the image receptor

Left anterior oblique (LAO) angle that places left anterior portion of the body closest to the image receptor

Left posterior oblique (LPO) angle that places left posterior part of the body closest to the image receptor

Right posterior oblique (RPO) angle that places right posterior portion of the body closest to the image receptor

Decubitus position patient lying down; central ray parallel to the floor (horizontal)

Left or right lateral decubitus patient lying on left or right side; central ray parallel to the floor (horizontal); anteroposterior (AP) or posteroanterior (PA) projection

Dorsal decubitus patient lying on back; central ray parallel to the floor (horizontal); lateral projection

Ventral decubitus patient lying on abdomen; central ray parallel to the floor (horizontal); lateral projection

Tangential central ray skims between body parts or skims body surface; shows profile of body part, free of superimposition

Axial longitudinal angulation of the central ray with the long axis of the body part; projection that refers to images obtained with central ray angled 10 degrees or more along long axis of part

Orbitomeatal line (OML) line from outer canthus of the eye to the auricular point; also called the radiographic baseline

Infraorbitomeatal line (IOML) line from just below the eye to the auricular point; also called Reid's baseline

Glabellomeatal line line from the glabella to the auricular point

Acanthiomeatal line (AML) line from the acanthion to the auricular point

Median sagittal plane (MSP) plane that passes vertically through the midline of the body from front to back; also called midsagittal plane

Sagittal plane any plane parallel to the MSP

Midcoronal plane plane that passes vertically through midaxillary region of the body and coronal suture of the cranium at right angles to the MSP

Coronal plane any plane passing vertically through the body from side to side

Transverse plane passes crosswise through the body at right angles to its longitudinal axis and the MSP and coronal planes; also called axial plane

Related Medical Terminology: Prefixes, Roots, and Suffixes

Prefixes

a-, an- without
ab- away from
ante- front
anti- against
bi- two
co- together
contra- against
decub- side
dors- back
dys- difficult
ect- outside
en- in
endo- within
epi- on
ex- out
hemi- half
hydro- water
hyper- above or greater
hypo- below or lesser
infero- below
mega- large
peri- around
poly- many
post- after
pre- before
pseudo- false
retro- backward

scler- hard
sub- below
super- above
trans- across
vent- front

Roots

angio vessel
arth joint
cardi heart
cephal brain
cerebro head
cerv neck
chole bile
chondr cartilage
cost rib
crani skull
cysto bladder
derm skin
encephal brain
enter intestine
gastr stomach
hem blood
hepat liver
leuk white
lith stone
nephr kidney
osteo bone

phren diaphragm
pneum air
pyel pelvis (renal)
viscer organ

Suffixes

-algia pain
-centesis puncture
-ectasis expansion
-ectomy excision
-emia blood
-genic origin
-iasis condition
-itis inflammation
-megaly enlargement
-myel spinal cord
-oid like
-oma tumor
-osis condition
-pathy disease
-plasty surgical correction
-pulm lung
-pyel pelvis (renal)
-rhaphy suture
-scopy inspection
-tomy incision

KEY REVIEW POINTS

Basic Procedures and Positioning Terminology

- Be able to define and understand the use of each of the terms presented.
- Be able to contrast the various recumbent, oblique, and decubitus positions.
- Locate and understand the use of the various body lines and planes.

Basic Principles of Positioning and Procedures*

- A. Body part placement
1. Body part should be placed on the image receptor in a position that allows for imaging of all anatomic features required for the procedure
 2. Allows for tight collimation

*Positioning routines vary from text to text and from department to department. The following is a general review of common routines. Questions on the certification exam could include any of these routines or combinations and variations of specific positions.

- B. *Alignment*: The long axis of the body part should correspond to the long axis of the image receptor except when the image receptor must be rotated to fit the entire part on the image receptor
- C. Precise visualization
1. Positioning must be absolutely accurate
 2. No rotation of image present
- D. Patient identification
1. Identification marker on image receptor should not obstruct view of relevant anatomy
 2. Patient information should include patient's name and date of exam
- E. Anatomic markers
1. Right or left markers must always appear on the image; use a radiopaque marker placed on the image receptor
 2. Radiopaque markers must be placed just inside the collimation field and should not obstruct relevant anatomy
- F. Other markers
1. *Time*: Time indicators should always be used when images are taken at specifically timed intervals
 2. *Direction*: If the image was taken with the patient in an erect position, the lead marker indicating *erect* or *upright* must appear on the image

3. *Inspiration/expiration*: Must be used for comparison studies of the chest
 4. *Internal/external*: Must be used when both forms of rotation constitute part of an exam
 5. *Numeric markers*: Must be used when taking a series of images in sequence (e.g., during trauma or surgical cases when follow-up is required in a short time)
- G. Routines
1. Minimum of two projections per exam except for certain cases in which a single survey image suffices (e.g., KUB)
 2. A minimum of two projections, 90 degrees from one another, must always be taken
 - a. Superimposition of structures may prevent visualization of some pathologic conditions
 - b. Lesions or foreign bodies require precise localization
 - c. Fractures must be seen from two points precisely 90 degrees from each other
 - d. Minimum of three projections (AP or PA, lateral, and oblique) required for proper visualization of joints
- c. 8-degree angle with glabellomeatal line
 - d. Also called the *radiographic baseline*
2. Infraorbitomeatal line (also called *Reid's baseline*)
 - a. Line from just below the eye to the auricular point
 - b. 7-degree angle with OML
 3. Glabellomeatal line
 - a. Line from the glabella to the auricular point
 - b. 8-degree angle with OML
 4. Acanthiomeatal line (AML)
 - a. Line from the acanthion to the auricular point

KEY REVIEW POINTS

Basic Principles of Positioning and Procedures

These are basic points you learned early in positioning class. They are simple concepts that may be used as straightforward questions or to form the basis of more complex questions. Master them.

Topography

- A. Cervical region
 1. *C1*: Mastoid tip
 2. *C2, C3*: Gonion
 3. *C5*: Thyroid cartilage
 4. *C7*: Vertebra prominens
- B. Thoracic region
 1. *T1*: 2 inches above sternal notch
 2. *T2, T3*: Level of manubrial notch and superior margin of scapula
 3. *T4, T5*: Level of sternal angle
 4. *T7*: Level of inferior angle of scapula
 5. *T10*: Level of xiphoid tip
- C. Lumbar region
 1. *L3*: Costal margin
 2. *L3, L4*: Level of umbilicus
 3. *L4*: Level of superiormost aspect of iliac crest
- D. Sacrum and pelvic region
 1. *S1*: Level of anterior superior iliac spine (ASIS)
 2. *Coccyx*: Level of pubic symphysis and greater trochanters
- E. Lines
 1. Orbitomeatal line (OML)
 - a. Line from outer canthus of the eye to the auricular point
 - b. 7-degree angle with infraorbitomeatal line (IOML)

KEY REVIEW POINTS

Topography

Positioning in the clinical setting and answering test questions on the certification exam are predicated on your knowledge of topography. Be certain you can identify these baselines.

Motion Control

- A. Involuntary motion (controlled with short exposure time and high-speed image receptor)
 1. Cardiac motion
 2. Peristalsis
 3. Muscular spasm
 4. Chills
 5. Pain
- B. Voluntary motion
 1. Belligerence
 2. Excitement
 3. Fear
 4. Nervousness
 5. Painful discomfort
 6. Age (children, elderly)
 7. Controlled by use of the following:
 - a. Clear communications
 - b. Sandbags
 - c. Sponges
 - d. Tape
 - e. Short exposure time
 - f. Patient comfort
 - g. Compression bands
 - h. Pediatric immobilizer (e.g., Pigg-O-Stat, for infants)
 - i. Sheets for mummification techniques (for children)
 - j. Instructions—clearly explain the exam to the patient
 - k. Obtain signature on consent form if required
 - l. Ask patient if he or she has any questions, ensuring informed consent
 - m. Describe exam in terminology the patient understands

- n. Describe exactly what will be done to the patient, including the approximate number of images to be taken and the duration of the exam
- o. Explain the reasons for removal of clothing and the extent of gowning
- p. Explain the reason for removal of all radiopaque objects in the area of interest
- q. Describe the required breathing pattern and the reasons for its use

KEY REVIEW POINTS

Motion Control

Be sure you can compare and contrast involuntary with voluntary motion. Understand all the factors that control each.

Exposure Modification

- A. Use of optimal radiographic technique ensures proper visualization of body parts
- B. Exposure technique may require modification because of some factors
 1. Pathologic conditions
 2. Age
 3. Conditions under which the images are being taken (e.g., mobile radiography, cross-table projections)
 4. Body habitus

KEY REVIEW POINTS

Exposure Modification

By using this knowledge and the information in [Chapter 4](#), you should be able to identify the various factors that affect exposure technique. Have a working knowledge of the changes needed and how to perform them.

Gonadal Shielding

- A. Used when gonads are within the primary beam or within 5 cm of the primary beam
- B. Used if the shielding does not interfere with the purpose of the exam
- C. Used on patients of reproductive age and younger

KEY REVIEW POINTS

Gonadal Shielding

Understand the process of gonadal shielding and its role in radiation protection. Review the material in [Chapter 3](#).

Body Habitus

- A. Hypersthenic
 1. Massive build
 2. Represents 5% of population
 3. Thorax is broad and deep
 4. Ribs are almost horizontal
 5. Thoracic cavity is shallow
 6. Lungs are short; narrow above and broad at the base
 7. Heart is short and wide
 8. Diaphragm is high
 9. Upper abdominal cavity is broad; lower part is small
 10. Stomach and gallbladder are high and horizontal
 11. Colon is high
- B. Sthenic
 1. Slight modification of hypersthenic
 2. Most common body habitus
 3. Present in 50% of population
- C. Hyposthenic
 1. Between asthenic and sthenic
 2. Present in 35% of population
- D. Asthenic
 1. Slender build
 2. Present in 10% of population
 3. Thorax is narrow and shallow
 4. Ribs slope sharply downward
 5. Thoracic cavity is long
 6. Lungs are long, broader above than at the base
 7. Heart is long and narrow
 8. Diaphragm is low, and abdominal cavity is short
 9. Stomach and gallbladder are low, vertical, and near the midline
 10. Colon is low, at median position

KEY REVIEW POINTS

Body Habitus

Every patient is unique, but each fits into a certain category. Be able to identify each body habitus and the anatomy of each.

Pediatric Radiography: General Principles

- A. Appropriately introduce radiographer to child and parent
- B. Radiographer should show a positive attitude toward the child
- C. Maintain clear communication with child and parent
- D. Determine extent of parental involvement
- E. Report suspected child abuse (nonaccidental trauma) to the appropriate radiologist, attending physician, radiology supervisor, or nurse
- F. Determine type of immobilization to be used for the exam
 1. Immobilization board
 2. Pediatric immobilizer (e.g., Pigg-O-Stat)
 3. Sandbags

4. Tape
 5. Compression bands
 6. Sheets and towels
- G. Practice *as low as reasonably achievable* (ALARA) principle
1. Gonadal shielding of children
 2. Tight collimation
 3. Pieces of lead used as contact shields
 4. Low mAs techniques
 5. No repeat images
- H. Determine whether patient preparation was adequately carried out
- I. Interview the parent and write down the appropriate history
- J. Briefly discuss case with radiologist to determine specifically which projections are needed and the extent of gonadal shielding that should be used if this is in doubt

KEY REVIEW POINTS

Pediatric Radiography: General Principles

Pediatric radiography requires specific skills, attention to detail, and attention to radiation protection. Be aware of all of the points in this section.

Trauma: General Principles

- A. Do no additional harm to the patient
- B. Work quickly and confidently, observing standard precautions
- C. Be prepared to modify conventional positions in response to patient's condition
- D. If patient is immobilized, transfer the patient to the x-ray table with as much assistance as possible.
- E. Skull and cervical spine injuries
 1. Cross-table lateral cervical spine image must be obtained before the patient is moved in any way
 2. Image must be approved by a physician before patient is moved or a cervical collar or sandbags are removed
- F. Each body part requires at least two images taken at 90-degree angles to one another
- G. Projections should approach routine positioning (as patient's condition permits), with the image receptor placed as close to the body part as possible
- H. Central ray entrance and exit points should be as close to routine as possible
- I. Long bone radiography
 1. Always include joint nearest the trauma
 2. Joint farthest from the trauma should also be included if possible; otherwise, separate images should be taken of that joint
- J. Splints or bandages
 1. Should not be removed unless permission has been obtained from the physician
 2. Modification of exposure technique may be necessary to compensate for splints and bandages
- K. Allow patient as much control over movement as possible
- L. Whether patient is conscious or unconscious, explain your movements clearly to encourage possible cooperation
- M. Be prepared to perform several exams at once
 1. *Example:* All AP projections should be taken in an uninterrupted sequence, then all lateral projections, and so on
 2. Reduces the number of times the patient or x-ray tube must be moved
 3. Allows overall procedure to be completed more quickly
- N. Provide lead aprons for anyone who may need to be in the room caring for a critically injured patient
- O. Move patient's extremities carefully to avoid displacing fractures further or causing internal hemorrhage
- P. Maintain a cooperative spirit
 1. Cooperate with other health care professionals, such as phlebotomists, respiratory therapists, physicians, and nurses, who may need to be caring for the patient simultaneously during the radiographic exam in cases of severe trauma
 2. The radiographer is a vital part of a trauma team and needs to work in harmony with the other health care professionals present for the proper care of the patient
- Q. Inability of the patient to move and difficulty obtaining routine projections must never be used as an excuse to submit poor-quality images
 1. Patients with severe trauma need fully diagnostic images to receive optimal care
 2. The radiographer must be proficient in radiographic exposure and positioning so that high-quality images may be obtained under difficult conditions

KEY REVIEW POINTS

Trauma: General Principles

Trauma radiography requires fast, accurate work on the part of the radiographer. Be sure you understand each concept presented in this section.

Review of Anatomy Relevant to Radiography

Planes of the Body

- A. Median sagittal plane (MSP); also called *midsagittal plane*
 1. Passes vertically through the midline of the body from front to back
 2. Divides body into equal right and left portions
 3. Any plane parallel to MSP is called a *sagittal plane*
- B. Midcoronal plane
 1. Passes vertically through the midaxillary region of the body and the coronal suture of the cranium at right angles to the MSP

2. Divides body into anterior and posterior portions
 3. Any plane passing vertically through the body from side to side is called a *coronal plane*
- C. Transverse plane (axial plane)
1. Passes crosswise through the body at right angles to its longitudinal axis and the MSP and coronal planes
 2. Divides body into superior and inferior portions

Clinical Divisions of the Abdomen

- A. Divided into four quadrants by a transverse plane and MSP intersecting at the umbilicus
- B. Quadrants
1. Right upper quadrant
 2. Right lower quadrant
 3. Left upper quadrant
 4. Left lower quadrant

Anatomic Divisions of the Abdomen

- A. Abdomen is divided into nine regions using four planes
1. Two transverse planes
 2. Two sagittal planes
- B. Planes are called *Addison's planes*
- C. Transverse planes are drawn
1. At the levels of the tip of the ninth costal cartilage
 2. At the superior margin of the iliac crest
- D. Two sagittal planes are drawn
1. Each midway between ASIS of the pelvis and MSP of the body
- E. Nine regions of the body
1. Superior
 - a. Right hypochondrium
 - b. Epigastrium
 - c. Left hypochondrium
 2. Middle
 - a. Right lumbar
 - b. Umbilical
 - c. Left lumbar
 3. Inferior
 - a. Right iliac
 - b. Hypogastrum
 - c. Left iliac

Skeletal System

Functions

- A. Provides rigid support system
- B. Protects delicate structures
- C. Bones supply calcium to the blood and are involved in formation of blood cells
- D. Bones provide attachment of muscles and form levers in the joint spaces, allowing movement

Ossification

- A. Cartilage is covered with perichondrium that is converted to periosteum
- B. *Diaphysis*: Central shaft

- C. *Epiphysis*: Located at both ends of the diaphysis
- D. Growth in bone length is provided by the metaphyseal plate, located between the epiphyseal cartilage and the diaphysis
- E. An osseous matrix is formed in the cartilage
- F. Bone appears at the site where cartilage existed
- G. Ossification is completed as the proximal epiphysis joins with the diaphysis between 20 and 25 years of age

Marrow

- A. Fills spaces of spongy bone
- B. Contains blood vessels and blood cells in various stages of development
- C. Red bone marrow
1. Site of formation of red blood cells and some white blood cells
 2. Found in spongy bone of adults
 - a. Sternum
 - b. Ribs
 - c. Vertebrae
 - d. Proximal epiphysis of long bones
- D. Yellow bone marrow
- E. *Fatty marrow*: Replaces red bone marrow in adults except in areas previously mentioned

Types of Bones

- A. Long bones (e.g., femur, humerus)
- B. Short bones (e.g., wrist, ankle bones)
- C. Flat bones (e.g., ribs, scapulae)
- D. Irregular bones (e.g., vertebrae, sesamoids [patella])

Descriptive Terminology for Bones

- A. Projections
1. *Process*: Prominence
 2. *Spine*: Sharp prominence
 3. *Tubercle*: Rounded projection
 4. *Tuberosity*: Larger rounded projection
 5. *Trochanter*: Very large bony prominence
 6. *Crest*: Ridge
 7. *Condyle*: Round process of an articulating bone
 8. *Head*: Enlargement at end of bone
- B. Depressions
1. *Fossa*: Pit
 2. *Groove*: Furrow
 3. *Sulcus*: Synonymous with groove
 4. *Sinus*: Cavity within a bone
 5. *Foramen*: Opening
 6. *Meatus*: Tubelike

Division of the Skeleton

- A. Axial skeleton
1. Composed of 74 bones
 2. Upright axis of the skeleton
 3. Components
 - a. Skull
 - b. Hyoid bone
 - c. Vertebral column

- d. Sternum
- e. Ribs
- B. Appendicular skeleton
 1. Composed of 126 bones
 2. Bones attached to the axial skeleton
 - a. Upper and lower extremities
 - b. Auditory ossicles—6 bones

Articulations

- A. Classification basis
 1. Structure
 2. Composition
 3. Mobility
- B. Fibrous joints (synarthroses)
 1. Surfaces of bones almost in direct contact, with limited movement
 2. Generally immovable
 3. No joint cavity or capsule
 4. *Examples:* Skull sutures
- C. Cartilaginous joints (amphiarthroses)
 1. No joint cavity; contiguous bones united by cartilage and ligaments
 2. Slightly movable
 3. *Examples:* Intervertebral disks, pubic symphysis
- D. Synovial joints (diarthroses)
 1. Approximating bone surfaces covered with cartilage
 2. Freely movable
 3. Bones held together by a fibrous capsule lined with synovial membrane and ligaments
 4. Examples of movement
 - a. *Hinge:* Permits motion in one plane only (e.g., elbow)
 - b. *Pivot:* Permits rotary movement in which a ring rotates around a central axis (e.g., proximal radioulnar articulation)
 - c. *Saddle:* Opposing surfaces are concavo-convex, allowing flexion, extension, adduction, and abduction (e.g., carpometacarpal joint of thumb)
 - d. *Ball and socket:* Capable of movement in an infinite number of axes; rounded head of one bone moves in a cuplike cavity of the approximating base (e.g., hip)
 - e. *Gliding:* Articulation of contiguous bones allows only gliding movements (e.g., wrist, ankle)
 - f. *Condylloid:* Permits movement in two directions at right angles to one another; circumduction occurs, rotation does not (e.g., radiocarpal joints)
- E. Bursae
 1. Sacs filled with synovial fluid; located where tendons or muscles slide over underlying parts
 2. Some bursae communicate with a joint cavity
 3. Prominent bursae found at the elbow, shoulder, hip, and knee
- F. Movements
 1. Gliding
 - a. Simplest kind of motion in a joint
 - b. Motion of a joint that does not involve any angular or rotary movements

2. *Flexion:* Decreases angle formed by the union of two bones
3. *Extension:* Increases the angle formed by the union of two bones
4. *Abduction:* Occurs by moving part of the appendicular skeleton away from the median plane of the body
5. *Adduction:* Occurs by moving part of the appendicular skeleton toward the median plane of the body
6. Circumduction
 - a. Occurs in ball-and-socket joints
 - b. Circumscribes the conic space of one bone by the other bone
7. *Rotation:* Turning on an axis without being displaced from that axis

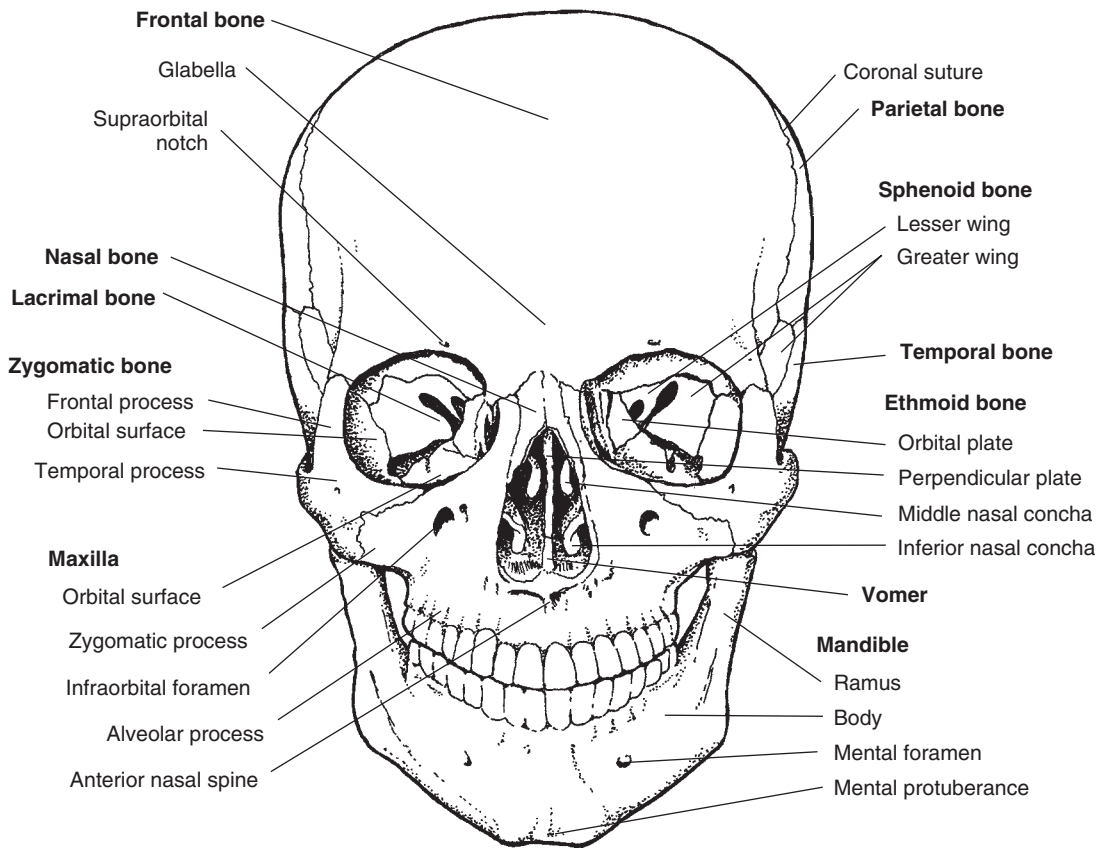
Skull Morphology

- A. Mesocephalic skull
 1. Considered “typical” skull
 2. Petrous ridge forms 47-degree angle with MSP
- B. Brachycephalic skull
 1. Petrous ridge forms 54-degree angle with MSP
 2. Short from front to back
 3. Broad from side to side
 4. Shallow from vertex to base
- C. Dolichocephalic
 1. Petrous ridge forms 40-degree angle with MSP
 2. Long from front to back
 3. Narrow from side to side
 4. Deep from vertex to base

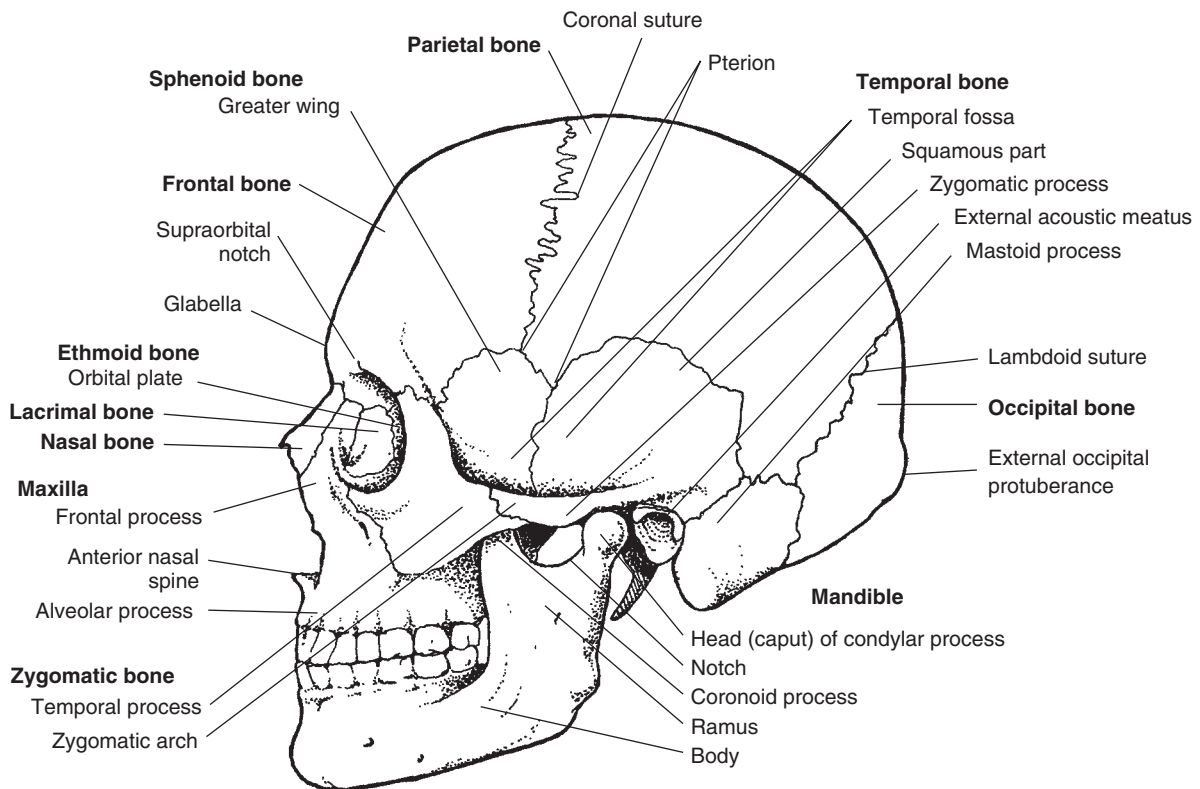
Axial Skeleton

Skull

- A. Cranium (Figures 5-1 and 5-2)
 1. Superior portion formed by frontal parietal and occipital bones
 2. Lateral portions formed by temporal and sphenoid bones
 3. Cranial base formed by temporal, sphenoid, and ethmoid bones
 4. *Fontanelles:* Soft spots at birth in which ossification is incomplete
- B. Frontal bone
 1. Forms the forehead
 2. Contains the frontal sinuses
 3. Forms the roof of the orbits
 4. Union with the parietal bones forms the coronal suture
- C. Parietal bones
 1. Union with occipital bone forms the lambdoid suture
 2. Union with temporal bone forms the squamous suture
 3. Union with sphenoid bone forms the coronal suture
- D. Temporal bones
 1. Contain the external auditory meatus and middle and inner ear structures
 2. *Squamous portion:* Above the meatus; zygomatic process articulates with the zygoma to form the zygomatic arch



• **Figure 5-1** Skull (anterior view).

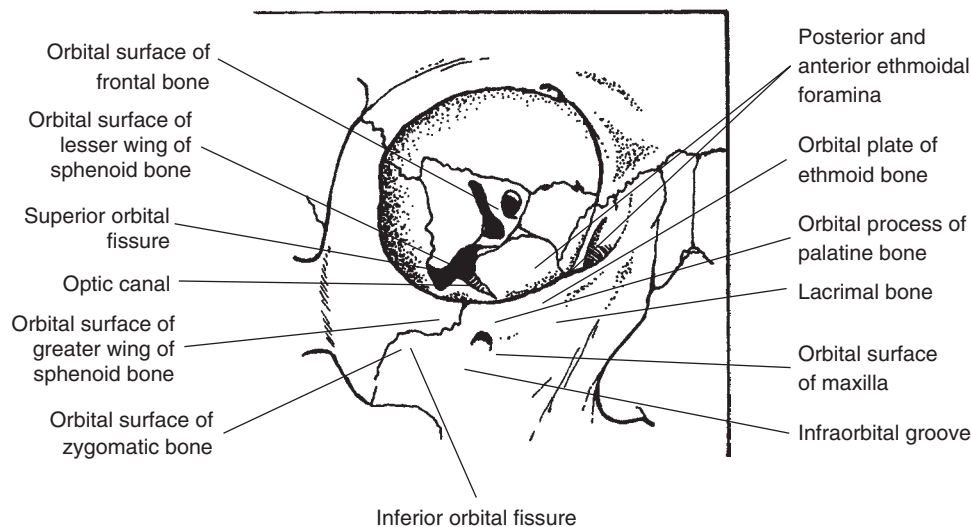


• **Figure 5-2** Skull (lateral view).

3. Petrous portion
 - a. Contains organs used for hearing and equilibrium
 - b. Prominent elevation on the floor of the cranium
 4. Mastoid portion
 - a. Protuberance behind the ear
 - b. Mastoid process
 5. *Mandibular fossa*: Articulates with the condyle on the mandible
 6. *Styloid process*: Anterior to the mastoid process; several neck muscles attach here
 7. *Jugular foramen*: Located between the petrous portion and the occipital bones; opening from which CN (cranial nerve) IX, CN X, and CN XI exit
- E. Sphenoid bone
1. Bounded by the ethmoid and frontal bones anteriorly and by the temporal and occipital bones posteriorly
 2. *Greater wings*: Lateral projections (Figure 5-3)
 - a. Form outer wall and floor of the orbits
 - b. *Foramen rotundum*: Round; located horizontally in anteromedial portion of the greater wing, adjacent to lateral wall of the sphenoid sinus; maxillary division of CN V exits
 - c. *Foramen ovale*: Oval; located laterally and posteriorly to foramen rotundum; mandibular division of CN V exits
 - d. *Foramen spinosum*: Located near posterior angle of the greater wing; lateral and posterior to foramen ovale; transmits an artery to the meninges
 - e. *Foramen lacerum*: Contains internal carotid artery
 - f. *Superior orbital fissure*: Transmits CN III and CN IV and part of CN V
 3. Lesser wings
 - a. Posterior part of the roof of the orbits
 - b. *Optic foramen*: CN II exits
 4. Body
 - a. *Sella turcica*: Holds the pituitary gland (hypophysis)
 - b. Contains the sphenoid sinuses
 - c. Medial and lateral pterygoid processes located here
- F. Ethmoid bone
1. Contributes to formation of the base of the cranium, orbits, and roof of the nose
 2. *Perpendicular plate*: Forms superior part of the nasal septum
 3. Horizontal plate (cribriform plate)
 - a. Located at right angles to perpendicular plate
 - b. Olfactory nerves pass through
 - c. Contains the crista galli; meninges of the brain attached to this process
 4. Lateral masses
 - a. Form the orbital plates
 - b. Contain superior and middle conchae (lateral walls of the nose)
 - c. Contain ethmoid sinuses
- G. Occipital bone
1. Forms the posterior part of the cranium
 2. *Foramen magnum*: Spinal cord enters to attach to brainstem
 3. Condyles (two)
 - a. On both sides of the foramen magnum
 - b. Articulate with depressions on C1 vertebrae
 4. *External occipital protuberance*: Located on the posterior surface

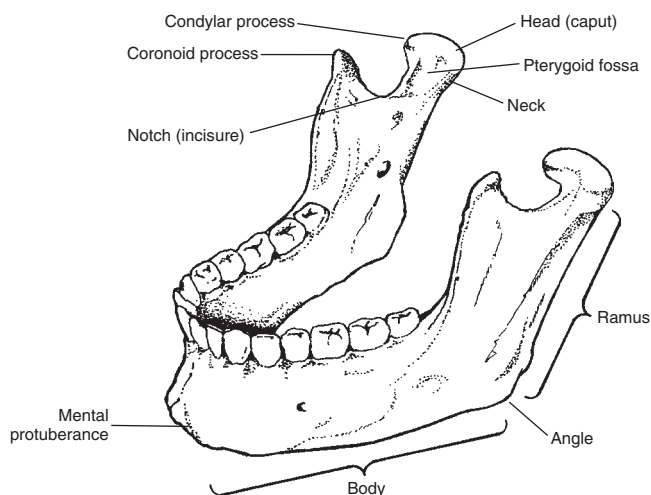
Facial Bones

- A. Appear suspended from middle and anterior parts of the cranium
- B. Ethmoid and frontal bones also contribute to the framework of the face
- C. Maxilla
 1. All facial bones except the mandible touch the maxilla
 2. *Alveolar process*: Forms upper jaw containing the maxillary teeth



• **Figure 5-3** Right orbit.

3. Forms the floor of the orbits; infraorbital foramen is inferior from the orbit
 4. Forms the walls of the nasal cavities and the hard palate (palatine process)
 5. *Maxillary sinus*: Large air space
- D. Mandible (Figure 5-4)
1. *Body*: Central horizontal portion
 - a. *Chin*: Symphysis in midline
 - b. *Alveolar process*: Contains the mandibular teeth
 - c. Mental foramen
 - (1) Below the first bicuspid on the outer surface
 - (2) Transmits nerves and blood vessels
 2. *Ramus*: Upward process on both sides of the posterior body of the mandible
 - a. *Condyle*: Articulates with the mandibular fossa
 - b. *Coronoid process*: Attachment site for the temporalis muscle
 - c. *Mandibular foramen*: Located on the inner surface
- E. Zygomatic bone
1. *Prominence of cheek*: Attaches to zygomatic process of the temporal bone to form the zygomatic arch
 2. Other margin of the orbit
- F. *Lacrimal*: Medial part of the wall of the orbit
- G. *Nasal bones*: Upper bridge of the nose
- H. Inferior nasal concha
1. Horizontally placed along the lateral wall of the nasal fossa
 2. Inferior to the middle and superior conchae of the ethmoid
- I. Palatine bones
1. Horizontal plates form the posterior part of the hard palate
 2. Perpendicular plates form the sphenoid palatine foramen
- J. Vomer
1. Plowshare-shaped bone
 2. Forms the lower part of the nasal septum



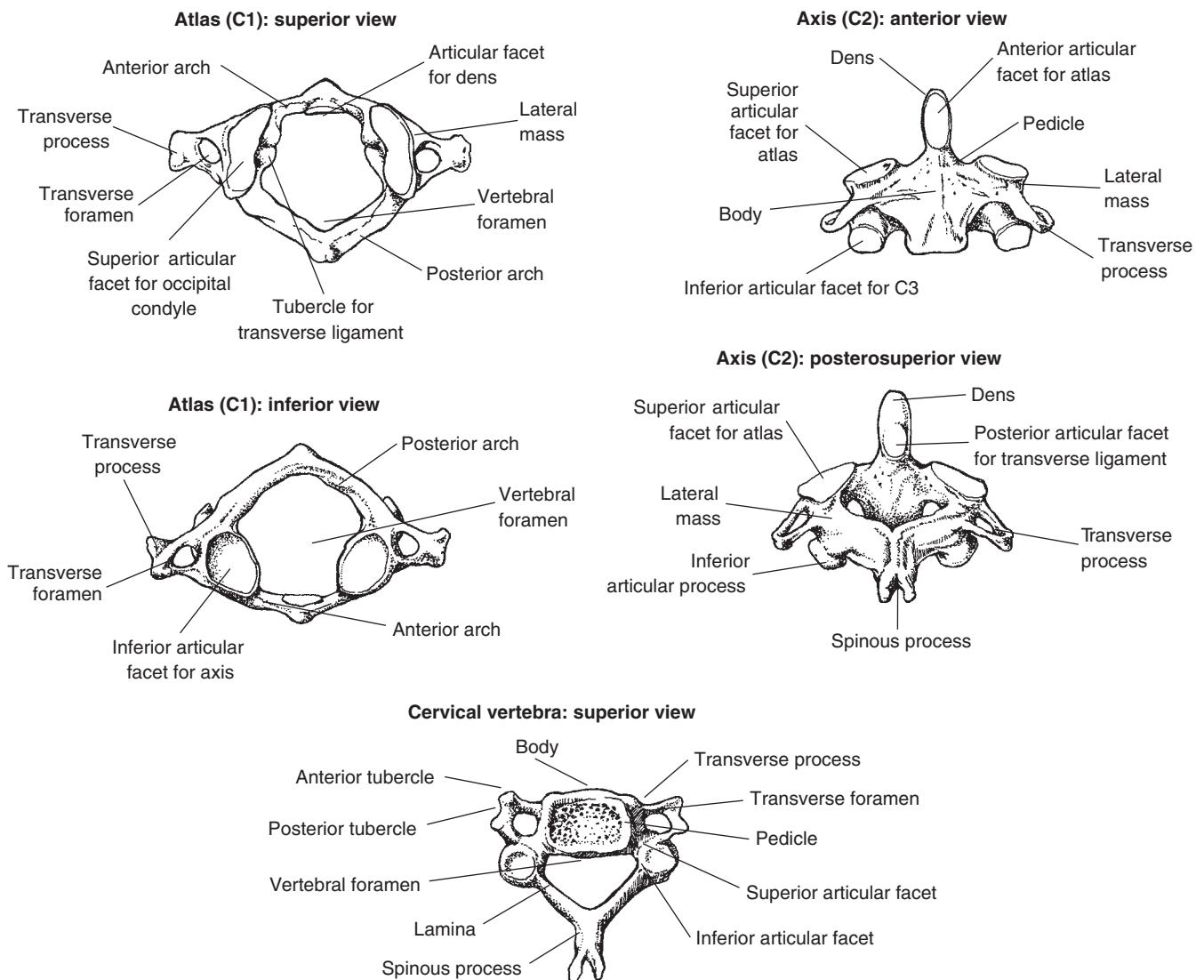
• Figure 5-4 Mandible (anterolateral superior view).

- K. Hyoid
1. U-shaped bone
 2. Body
 3. Greater horn
 4. Lesser horn
 5. Suspended by ligaments from the styloid process

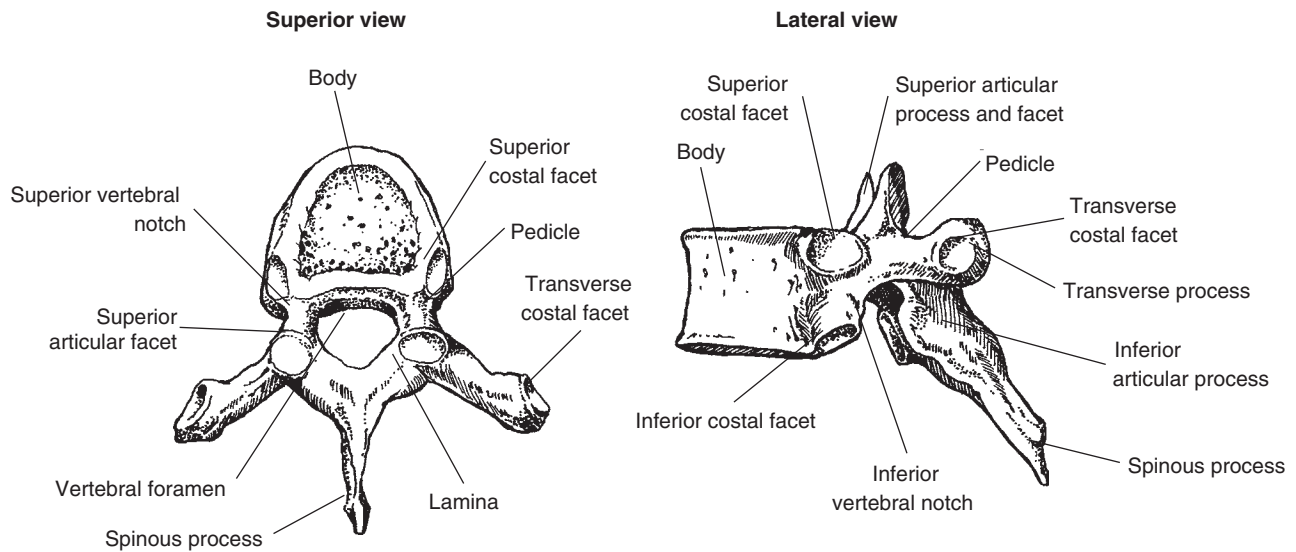
Vertebral Column

- A. Part of the axial skeleton
1. Supports the head
 2. Gives base to the ribs
 3. Encloses the spinal cord
- B. Vertebrae
1. Consist of 34 bones that make up the spinal column
 - a. *Cervical*: 7 bones
 - b. *Thoracic*: 12 bones
 - c. *Lumbar*: 5 bones
 - d. *Sacral*: 5 bones
 - e. *Coccygeal*: 4 or 5 bones
 2. In adults, the vertebrae of the sacral and coccygeal regions are united into two bones, the sacrum and the coccyx
- C. *Curvatures*: From a lateral view, there are four curves, alternately convex and concave ventrally
1. The two convex curves are the cervical and lumbar
 2. The two concave curves are the thoracic and sacral
- D. Vertebral morphology
1. Each vertebra differs in size and shape but has similar components
 2. *Body*: Central mass of bone
 - a. Weight bearing
 - b. Forms anterior part of vertebrae
 3. *Pedicles of the arch*: Two thick columns that extend backward from the body to meet the laminae of the neural arch
 4. *Processes*: Seven (one spinous [except C1], two transverse, two superior articular, and two inferior articular)
 - a. Spinous process extends backward from the point of the union of the two laminae
 - b. Transverse processes project laterally on both sides from the junction of the laminae and the pedicle
 - c. Articular processes arise near the junction of the pedicle and the laminae; superior processes project upward, inferior processes project downward
 - d. Surfaces of the processes are smooth
 - e. Inferior articular processes of the vertebrae fit into the superior articular processes below
 - f. Form true joints, but the contacts established serve to restrict movement
- E. Distinguishing features
1. *Cervical region*: Triangular shape
 - a. All have foramina in the transverse processes (upper six transmit the vertebral artery)
 - b. Spinous processes are short
 - (1) C3 to C5 are bifurcated
 - (2) C7 is a long prominence felt at the back of the neck

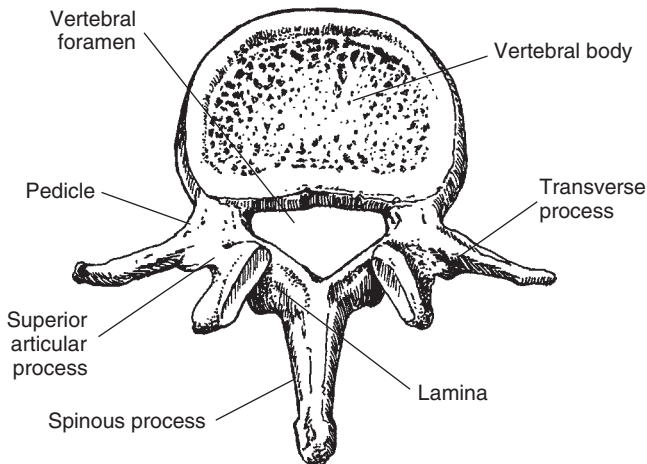
- c. Have small bodies (except for C1 vertebra)
 - d. C1 vertebra (atlas) (Figure 5-5)
 - (1) No body
 - (2) Anterior and posterior arches and two lateral masses
 - (3) Superior articular processes join with the condyles of the occipital bone
 - e. C2 vertebra (axis): Process on the upper surface of the body (dens or odontoid); forms a pivot about which the axis rotates
2. Thoracic region (Figure 5-6)
 - a. Presence of facets for articulation with the ribs
 - b. Processes are larger and heavier than processes of the cervical region
 - c. Spinous process is projected downward at a sharp angle
 - d. Circular vertebral foramen
 3. Lumbar region (Figure 5-7)
 - a. Large and heavy bodies
 - b. Four transverse lines separate the bodies of the vertebrae on the pelvic surface
 - c. Triangular shape: Fitted between the halves of the pelvis
 - d. Four pairs of dorsal sacral foramina communicate with four pairs of pelvic sacral foramina
 4. Sacral vertebrae
 - a. Formed by fusion of five sacral segments in curved, triangular bone
 - b. Base directed obliquely, superiorly, and anteriorly
 - c. Apex directed posteriorly and inferiorly
 - d. Longer, narrower, and more vertical in males than in females
 - e. Body of sacrum has sacral promontory, a prominent ridge at the upper anterior margin



• **Figure 5-5** Distinguishing features of cervical vertebrae.



• **Figure 5-6** Thoracic vertebra.



• **Figure 5-7** Lumbar vertebra (superior view).

5. Coccygeal vertebrae

- a. Four to five modular pieces fused together
- b. Triangular, with the base above and apex below

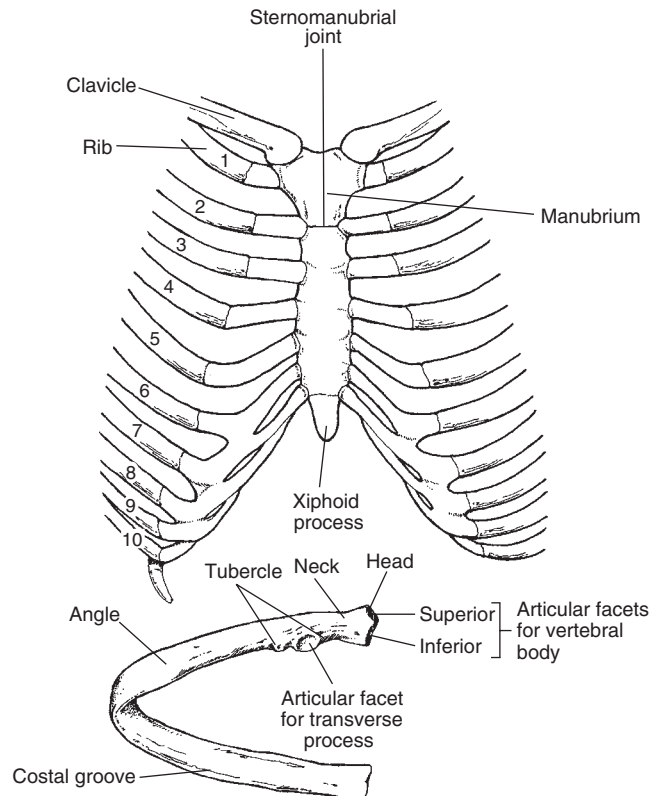
F. Defects

- a. *Lordosis*: Exaggerated lumbar concavity
- b. *Scoliosis*: Lateral curvature of any region
- c. *Kyphosis*: Exaggerated convexity in thoracic region

Bones of the Thorax

A. Sternum

1. Forms medial part of the anterior chest wall
2. *Manubrium (upper part)*: Clavicle and first rib articulate with the manubrium; contains notch on superior border called *jugular (manubrial) notch*
3. *Body (middle blade)*: Ribs articulate with the body via the costal cartilages
4. Xiphoid (blunt cartilaginous tip)



• **Figure 5-8** Sternocostal articulations (anterior view); middle rib (posterior view).

B. Ribs—12 pairs (**Figure 5-8**)

1. Each rib articulates with both the body and the transverse process of its corresponding thoracic vertebra
2. Second to ninth ribs articulate with the body of the vertebra above
3. Ribs curve outward, forward, and then downward

4. Anteriorly, each of the first seven ribs joins a costal cartilage that attaches to the sternum
5. Next three ribs (eighth to tenth) join the cartilage of the rib above
6. Eleventh and twelfth ribs do not attach to the sternum and are called *floating ribs*

Appendicular Skeleton

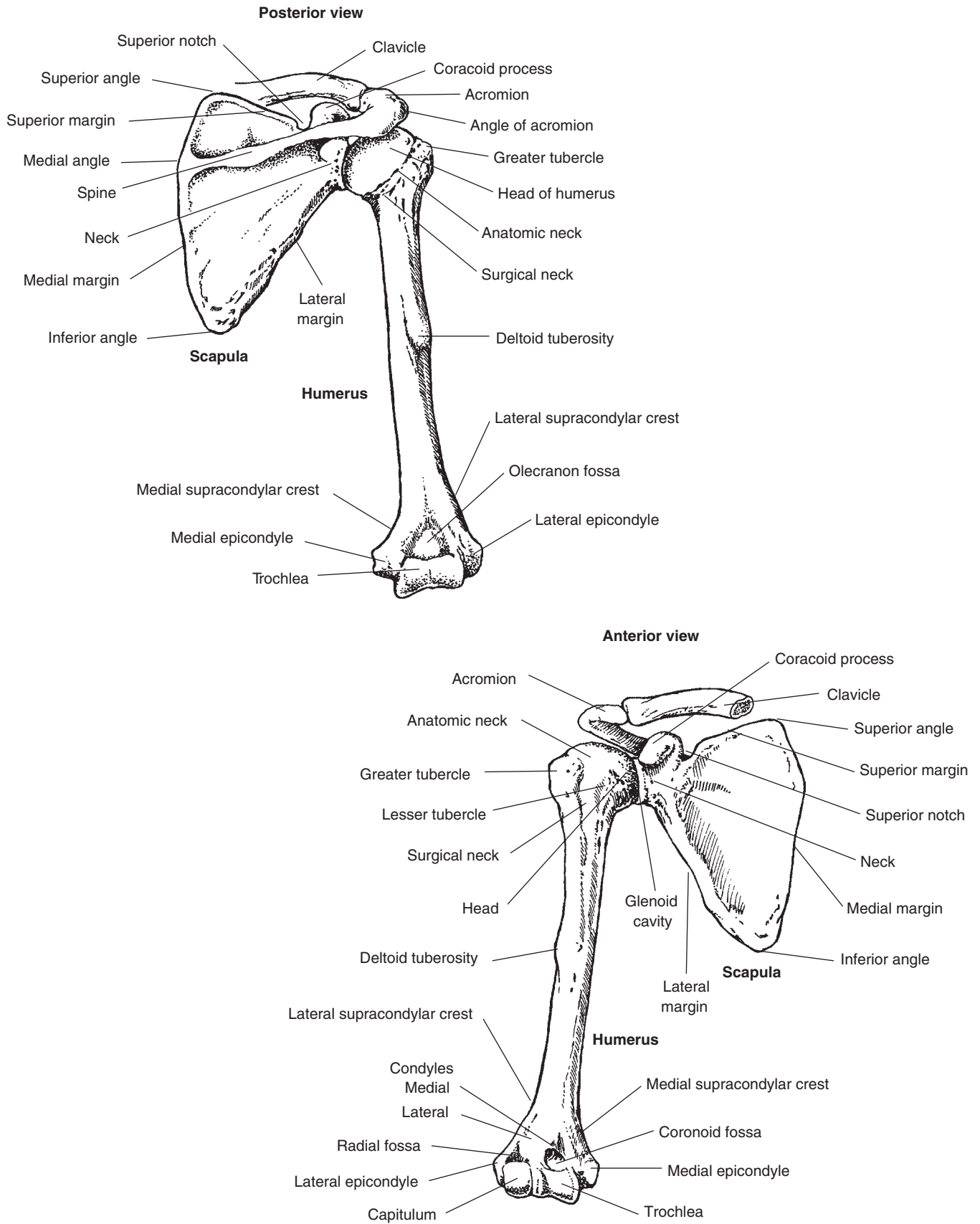
Upper Extremity

- A. *Shoulder*: Clavicle and scapula (Figure 5-9)
 1. Clavicle
 - a. Articulates with the manubrium at the sternal end
 - b. Articulates with the scapula at the lateral end
 - c. Slender S-shaped bone that extends horizontally across the upper part of the thorax
 2. Scapula (see Figure 5-9)
 - a. Triangular bone with the base upward and the apex downward
 - b. Lateral aspect contains the glenoid cavity (fossa), which articulates with the head of the humerus
 - c. Spine extends across the upper part of the posterior surface; expands laterally and forms the acromion (point of shoulder)
 - d. Coracoid process projects anteriorly from the upper part of the neck of the scapula
- B. Humerus
 1. Consists of a shaft (diaphysis) and two ends (epiphyses)
 2. Proximal end has a head that articulates with the glenoid cavity (fossa) of the scapula
 3. Greater and lesser tubercles lie below the head
 - a. Intertubercular groove (bicipital groove) is between them; long tendon of the biceps attaches here
 - b. Surgical neck is below the tubercles
 4. Radial groove runs obliquely on the posterior surface; radial nerve is here
 5. Deltoid muscles attach in a V-shaped area in the middle of the shaft called the *deltoid tuberosity*
 6. Distal end has two projections
 - a. *Capitulum*: Lateral, articulates with the radius; expanded area just superior is called the *lateral epicondyle*
 - b. *Trochlea*: Medial, articulates with the ulna; expanded area just superior is called the *medial epicondyle*
- C. Forearm (Figure 5-10)
 1. Radius
 - a. Lateral bone of the forearm
 - b. Radial tubercle (tuberosity) located below the head on the medial side
 - c. Proximal end has disklike head
 - d. Neck just inferior to head
 - e. Distal end broad for articulation with the wrist
 - f. Has styloid process on its lateral side
 2. Ulna
 - a. Medial bone of the forearm
 - b. Conspicuous part of the elbow joint (olecranon)

- c. Curved surface that articulates with the trochlea of the humerus is the trochlear notch
 - d. Lateral side concave (radial notch); articulates with the head of the radius
 - e. Distal end contains the styloid process
- D. Hand and wrist (Figure 5-11)
 1. Carpal bones—8
 - a. Arranged in two rows of four
 - b. From lateral to medial, proximal row—scaphoid, lunate, triquetrum, and pisiform
 - c. From lateral to medial, distal row—trapezium, trapezoid, capitate, and hamate
 2. Metacarpal bones—5
 - a. Framework of the hand
 - b. Numbered 1 through 5, beginning on the lateral side
 3. Phalanges—14
 - a. Form the fingers
 - b. Three phalanges in each finger; two phalanges in the thumb

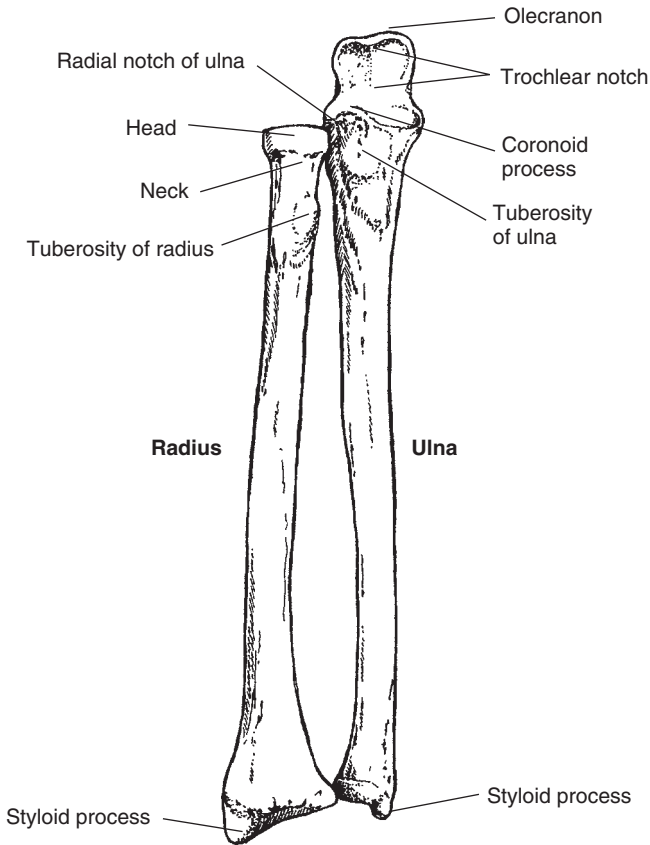
Lower Extremity

- A. Hip (os coxae or innominate) (Figure 5-12)
 1. Constitutes pelvic girdle
 2. United with the vertebral column
 3. Union of three parts that is marked by a cup-shaped cavity (acetabulum)
 4. Ilium
 - a. Prominence of the hip
 - b. Superior border is the crest
 - c. *ASIS*: Projection at the anterior tip of the crest; just inferior to the ASIS is the anterior inferior iliac spine
 - d. Corresponding projections on the posterior part are the posterior superior and posterior inferior iliac spines
 - e. *Greater sciatic notch*: Located beneath the articular surface
 - f. Most is a smooth concavity (iliac fossa)
 - g. Posteriorly, it is rough and articulates with the sacrum in the formation of the sacroiliac joint
 5. Pubic bone
 - a. Anterior part of the innominate bone
 - b. *Symphysis pubis*: Joining of the right and left pubic bones at the midline
 - c. Body and two rami
 - (1) Body forms one fifth of acetabulum
 - (2) Superior ramus extends from the body to the median plane; superior border forms the pubic crest
 - (3) Inferior ramus extends downward and meets with the ischium
 - (4) Pubic arch is formed by the inferior rami of both pubic bones
 6. Ischium
 - a. Forms the lower and back part of the innominate bone



• **Figure 5-9** Humerus and scapula.

Radius and ulna in supination: anterior view



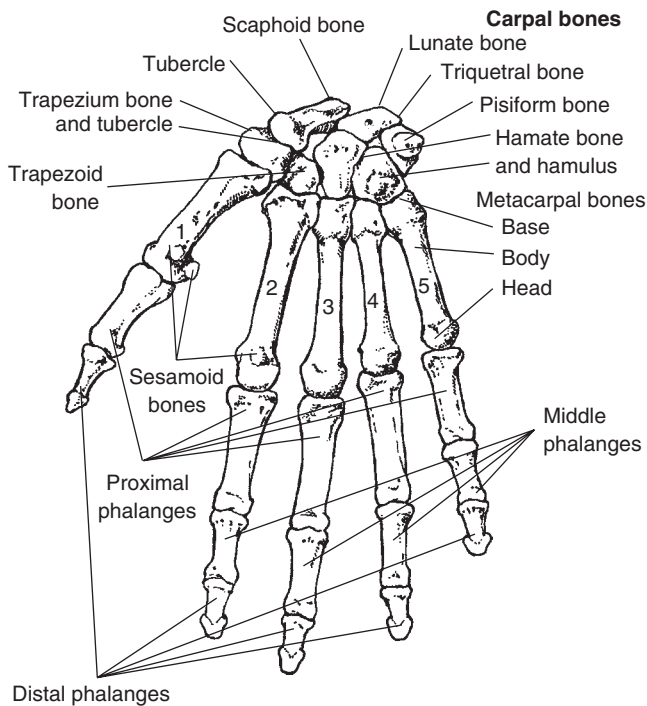
• **Figure 5-10** Forearm.

- b. Body
 - (1) Forms two fifths of the acetabulum
 - (2) Ischial tuberosity supports the body in a sitting position
- c. *Ramus*: Passes upward to join the inferior ramus of the pubis
- d. Opening created by this ring is known as the *obturator foramen*

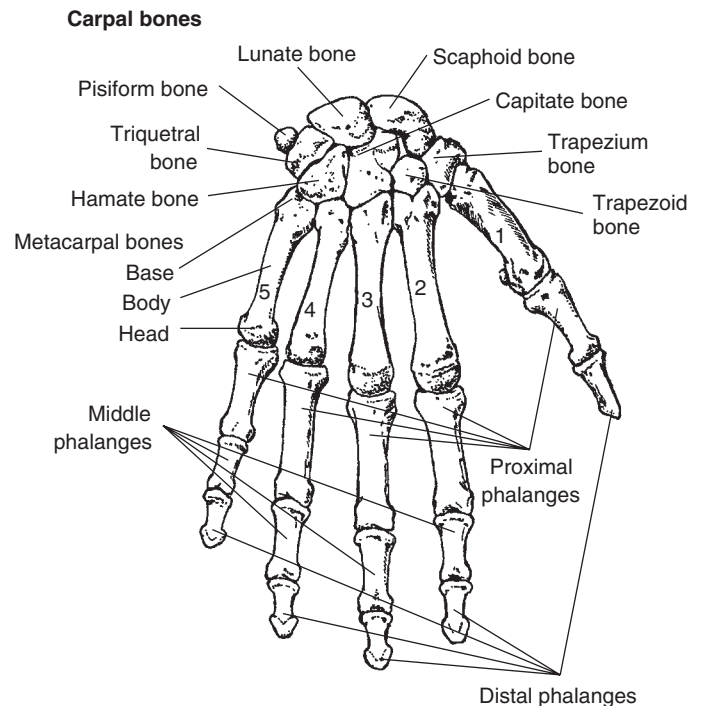
B. Pelvis

1. Formed by the right and left hip bones, sacrum, and coccyx
2. Greater pelvis
 - a. Bounded by the ilia and lower lumbar vertebrae
 - b. Gives support to the abdominal viscera
3. Lesser pelvis
 - a. Brim of the pelvis corresponds to the sacral promontory
 - b. Inferior outlet is bounded by the tip of the coccyx, ischial tuberosities, and inferior rami of the pubic bones
4. Female pelvis
 - a. Shows adaptations related to functions as a birth canal
 - b. Wide outlet
 - c. Angle of the pubic arch is obtuse
5. Male pelvis
 - a. Shows adaptations that contribute to power and speed
 - b. Heart-shaped outlet
 - c. Angle of the pubic arch is acute

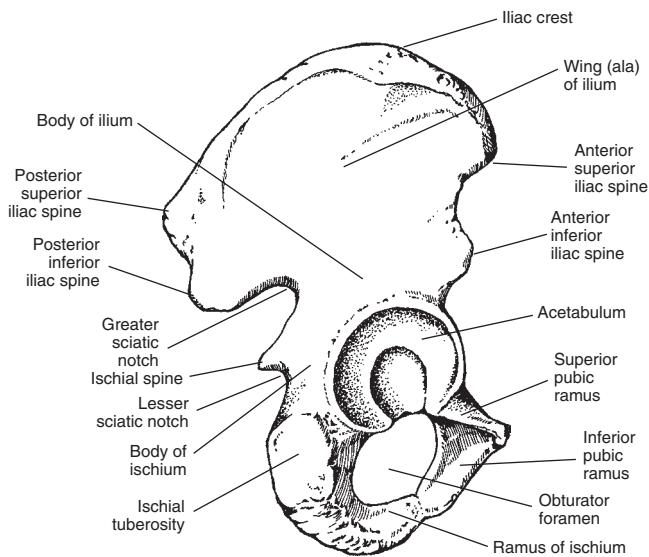
Right hand: palmar view



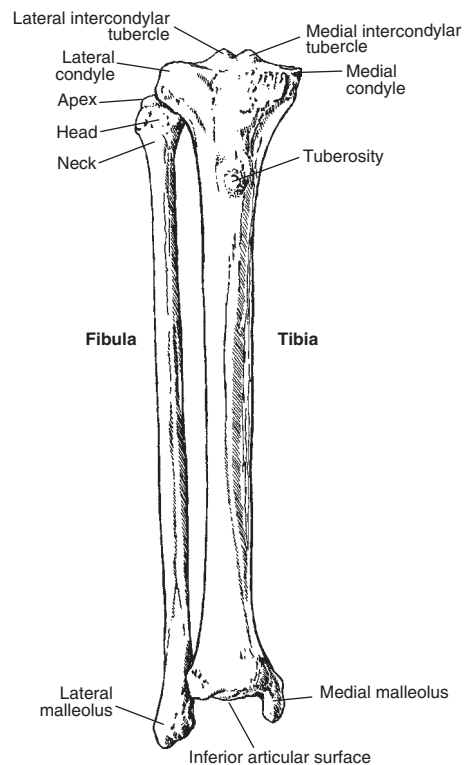
Right hand: dorsal view



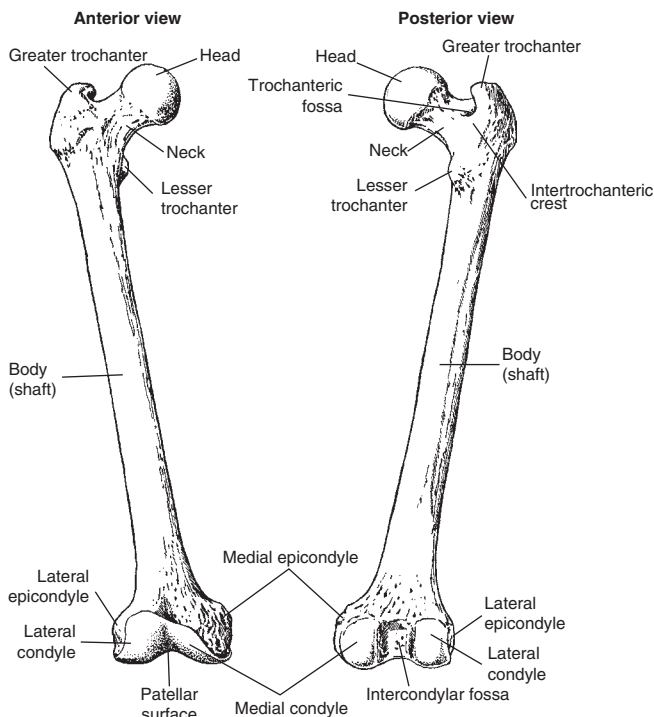
• **Figure 5-11** Wrist and hand.



• **Figure 5-12** Innominate bone (lateral view).



• **Figure 5-14** Tibia and fibula (anterior view).



• **Figure 5-13** Femur.

C. Femur (**Figure 5-13**)

1. Longest and strongest bone of the body
2. Proximal end has a rounded head that articulates with the acetabulum
3. Constricted portion is neck
4. Greater and lesser trochanters connected by intertrochanteric crest
5. Slightly arched shaft concave posteriorly
6. Distal end has two condyles separated on the posterior side by the intercondyloid fossa

D. Patella

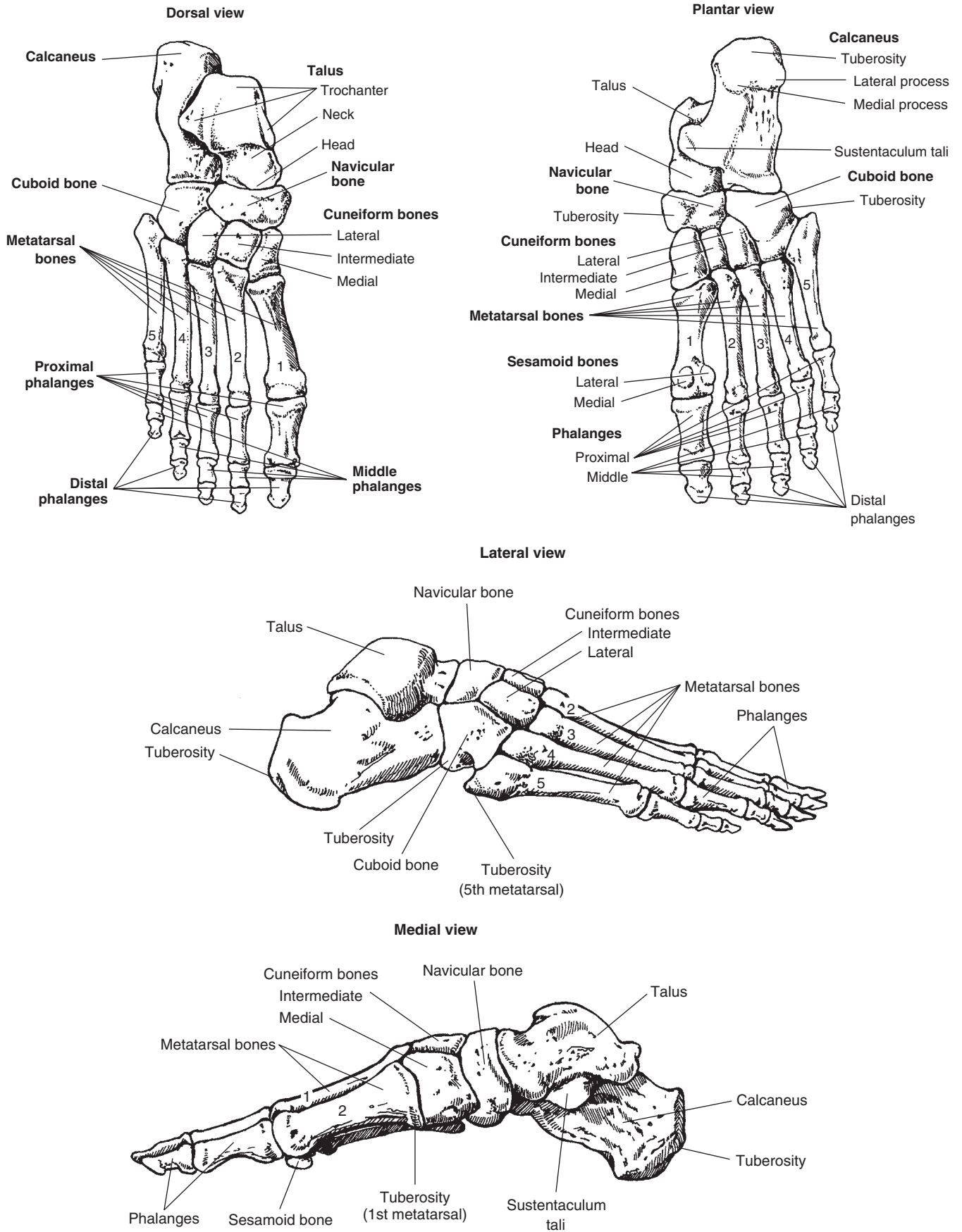
1. Sesamoid bone
2. Embedded in the tendon of the quadriceps muscle
3. Articulates with the femur

E. Leg (**Figure 5-14**)

1. *Tibia*: Medial bone
 - a. Proximal end has two condyles that articulate with the femur
 - b. Triangular shaft
 - (1) *Anterior*: Shin
 - (2) *Posterior*: Soleal line
 - (3) *Distal*: Medial malleolus articulates with the lattice that forms the ankle joint
2. *Fibula*: Lateral bone
 - a. Articulates with lateral condyle of the tibia but does not enter the knee joint
 - b. Distal end projects as the lateral malleolus

F. Ankle, foot, and toes (**Figure 5-15**)

1. Adapted for supporting weight, but similar in structure to the hand
2. Talus
 - a. Occupies the uppermost and central portion of the tarsus
 - b. Distributes the body weight from the tibia above to the other tarsal bones
3. *Calcaneus (os calcis, heel)*: Located beneath the talus
4. *Navicular*: Located in front of the talus on the medial side; articulates with three cuneiform bones distally



• Figure 5-15 Foot.

5. *Cuboid*: Lies along the lateral border of the navicular bone
6. Metatarsals
 - a. First, second, and third metatarsals lie in front of the three cuneiform bones
 - b. Fourth and fifth metatarsals lie in front of the cuboid bone
7. Phalanges
 - a. Distal to the metatarsals
 - b. Two in the great toe; three in each of the other four toes
8. Longitudinal arches of the foot—two
 - a. *Lateral*: Formed by the calcaneus, talus, cuboid, and fourth and fifth metatarsal bones
 - b. *Medial*: Formed by the calcaneus; talus; navicular; cuneiform; and first, second, and third metatarsal bones
9. *Transverse arches*: Formed by the tarsal and metatarsal bones

Nervous System*

- A. Adapts to environmental influences
 1. By stimulating skeletal, cardiac, and smooth muscles
 2. Adaptation by the muscular system is almost immediate
- B. Organized into different systems
 1. Central nervous system (CNS)
 - a. Composed of the brain and spinal cord
 2. Peripheral nervous system (PNS)
 - a. Contains the nerves to and from the body wall that connect to the CNS
 - b. Also known as the *somatic division* because it is under voluntary control
 3. Autonomic nervous system (ANS)
 - a. Not under conscious control (involuntary)
 - b. Provides stimulus for the viscera and smooth and cardiac muscles
 - c. Sympathetic division includes motor (afferent) nerves from the ANS
 - d. Parasympathetic division involves motor (efferent) nerves from the ANS
- C. Nerve cell: Neuron
 1. Dendrite carries impulse toward the cell body under normal conditions
 2. Axon carries impulse away from the cell body and makes contact with the next cell; release of chemicals starts impulse in the next neuron
 3. *Myelin sheath*: Fatty substance around some cell axons provides insulation
 4. Neurons can carry impulses in different directions

- a. Afferent neurons carry the sensory information to the CNS
- b. Efferent neurons carry the motor information away from the CNS
5. Central neurons are found entirely within the CNS; relay information within the system
 - a. Spinal cord is approximately 45.8 cm long; occupies the upper two thirds of the vertebral canal
 - b. There are 31 pairs of spinal nerves; each has a dorsal (afferent) route and a ventral (efferent) route
- D. Brain is composed of four regions
 1. Cerebrum
 - a. Seat of conscious activities
 - b. Largest portion of the brain
 - c. Superiormost location
 - d. *Cerebral cortex*: Thin outside layer; gray color; composed of several layers of cells; convoluted surface
 - e. *Longitudinal fissure*: Divides cerebrum into two hemispheres
 - f. *Corpus callosum*: Heavy band of white fibers; forms the floor of the longitudinal fissure
 - g. *Central fissure*: Posterior to midline
 - h. *Frontal lobe*: Anterior to the central fissure
 - i. *Parietal lobe*: Posterior to the central fissure
 - j. *Temporal lobe*: Below the lateral fissure
 - k. *Occipital lobe*: Posterior part of the brain
 - l. *Broca's area*: Controls the muscular part of speech
 - m. *Somesthetic area*: Interprets body sensations
 - n. *Visual area*: Fibers from the medial part of the retina cross to opposite sides in the brain; fibers from the lateral portion do not cross
 - o. *Auditory area*: Superior central portion of the temporal lobe
 - p. *Prefrontal area*: Personality characteristics
 2. *Cerebellum*: Coordinates balance and equilibrium
 3. Medulla oblongata
 - a. Bulb of the spinal cord located inside the foramen magnum
 - b. White on the outside, gray on the inside
 - c. Controls three vital functions—cardiac, respiratory, and basal motor
 - d. Also controls chewing, salivation, swallowing, emesis, lacrimation, blinking, coughing, and sneezing
 - e. *Pons*: Ropelike mass of white fibers; connects the halves of the cerebellum
 4. Mesencephalon
 - a. Short part of the brainstem
 - b. Above the pons
 - c. Mostly white matter
- E. *Meninges*: Membranous coverings of the brain and spinal cord
 1. Dura mater
 - a. Double layer around the brain
 - b. Single layer around the spinal cord, including the cauda equina

*The nervous, cardiovascular, and lymphatic systems are not included in the content specifications for the certification exam. Their inclusion here supports the goal of this text as a study guide for use throughout the radiography program.

2. Arachnoid
 - a. Membrane just inside the dura mater
 - b. Relatively thin
 3. Pia mater
 - a. Soft covering that fits against the brain and spinal cord
 - b. Contains an enormous amount of blood
 4. Subarachnoid space
 - a. Threadlike structure through which cerebrospinal fluid circulates
 - b. Located between the pia mater and arachnoid
- F. Cranial nerves
1. Part of the PNS
 2. Originate at the base of the brain
 3. 12 pairs of cranial nerves
 4. Referred to by name or Roman numerals
 5. Provide motor impulses, sensory impulses, or mixed impulses

Heart

- A. Composed of cardiac muscle; pumps the blood through the circulatory system
- B. Located behind the sternum
- C. The size of a human fist
- D. The apex of the heart points down and to the left
- E. Located in a space between the lungs and the thoracic cavity, known as the *mediastinum*
- F. Composed of four chambers—two atria and two ventricles
 1. Blood from the superior and inferior venae cavae fills the right atrium and passes into the right ventricle through the tricuspid valve
- G. The unoxygenated blood moves from the right ventricle to the lungs through the semilunar valve and the pulmonary artery
- H. Oxygenated blood is sent from the lungs to the left atrium through the pulmonary veins; the left semilunar valve separates the left atrium from the pulmonary veins
 - I. From the left atrium, blood flows through the mitral valve into the left ventricle
 - J. Blood enters circulation by passing through the left semilunar valve into the aorta
- K. Heart wall consists of three layers
 1. Visceral *pericardium* or *epicardium*
 2. *Myocardium*: Heaviest covering
 3. *Endocardium*: Smooth, continuous covering
 4. All valves and chambers are lined by endothelium
- L. Heartbeat
 1. Averages 70 to 72 beats per minute
 2. Heart cannot contract without nerve impulses
 3. Nerves regulate the rate of the beat
- M. Cardiac cycle
 1. Consists of a relaxation-contraction cycle
 2. Lasts for approximately 0.8 second
- N. Electrocardiogram is a record of the action current as it travels across the heart

Circulatory System

- A. Overview
 1. The connection of the heart to the arteries, arterioles, capillaries, venules, and veins
 2. The system also interacts with the circulatory system
- B. Arteries
 1. Thick-walled elastic vessels
 2. End in arterioles
- C. Arterioles
 1. Smallest branch of an artery
 2. Connected to venules by capillaries
- D. Capillaries
 1. Connect arterioles to venules
 2. Are lined by a thin layer of endothelium
 3. Capillaries can dilate or constrict, depending on the needs of the tissue
 4. Red blood cells go through capillaries one cell at a time
- E. Venules
 1. Connected to veins that carry blood toward the heart and carry unoxygenated blood (except in the pulmonary vein)
- F. Veins
 1. Have the same layers as arteries but are thinner
 2. Veins collapse without blood
 3. Valves in the veins help resist forces of gravity
- G. Arteriovenous shunt (anastomosis)
 1. A large blood vessel that connects an artery and vein directly
 2. Skin color is caused by blood in the capillaries and anastomosis; anastomosis is important for heat distribution
 3. Found only in the hands, face, and toes, where the body is exposed to weather

Arterial Systemic Circulation

- A. Aorta
 1. Arises from the left ventricle of the heart
 2. First 5 cm is called the *ascending aorta*
 3. Two (left and right) coronary arteries branch off directly above the left semilunar valve and supply blood to the cardiac muscle
- B. Aortic arch
 1. Loops back over the top of the heart and left of the trachea
 2. Continues down in back of the heart
 3. Three arteries come off the arch
 - a. Brachiocephalic
 - (1) Only a few centimeters in length
 - (2) Right subclavian artery arises from the brachiocephalic artery and supplies blood to the right shoulder
 - (3) Right common carotid artery arises from the brachiocephalic artery and supplies blood to the right side of the head

- b. Left common carotid artery supplies blood to the left side of the head
 - c. Left subclavian artery supplies branches to the upper chest and scapula
- C. Carotid arteries
- 1. Supply the head
 - 2. Right carotid artery originates from the brachiocephalic artery
 - 3. Left carotid artery originates from the aortic arch
- D. Subclavian arteries
- 1. Provide blood to the shoulder and arm
 - 2. Left subclavian artery branches from the aortic arch
 - 3. Right subclavian artery branches from the brachiocephalic artery
 - 4. Pass over the first rib and under the clavicle
 - 5. Become the axillary arteries as they pass through the shoulder region
 - 6. First branch off the subclavian artery is the vertebral artery
- E. Vertebral artery
- 1. Passes up the neck through the transverse foramen of the cervical vertebrae
 - 2. Enters the skull through the foramen magnum
 - 3. The two paired arteries join on the ventral side of the medulla and become the basilar artery; this artery joins branches from the internal carotid artery to form the circle of Willis, also called the *cerebral arterial circle*
- F. Axillary artery
- 1. Becomes the brachial artery at the humerus
 - 2. Moves along the medial surface across the elbow region and divides into radial and ulnar arteries
- G. Radial artery
- 1. Moves along the radius and crosses it at the distal end
 - 2. A pulse can be felt at the distal end
 - 3. Moves across the metacarpals and deep into the palm
 - 4. Forms a loop that connects with the ulnar artery
- H. Ulnar artery
- 1. Travels down the medial surface of the forearm
 - 2. Becomes the superficial palmar artery, which joins with the radial artery
 - 3. Digital arteries supply the fingers and branch off from the palmar loop
- I. *Descending aorta*: Consists of the thoracic and abdominal sections of the aorta
- 1. Thoracic aorta
 - a. Starts after the left subclavian artery branches off the aortic arch
 - b. Extends from T4–5 to T12–L1
 - c. Passes down and in front of the vertebral column and through the diaphragm
 - d. Gives off several branches supplying the ribs, lungs, and diaphragm
 - e. After it passes through the diaphragm, it is called the *abdominal aorta*
2. Abdominal aorta
- a. Extends to the L4 vertebra
 - b. Gives rise to the visceral and parietal arteries
 - c. *Celiac artery*: Visceral artery that is 1.5 cm long; it divides into several branches
 - (1) *Left gastric artery*: Smallest branch to the stomach
 - (2) *Hepatic artery*: Supplies most of the blood to the liver; divides at the liver
 - (a) *Cystic artery*: Serves the gallbladder
 - (b) *Gastric duodenal artery*: Divides to serve the stomach, pancreas, and duodenum
 - (3) *Splenic artery*: Largest branch to the spleen
 - d. *Superior mesenteric artery*: Supplies all of the small intestine except the duodenum and superior ascending and transverse portion of the colon; comes off the front of the aorta below the celiac artery
 - e. *Inferior mesenteric artery*: Supplies blood for part of the transverse colon and all of the descending and sigmoid colon, rectum, and bladder
 - f. *Renal artery*: Supplies the kidneys; located below the superior mesenteric artery
 - (1) Right renal artery slightly longer and lower because the aorta is slightly left of the midline
 - (2) Enters the kidney at the hilus
 - g. *Suprarenal artery*: Branches off the aorta above the renal artery (may be branches of the renal arteries)
 - h. Aorta bifurcates and becomes the right and left common iliac arteries
- J. Common iliac arteries bifurcate
- 1. Internal iliac artery supplies the pelvic wall and viscera
 - 2. External iliac artery goes into the thigh
 - a. Passes over the pelvic brim and under the inguinal ligament
 - b. Becomes the femoral artery
- K. Femoral artery
- 1. Supplies thigh
 - 2. Becomes the popliteal artery just above the knee and goes behind the knee to bifurcate
 - a. Anterior tibial artery
 - b. Posterior tibial artery
 - c. Anterior and posterior tibial arteries spread out at the ankle and become the dorsal artery of the foot

Venous Systemic Circulation

- A. Consists of one set of superficial veins and one set of deep veins
- B. Veins have a higher blood capacity than arteries but have lower blood pressure and velocity
- C. Three sets of veins connect to the heart
 - 1. *Vena cava*: Superior and inferior
 - a. Serve the body
 - b. Return unoxygenated blood

2. Coronary sinus
 - a. Serves the heart
 - b. Returns unoxygenated blood
3. Pulmonary veins
 - a. Serve the lungs (two per lung)
 - b. Return oxygenated blood to the left atrium
- D. Superior vena cava
 1. Begins at the level of the first rib
 2. Is formed by two veins
 - a. Left and right brachiocephalic veins (return blood from the head, shoulders, and arms)
 - b. Each brachiocephalic vein is a union of the internal jugular vein with the subclavian vein
- E. Jugular veins drain blood from the head
 1. External jugular vein
 - a. Drains the face and the scalp
 - b. Is the union of three main veins that unite just below the ear and empty into the subclavian vein
 2. Internal jugular vein
 - a. Returns from the internal carotid vein
 - b. Originates in the skull
- F. Vertebral veins
 1. Arise outside of the skull at the level of the atlas
 2. Pass through the transverse foramen to the subclavian artery
- G. Arms and shoulders are drained by the deep veins that run alongside the arteries
- H. Inferior vena cava
 1. Formed by two common iliac veins at the L5 vertebra in front of the vertebral column
- I. Azygos vein
 1. Branches off the inferior vena cava at the level of the renal veins
 2. Goes through the aortic hiatus of the diaphragm just below the heart
 3. Empties into the superior vena cava
 4. Picks up veins from the esophagus and bronchi
- J. Other veins serving the abdomen and thorax are named for the region or organs that they serve
- K. Veins of the lower extremities
 1. Deep veins have the same names as the arteries
 2. Superficial veins
 - a. *Great saphenous vein*: Drains the dorsalis pedis of the foot
 - b. *Small saphenous vein*: Drains the lateral side of the foot
 - c. *Popliteal vein*: Drains the lateral side of the leg
 2. Is constantly moving
 3. Similar to plasma without large proteins
- D. Lymph is tissue fluid that has been reabsorbed into lymphatic vessels
- E. Valves are necessary in the lymphatic system
 1. To keep fluid flowing in the right direction
 2. Most valves are located in the arms and legs, where gravity is a problem
- F. Lymph nodes
 1. Spongy masses of tissue through which lymph filters
 2. Have more afferent vessels leading to the node than efferent vessels leaving the node
- G. Lymphocytes are small white blood cells that originate from stem cells
- H. Right lymphatic duct
 1. Drains the upper right quadrant of the thorax, right arm, and right side of the head
 2. Empties into the right subclavian vein
- I. Thoracic duct
 1. Drains the rest of the body
 2. Begins at the cisterna chyli
 3. Passes up the left side of the vertebral column, through the aortic hiatus of the diaphragm, and into the left subclavian vein
- J. Lymphoid tissue is found in various anatomic structures
 1. *Spleen*: The graveyard of red blood cells
 2. *Thymus*: Atrophies after puberty but is involved in the cell-mediated immune system
 3. *Tonsils*: Located in the oral cavity

Respiratory System

- A. *Respiratory tract*: Begins at the nostril opening and extends to the alveoli of the lungs
- B. Air is drawn in through the nose, where it is warmed, humidified, and cleansed
- C. Nasal cavity is lined with olfactory epithelium in the sphenoidal recess and by respiratory epithelium in the lower part
- D. Superior, middle, and inferior turbinates are located on the lateral surface of the nasal cavity
- E. Frontal, ethmoidal, maxillary, and sphenoidal sinuses empty into the nasal cavity
- F. Pharynx
 1. Second part of the respiratory tract
 2. Starts at the base of the skull and extends to the esophagus
 3. Divided into three parts
 - a. *Nasopharynx*: Behind the nasal cavity
 - (1) *Eustachian tube (auditory tube)*: Connects the middle ear with the pharynx; open only during swallowing; equalizes pressure
 - (2) *Pharyngeal tonsils (adenoids)*: A mass of lymphoid tissue on the upper back wall of the nasopharynx

Lymphatic System

- A. Carries lymph
- B. Involved in the maintenance of fluid pressure
- C. Contains lymph glands that filter foreign particles
 1. Tissue fluid is located in the intracellular spaces and is derived from the blood

- b. *Oropharynx*: Extends from the soft palate to the base of the tongue; separated from the oral cavity by the palatine arches
 - c. *Laryngopharynx*: Extends from the hyoid bone to the larynx
- G. Larynx
- 1. Located at the base of the tongue
 - 2. Comprises nine cartilages
- H. Vocal chords
- 1. Folds of mucous membranes
 - 2. Elastic connective tissue at the edges
- I. Trachea
- 1. Approximately 12 cm long
 - 2. In front of esophagus
 - 3. Composed of 16 to 20 C-shaped rings that prevent its collapse
 - 4. At the end of T4 vertebra, the trachea divides into left and right branches known as the *primary bronchi*
- J. Primary bronchi
- 1. Left primary bronchus is longer than the right and forms a sharp angle
 - 2. Right primary bronchus has a larger diameter than the left and comes off forming an almost straight line
- K. Secondary bronchi branch off the primary bronchi
- 1. Three secondary bronchi for the right lung, one per lobe
 - 2. Two secondary bronchi for the left lung, one per lobe
- L. Tertiary bronchi
- 1. Branch off the secondary bronchi
 - 2. Each lung has 10 tertiary bronchi because there are 10 segments per lung
- M. *Bronchioles*: Smaller branches of the tertiary bronchi
- 1. *Terminal bronchioles*: Not involved in gaseous exchange
 - 2. *Respiratory bronchioles*: Branch off the terminal bronchioles; first site of diffusion of oxygen into the blood
- N. Alveolar ducts
- 1. Branch off the respiratory bronchioles
 - 2. Alveolar sacs attach to the alveolar ducts
- O. Two cone-shaped lungs in the thoracic cavity
- 1. Base rests on the diaphragm
 - 2. Apex is located at the level of the clavicle
 - 3. Right lung
 - a. Has three lobes—superior, middle, and inferior
 - b. Larger than the left lung
 - 4. Left lung
 - a. Smaller than the right lung because two thirds of the heart is located on the left side
 - b. Contains only two lobes
 - 5. 10 bronchopulmonary segments per lung
 - a. Each has a branch from the tertiary bronchi
 - b. Used as points of reference for surgery
- P. Cardiac notch: Depression on the medial surface of the left lung
- 1. Hilus
 - a. Point of attachment to a lung
 - b. Blood vessels, bronchial tree, and nerves enter at the hilus
- Q. *Pleura*: Serous membrane surrounding the visceral and parietal layers of each lung
- 1. Space between the two layers is the pleural cavity
 - 2. Lungs are not located in the pleural cavity
- R. Mechanics of respiration
- 1. Involve changing the pressure in the lungs to cause inspiration or expiration
 - 2. Inspiration
 - a. Occurs when the air pressure in the lungs is decreased
 - b. Causes the volume of the lungs to increase
 - c. External intercostal muscles cause the ribs to elevate and increase the size of the chest cavity
 - d. Dome-shaped diaphragm between the thoracic and abdominal cavities pulls downward when contracted
 - e. Also increases the size of the chest cavity
 - 3. Expiration
 - a. Basically a passive movement
 - b. Ribs fall down
 - c. Diaphragm is pushed up by the abdominal viscera
 - d. Abdominal muscles force the abdominal contents up
 - e. Internal intercostal muscles pull the ribs down

Digestive System

- A. Digestive or alimentary tract
- 1. Consists of a tube 6 m long from the mouth to the anus
 - 2. Selectively absorbs nutrients and water for the body
- B. Mouth
- 1. Site where food processing and digestion begin
 - 2. Secondary teeth tear and grind the food
- C. Tongue
- 1. Fibromuscular organ
 - 2. Contains the taste buds
 - 3. Transmits the sensation of taste to the brain
 - 4. Rolls the food into a bolus for swallowing
- D. Saliva
- 1. Added to help food become a bolus for easier passage down the esophagus
 - 2. Produced by three major paired glands and many minor glands
- E. Salivary glands
- 1. Parotid glands
 - a. Located in the preauricular region
 - b. Saliva travels down Stensen's (parotid) duct, which opens opposite the second maxillary molar
 - 2. Sublingual glands
 - a. Lie under the tongue and rest against the mandible
 - b. Saliva travels down Bartholin's duct and enters the oral cavity through Rivinus' (lesser sublingual) ducts on the sublingual fold
 - 3. Submandibular glands
 - a. Lie on the medial surface of the mandible
 - b. Saliva travels down Wharton's (submandibular) duct and is released into the mouth at the sublingual caruncles

F. Swallowing

1. Bolus of food moves from the mouth and pharynx to the esophagus
2. During swallowing, the soft palate is pushed back against the posterior pharyngeal wall, closing the passage to the nasopharynx
3. Larynx is elevated; superior opening is protected by the epiglottis
4. Bolus moves into esophagus
5. *Esophagus*: Muscular tube located posterior to the trachea and connected to the stomach
6. Bolus is moved through esophagus by peristalsis and gravity

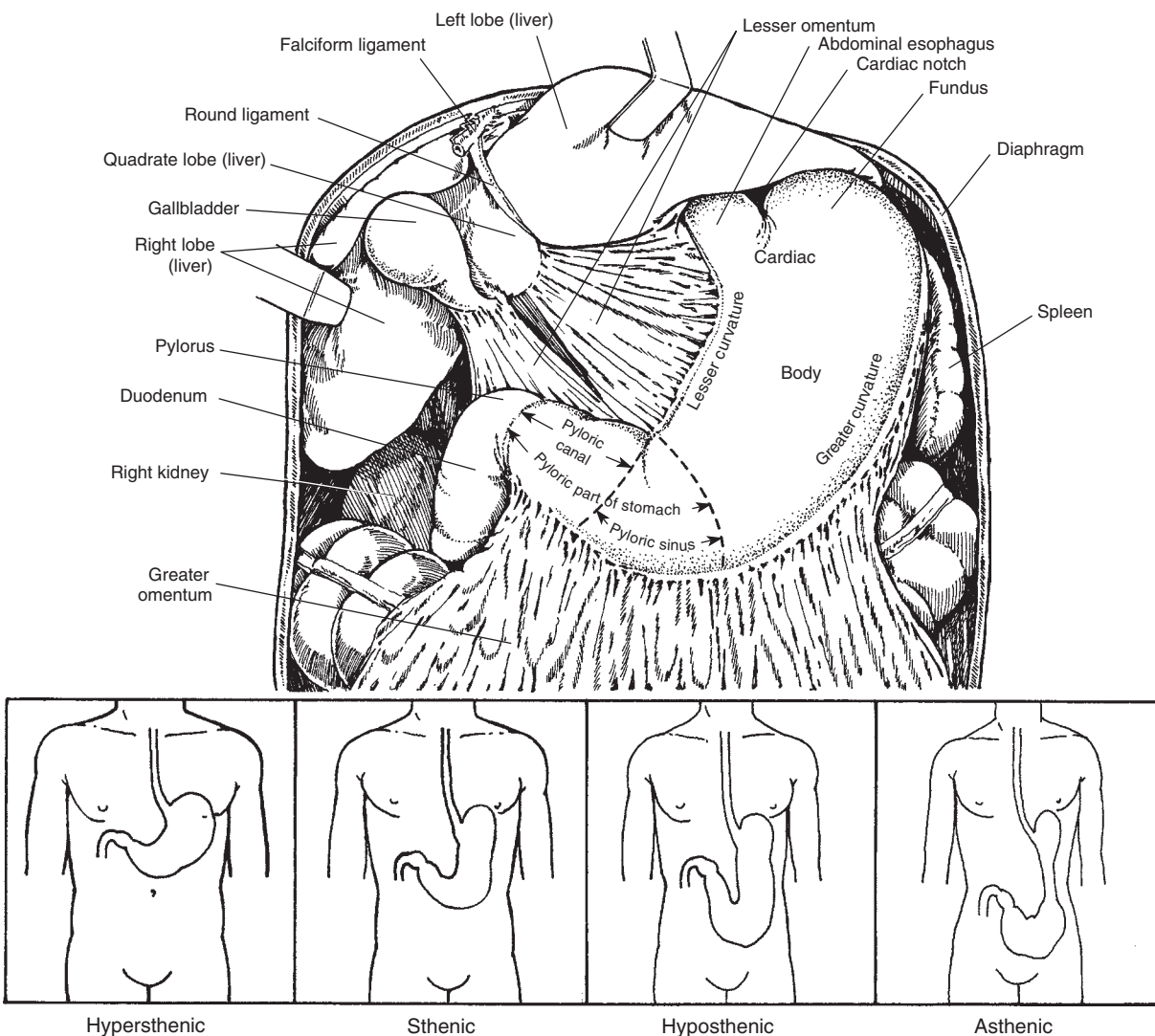
G. *Stomach*: Dilated portion of the alimentary canal lying in the upper abdomen just under the diaphragm (Figures 5-16 and 5-17)

1. Functions
 - a. Stores food

- b. *Digests*: Secretes pepsin, renin, and gastric lipase
 - c. Produces hydrochloric acid
2. Shaped like the letter “J”; internal surface is wrinkled (rugae)
 - a. *Cardiac portion*: Esophagus entrance
 - b. *Body*: Main part
 - c. *Fundus*: Bulge at the upper end, left of the esophageal area
 - d. *Pyloric portion*: Narrow distal end that connects with the small intestine

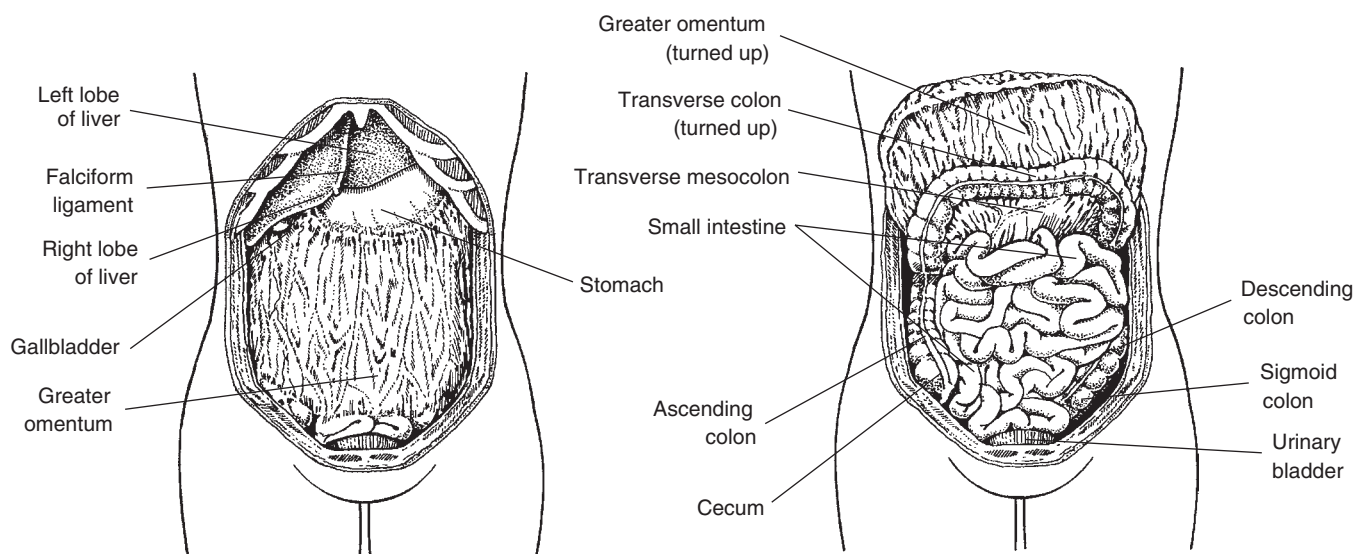
H. *Small intestine*: Thin-walled muscular tube

1. Three portions
 - a. *Duodenum (horseshoe-shaped)*: Bile and pancreatic secretions are added to the small intestine
 - b. *Jejunum (1.5 m long)*: Greatest amount of absorption
 - c. *Ileum (2.5 m long)*: Connects with the large intestine
2. Secretes several enzymes and substances



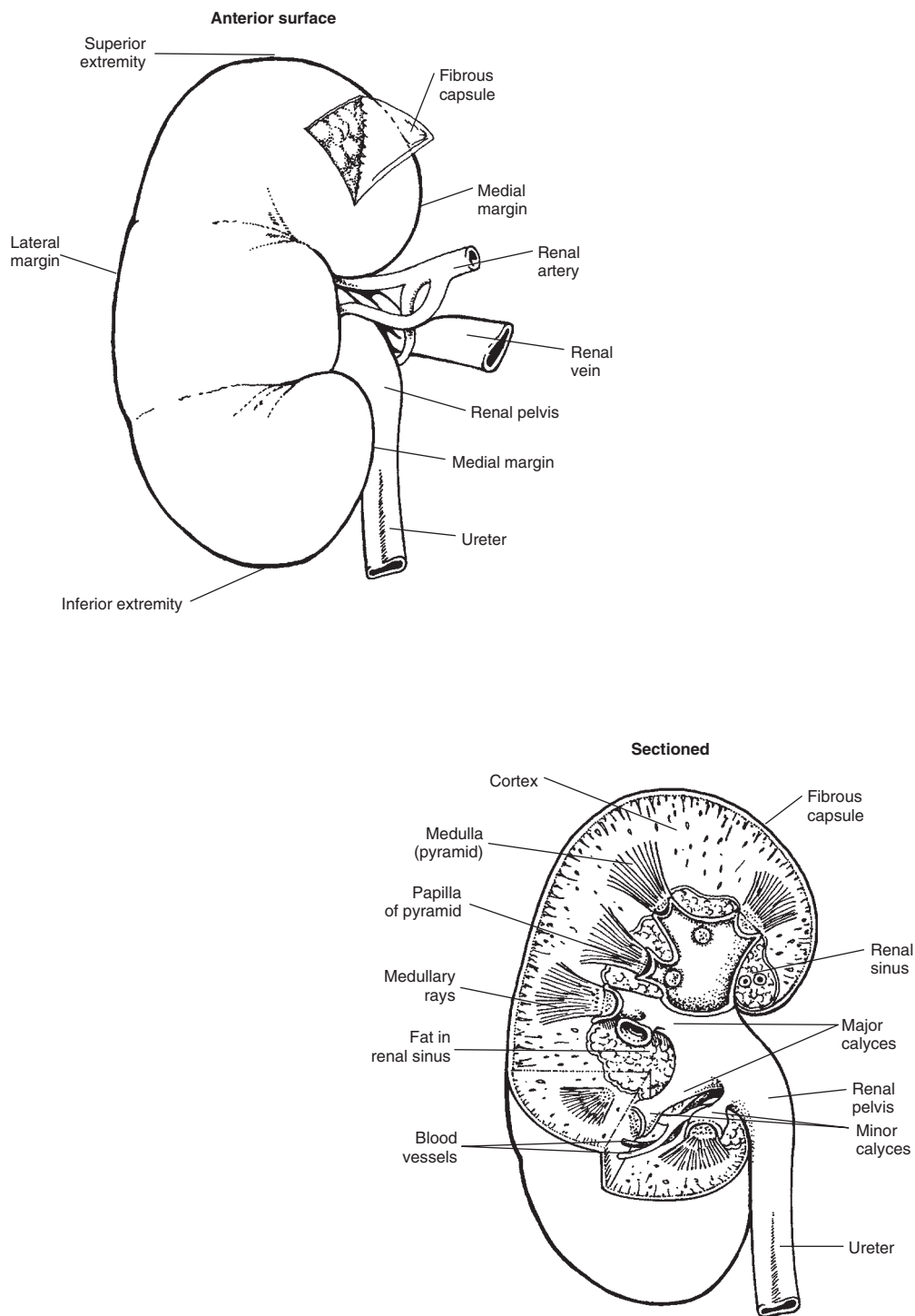
Variations in position and contour of stomach in relation to body habitus

• Figure 5-16 Stomach.



• **Figure 5-17** Abdominal viscera.

- I. *Large intestine*: Approximately 1.5 m long and in several divisions
- Cecum
 - Blind pouch in the lower right quadrant
 - Appendix attaches to cecum
 - Ileocecal sphincter separates the ileum from the cecum
 - Colon
 - Ascending*: From cecum to the hepatic flexure
 - Transverse*: From hepatic flexure to the splenic flexure
 - Descending*: From splenic flexure to the level of the pelvic bone on the left side of the body
 - Sigmoid*: S-shaped curve
 - Rectum*: From sigmoid colon down to the pelvic diaphragm
 - Anus*: 3 cm in length
- J. *Pancreas*: Exocrine and endocrine gland
- Exocrine
 - Produces pancreatic juice that is collected by the pancreatic (Wirsung's) duct and carried away
 - Joins the common bile duct to form Vater's (hepatopancreatic) ampulla, which penetrates the walls of the abdomen
 - Endocrine*: Releases insulin that controls blood glucose levels; also releases glucagon and somatostatin
- K. Liver
- Largest and most active gland in the body
 - Two main lobes and several lobules
 - Lobules produce bile that is carried away and stored in the gallbladder
 - Stores glycogen
 - Detoxifies waste
 - Plays major role in metabolism
- L. Bile ducts
- Two main hepatic ducts join to form common hepatic duct
 - Common hepatic duct unites with cystic duct (attached to the gallbladder) to form common bile duct
 - In some cases, common bile duct joins pancreatic duct to enter hepatopancreatic ampulla
 - Hepatopancreatic ampulla opens into descending duodenum
 - In other cases, common bile duct and pancreatic duct enter duodenum directly and separately
 - Distal end of common bile duct controlled by hepatopancreatic sphincter (sphincter of Oddi)
- M. Gallbladder
- Thin-walled sac with capacity of approximately 2 oz
 - Concentrates and stores bile and evacuates bile during digestion
 - Contraction of gallbladder is controlled by the hormone cholecystokinin
- ### Urinary System
- A. Kidneys (Figure 5-18)
- Paired, bean-shaped organs on both sides of the vertebral column
 - Renal artery and vein and ureter (which leads to the bladder) are attached to the center of the kidney at the hilus
 - Outer part of the kidney is called the *cortex*, and inner part is called the *medulla*
 - Medulla consists of several pyramids
 - Apices of the pyramids project into the calyces
 - Nephron is the functional unit of the kidney
 - Kidneys connected to the bladder by the ureters
- B. Ureters
- Approximately 27 cm long
 - Urine flows down the ureters via peristalsis
- C. Bladder
- Lies behind the symphysis pubis
 - Serves as a reservoir for the urine



• **Figure 5-18** Kidney.

D. Urethra

1. Connects the bladder to the exterior
2. Female urethra is approximately 4 cm long
3. Male urethra is approximately 20 cm long

E. Blood is filtered first in the glomeruli

1. Passed through the glomerular membrane into Bowman's capsule and then into the proximal tubules

2. Filtration rate determined by the filtration pressure
3. Modified as it passes through the tubules by means of reabsorption and secretion
 - a. Proximal convoluted tubule
 - b. Loop of Henle
 - c. Distal collecting tubule
4. Waste products are not reabsorbed

KEY REVIEW POINTS

Review of Anatomy Relevant to Radiography

- Identify, in words or on drawings, the various planes and divisions of the body.
- As you review the systems of the body, focus on the skeletal, respiratory, digestive, and urinary systems. These are the systems most often radiographed.
- The drawings in the chapter are invaluable. Be certain you can identify the labeled anatomy.

Review of Radiographic Positioning, Procedures, and Pathology

Skeletal System

Pathologic Conditions Imaged*

- A. Acromegaly
 1. Endocrine disorder that causes bones to become thick and coarse
 2. Harder to penetrate
- B. Ankylosing spondylitis
 1. Inflammatory disease of the spine and adjacent structures that causes severe pain and fusion of the joints involved
- C. Bony cyst
 1. Fluid-filled sacs in fibrous tissue
 2. Easier to penetrate
- D. Bursitis
 1. Inflammation of bursa; causes severe pain
 2. Harder to penetrate if calcium has deposited
- E. Callus
 1. New bony deposit surrounding healing fractures
 2. Harder to penetrate
- F. Clubfoot (talipes)
 1. Congenital malformation of the foot that causes the foot to turn in at the ankle
- G. Congenital hip anomaly
 1. Caused by malformation of the acetabulum in which the femoral head displaces superiorly and posteriorly
- H. Disk herniation
 1. Protrusion of an intervertebral disk
- I. Ewing's sarcoma
 1. Malignant, destructive tumor of bone marrow
 2. Easier to penetrate
- J. Fractures: Disruption of bone tissue
 1. *Complete fracture*: Discontinuity between two or more fragments
 2. *Incomplete fracture*: Partial discontinuity; portion of the cortex is intact
 3. *Closed fracture*: Overlying skin is intact
 4. *Compound fracture*: Overlying skin is broken; bony fragments
 5. *Transverse fracture*: Runs at right angle to the long axis of the bone
 6. *Oblique fracture*: Runs at approximately a 45-degree angle to the long axis of the bone
 7. *Spiral fracture*: Encircles the shaft of the bone
 8. *Avulsion fracture*: Small fragments of bone torn off bony prominences
 9. *Comminuted fracture*: Produces more than two fragments
 10. *Compression fracture*: Causes compaction of the bone, resulting in decreased length or width
 11. *Stress fracture*: Results from repeated stresses placed on the bone
 12. *Pathologic fracture*: Occurs as a result of bone disease
 13. *Greenstick fracture*: Incomplete fracture with cortex intact on opposite side of the bone from the fracture
 14. *Bowing fracture*: Occurs when stress applied to the bone causes the bone to bow but not fracture completely
 15. *Undisplaced fracture*: Lack of angulation or separation of fractured bone
 16. *Displacement*: Separation of bone fragments
 17. *Angulation*: Deformity of the axes of major fragments of bone
 18. *Dislocation*: Displacement of a bone from its normal site of articulation
 19. *Subluxation*: Partial loss of continuity in a joint
 20. *Fracture healing*: Characterized radiographically by calcium deposits across the fracture line that unite the fracture fragments
 21. *Battered child syndrome*: Multiple fractures at various stages of healing located in the long bones and the skull; also characterized by fractures at unusual sites (e.g., ribs, scapula, sternum, spine, and clavicles)
 22. *Colles fracture*: Transverse fracture through the distal radius with posterior angulation and overriding of the distal fracture fragment
 23. *Boxer fracture*: Transverse fracture of neck of the fifth metacarpal with palmar angulation of the distal fragment
 24. *Elbow fractures*: In addition to bony involvement, image shows dislocation of elbow fat pads; this necessitates the use of appropriate radiographic exposure
 25. *Pott fracture*: Fracture of medial and lateral malleoli of the ankle with ankle joint dislocation
 26. *Bimalleolar fracture*: Fracture of both medial and lateral malleoli
 27. *Trimalleolar fracture*: Fracture of the posterior portion of the tibia and the medial and lateral malleoli
 28. *Jefferson fracture*: Comminuted fracture of the ring of the atlas, involving both anterior and posterior arches and causing displacement of the fragments

*Designation of "harder to penetrate" or "easier to penetrate" does not signify that alteration of exposure technique is required.

29. *Hangman fracture*: Caused by acute hyperextension of the head on the neck; characterized by fracture of the arch of C2 and anterior subluxation of C2 onto C3; caused primarily by motor vehicle accidents
30. *Seat belt fracture*: Transverse fracture of lumbar vertebrae in addition to substantial abdominal injuries
- K. Hydrocephalus
1. Abnormal accumulation of cerebrospinal fluid in the brain
 2. Harder to penetrate
- L. Giant cell myeloma
1. Benign or malignant tumor arising on bone with large bubble appearance
 2. Easier to penetrate
- M. Gout
1. Metabolic disorder in which urate crystals are deposited in the joints, most commonly the great toe, and cause extreme swelling
 2. Harder to penetrate
- N. Multiple myeloma
1. Malignancy of plasma cells resulting in destruction of bone, failure of bone marrow, and impairment of renal function
 2. Easier to penetrate
- O. Osteoarthritis
1. Form of arthritis characterized by degeneration of one or several joints
 2. Easier to penetrate
- P. Osteoblastic metastases
1. Dense, sclerotic tumors in bone
 2. Harder to penetrate
- Q. Osteochondroma
1. Benign projection of bone in the young
 2. Harder to penetrate
- R. Osteogenic sarcoma
1. Destructive cancer at the end of long bones
 2. Easier to penetrate (except for sclerotic area)
- S. Osteoma
1. Benign, small, round tumor
 2. Harder to penetrate
- T. Osteogenesis imperfecta
1. Inherited condition causing poor development of connective tissue and brittle, easily fractured bones
 2. Easier to penetrate
- U. Osteomyelitis
1. Bacterial infection of bone and bone marrow
 2. Easier to penetrate
- V. Osteolytic metastases
1. Arise in medullary canal to destroy bone
 2. Easier to penetrate
- W. Osteomalacia
1. Abnormal softening of bone
 2. Easier to penetrate
- X. Osteopetrosis
1. Inherited condition causing increased bone density
 2. Harder to penetrate
- Y. Osteoporosis
1. Abnormal demineralization of bone
 2. Easier to penetrate
- Z. Paget disease (osteitis deformans)
1. Nonmetabolic bone disease causing bone destruction and unorganized bone repair
 2. Difficult to image properly because some areas that are easier to penetrate are adjacent to structures that are harder to penetrate
- AA. Rheumatoid arthritis
1. Destructive collagen disease with inflammation and joint swelling
 2. Harder to penetrate
- BB. Rickets
1. Soft, pliable bones resulting from deficiency of vitamin D and sunlight
 2. Easier to penetrate
- CC. Scoliosis
1. Abnormal lateral curvature of the spine
- DD. Spina bifida
1. Defect of posterior aspect of spinal canal caused by failure of vertebral arch to form properly
- EE. Spondylolysis
1. Defect in pars interarticularis, which is between the superior and inferior articular processes of a vertebra
 2. No displacement present
- FF. Spondylolisthesis
1. Spondylolysis with displacement

Digits (Fingers)

- A. PA
1. *Patient position*: Seated
 2. *Part position*: Separate and center extended digit of interest with palmar surface of hand firmly against image receptor
 3. *Central ray*: Perpendicular, entering proximal interphalangeal joint
- B. Lateral
1. Patient position: Seated
 2. Part position
 - a. Extend digit of interest
 - b. Close rest of digits into a fist
 - c. Adjust digit of interest parallel to image receptor plane
 - d. Immobilize extended digit
 3. *Central ray*: Perpendicular, entering proximal interphalangeal joint
- C. Oblique
1. Patient position: Seated
 2. Part position
 - a. Place patient's hand in lateral position, ulnar side down
 - b. Center to image receptor
 - c. Rotate palm 45 degrees toward image receptor until digits are resting on support
 - d. Immobilize separated digits
 3. *Central ray*: Perpendicular, entering proximal interphalangeal joint

Thumb

- A. AP, lateral, oblique
 1. Patient position: Seated
 2. Part position
 - a. *AP*: Patient's hand is turned in extreme internal rotation, thumb resting on image receptor and other fingers held out of the way
 - b. *Lateral*: Hand in natural, arched position, palm down; adjust hand to put thumb in true lateral position
 - c. *Oblique*: Abduct thumb, palm down
 3. *Central ray (all projections)*: Perpendicular to metacarpophalangeal joint

Hand

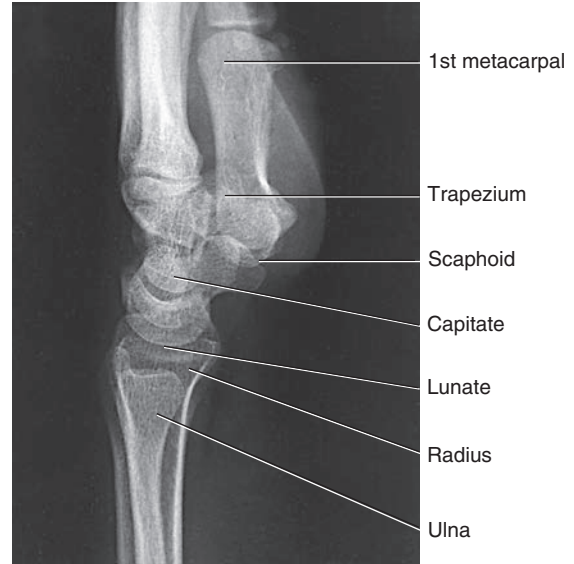
- A. PA
 1. Patient position: Seated
 2. Part position
 - a. Patient rests forearm on table with palmar surface firmly against image receptor
 - b. Spread digits slightly
 3. *Central ray*: Perpendicular to third metacarpophalangeal joint
- B. Oblique
 1. *Patient position*: Seated, forearm resting on table with hand on image receptor in lateral position, ulnar side down
 2. Part position
 - a. Rotate hand medially
 - b. Place digits on a 45-degree radiolucent support to show interphalangeal joints
 - c. Adjust digits parallel to image receptor
 3. *Central ray*: Perpendicular to third metacarpophalangeal joint
- C. Lateral
 1. *Patient position*: Seated, resting ulnar surface of forearm on table with hand in true lateral position
 2. Part position
 - a. Extend digits with first digit (thumb) placed at a right angle to palm of hand
 - b. As an option, patient may "fan" fingers and place on positioning sponge to reduce superimposition of phalanges
 - c. Center metacarpophalangeal joints to image receptor
 - d. Adjust palmar surface of hand perpendicular to image receptor
 3. *Central ray*: Perpendicular to second metacarpophalangeal joint

Wrist

- A. PA
 1. *Patient position*: Seated, forearm resting on table
 2. Part position
 - a. Center carpus to image receptor area
 - b. Digits are flexed slightly to place wrist in contact with image receptor
 3. *Central ray*: Perpendicular to midcarpal area (Figure 5-19)
- B. Lateral
 1. *Patient position*: Elbow is flexed 90 degrees, with forearm and arm in contact with table
 2. *Part position*: Center carpals and adjust hand so wrist is in a lateral position
 3. *Central ray*: Perpendicular to wrist joint (Figure 5-20)



• **Figure 5-19** PA wrist. C, Capitate; G, trapezium; H, hamate; L, lunate; P, pisiform; S, scaphoid; T, triquetrum.



• **Figure 5-20** Lateral wrist.

3. *Central ray*: Perpendicular to midcarpal area (Figure 5-19)
- B. Lateral
 1. *Patient position*: Elbow is flexed 90 degrees, with forearm and arm in contact with table
 2. *Part position*: Center carpals and adjust hand so wrist is in a lateral position
 3. *Central ray*: Perpendicular to wrist joint (Figure 5-20)



• **Figure 5-21** PA oblique wrist.

C. Oblique

1. *Patient position:* Seated, ulnar surface of wrist on image receptor
2. Part position
 - a. Center carpus to image receptor area
 - b. From true lateral position, rotate part approximately 45 degrees medially and support on sponge
3. *Central ray:* Perpendicular to image receptor, entering midcarpal area just distal to radius (**Figure 5-21**)

D. Scaphoid (navicular)

1. *Patient position:* Elbow is flexed 90 degrees, with forearm and arm in contact with table
2. Part position
 - a. Center carpals to image receptor area
 - b. Place patient's wrist in extreme ulnar flexion
3. *Central ray:* Perpendicular to scaphoid; option to delineate fracture may require angulation of 10 to 15 degrees proximally (toward elbow) or distally; another approach is to elevate distal end of image receptor approximately 20 degrees

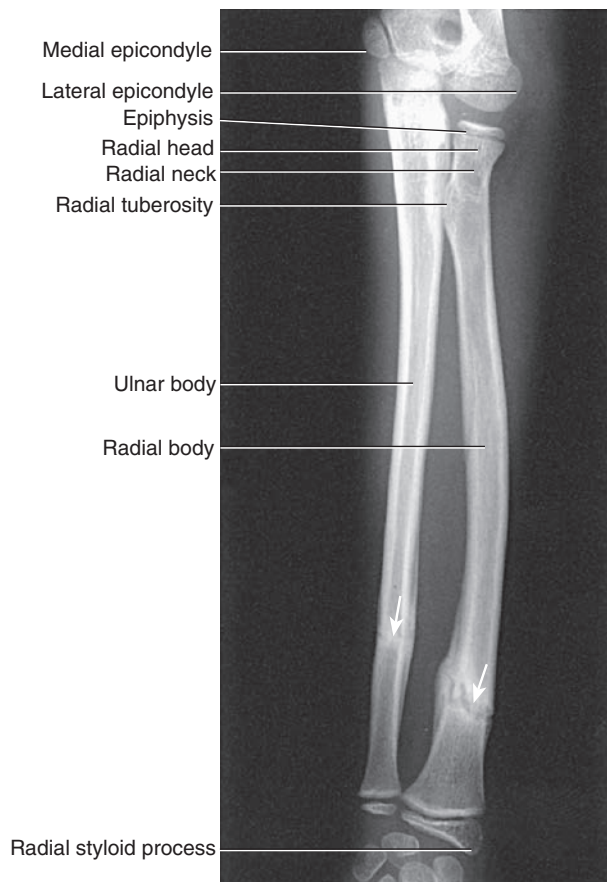
Forearm

A. AP

1. *Patient position:* Seated
2. Part position: Supinate hand and center forearm to image receptor to include joints of interest
3. *Central ray:* Perpendicular to midpoint of forearm (**Figure 5-22**)

B. Lateral

1. *Patient position:* Seated, with humerus and forearm in contact with table; elbow flexed
2. Part position
 - a. Elbow is flexed 90 degrees
 - b. Adjust hand to lateral position (thumb up)



• **Figure 5-22** AP forearm with fractured radius and ulna.

- c. Center forearm to image receptor to include joints of interest
3. *Central ray:* Perpendicular to midpoint of forearm (**Figure 5-23**)

Elbow

A. AP

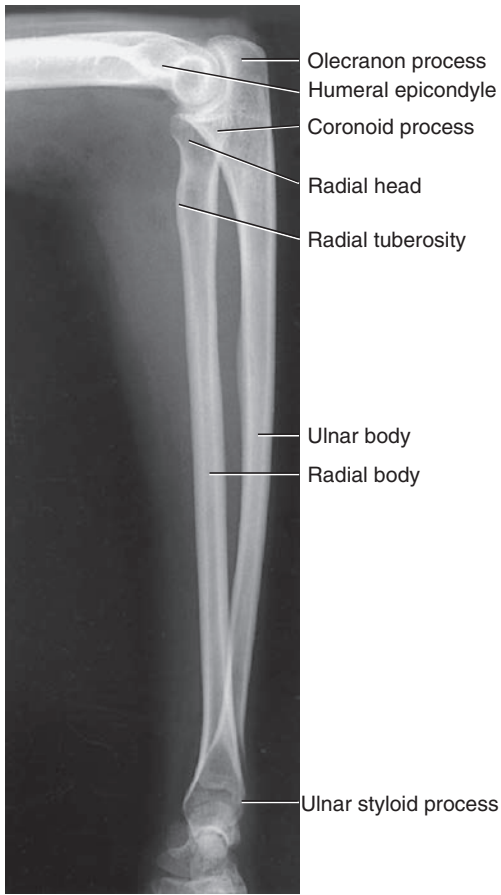
1. *Patient position:* Seated, with arm extended
2. Part position
 - a. Extend patient's elbow
 - b. Supinate hand
 - c. Center elbow joint to image receptor
 - d. Patient may have to lean slightly laterally to ensure AP alignment
3. *Central ray:* Perpendicular to elbow joint (**Figure 5-24**)

B. Lateral

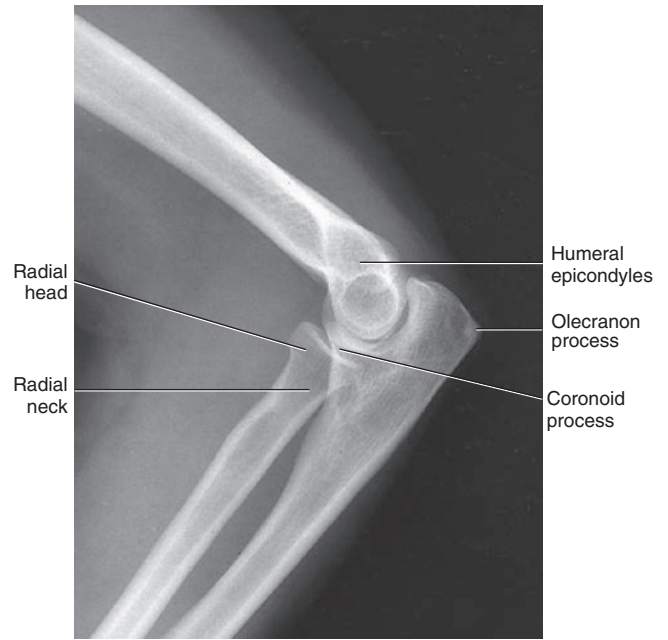
1. *Patient position:* Seated, with elbow flexed 90 degrees; humerus and forearm resting on table
2. Part position
 - a. Center 90-degree flexed elbow joint to image receptor
 - b. Adjust wrist and hand in lateral position
3. *Central ray:* Perpendicular to elbow joint (**Figure 5-25**)

C. Medial oblique

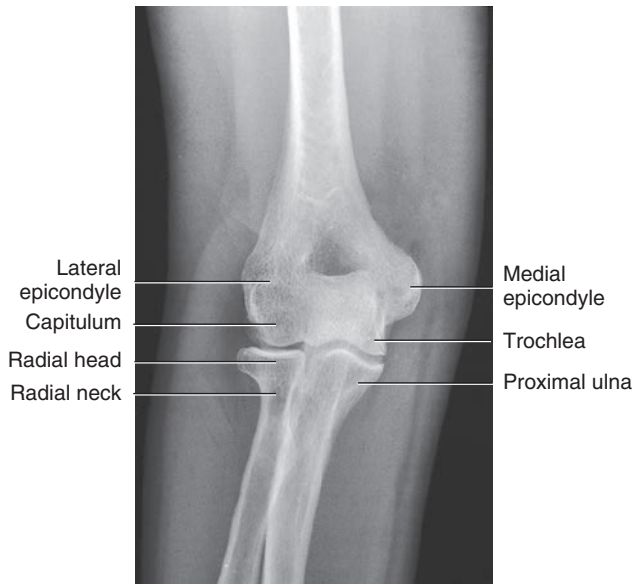
1. *Patient position:* Seated, with arm extended
2. Part position
 - a. Pronate hand
 - b. Medially rotate arm



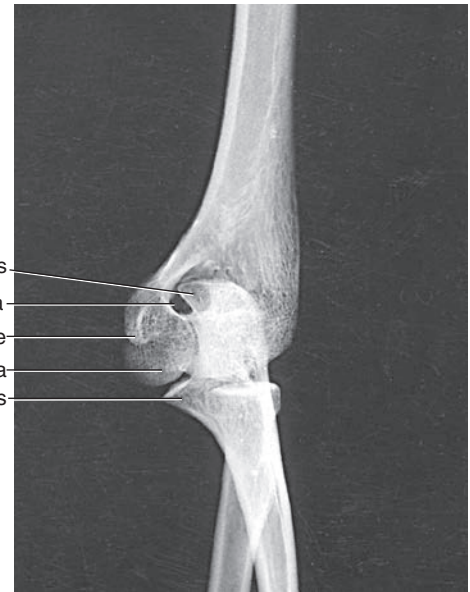
• **Figure 5-23** Lateral forearm.



• **Figure 5-25** Lateral elbow.



• **Figure 5-24** AP elbow.



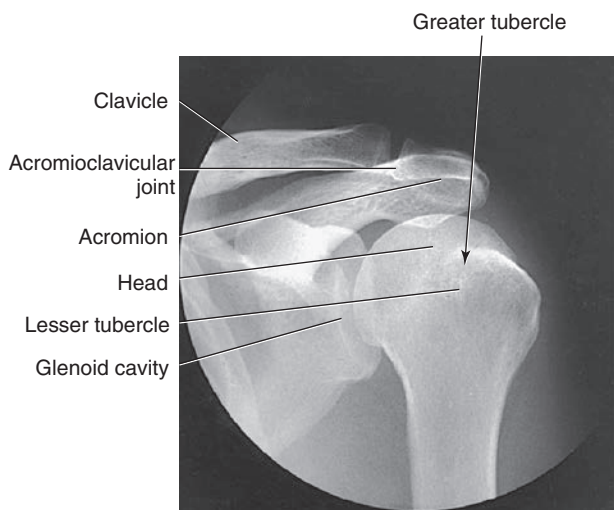
• **Figure 5-26** AP oblique elbow.

- c. Adjust anterior surface of elbow (epicondyles) at angle of 40 to 45 degrees
- 3. *Central ray:* Perpendicular to elbow joint (**Figure 5-26**)
- D. Lateral oblique
 - 1. *Patient position:* Seated, with arm extended
 - 2. Part position

- a. Rotate patient's hand laterally
- b. Adjust posterior surface of elbow at a 40-degree angle to image receptor
- 3. *Central ray:* Perpendicular to elbow joint

Humerus

- A. AP
 - 1. *Patient position:* Erect or supine
 - 2. Part position
 - a. Unless it is contraindicated, supinate patient's hand and adjust humerus with epicondyles parallel to image receptor; keep humerus in neutral



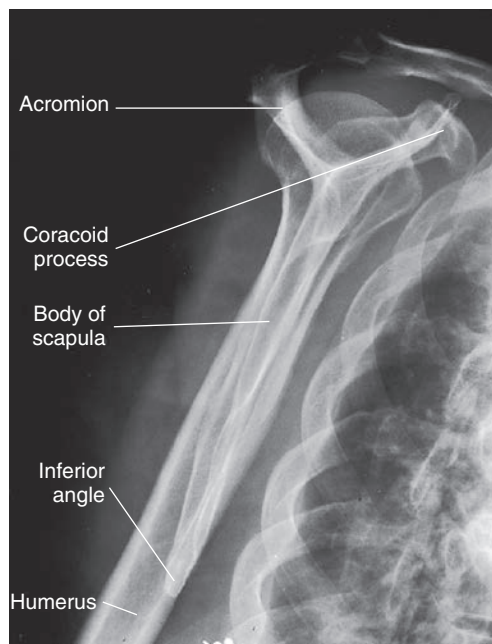
• **Figure 5-27** AP shoulder.

position if fracture is suspected or if reexamining healing fracture with a hanging cast

- b. If patient is recumbent, elevate and support opposite shoulder
 - c. Center humerus to image receptor
 3. *Central ray:* Perpendicular to midpoint of humerus
- B. Lateral
1. *Patient position:* Erect or supine
 2. Part position
 - a. Unless it is contraindicated, slightly abduct the arm and center arm to image receptor
 - b. Medially rotate forearm until epicondyles are perpendicular to image receptor
 3. *Central ray:* Perpendicular to midpoint of humerus

Shoulder

- A. AP
1. *Patient position:* Erect or supine
 2. Part position
 - a. Center area of coracoid process to image receptor
 - b. Rotate patient slightly to place affected scapula parallel to image receptor
 - c. Adjust hand in (1) external rotation to obtain AP projection of humerus or (2) internal rotation for lateral position of humerus
 - d. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to coracoid process (**Figure 5-27**)
- B. Transthoracic lateral
1. *Patient position:* Erect or supine
 2. Part position
 - a. Raise uninjured arm and rest on head
 - b. Elevate uninjured shoulder as much as possible
 - c. *Respiration:* Full inspiration or slow breathing
 3. *Central ray:* Adjust patient to project humerus between vertebral column and sternum; unless it is contraindicated, adjust humeral epicondyles perpendicular



• **Figure 5-28** PA oblique shoulder (scapular Y).

to image receptor; central ray perpendicular to median coronal plane, exiting surgical neck of affected humerus; if patient cannot elevate unaffected shoulder, the central ray may be angled 10 to 15 degrees cephalad

- C. PA oblique (scapular Y)
1. *Patient position:* Erect or prone oblique
 2. Part position
 - a. Center anterior surface of affected shoulder to image receptor
 - b. Rotate patient so that midcoronal plane forms a 60-degree angle from image receptor
 - c. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to shoulder joint at level of scapulohumeral joint (**Figure 5-28**)

Acromioclavicular Articulations

- A. AP
1. *Patient position:* Upright if condition permits
 2. Part position
 - a. Adjust midpoint of image receptor to level of acromioclavicular (AC) joints
 - b. Center MSP of patient's body to midline of image receptor, if both AC joints can be shown on one image
 - c. Otherwise, center to each individual AC joint for two separate exposures
 - d. To show AC separation, sandbags of equal weight should be attached to each wrist, and a second image should be obtained without weights
 - e. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor, midway between AC joints or perpendicular to each AC joint

Clavicle

A. PA

1. *Patient position:* Erect or prone; may be AP for patient comfort
2. Part position
 - a. Center clavicle to center of image receptor midway between midline of body and coracoid process
 - b. Head may be turned away from affected side
 - c. *Respiration:* Suspended
3. *Central ray:* Perpendicular to midshaft of clavicle

B. PA axial

1. *Patient position:* Erect or prone; may be supine (AP axial) for patient comfort
2. Part position
 - a. Center clavicle to midline of table with image receptor midway between MSP and coracoid process
 - b. Head may be turned away from affected side
 - c. *Respiration:* Suspended
3. *Central ray:* Angle 25 to 30 degrees caudad, centered to the midshaft of the clavicle (25 to 30 degrees cephalad if performed AP)

Scapula

A. AP

1. *Patient position:* Supine or upright (upright preferred when shoulder is tender)
2. Part position
 - a. Abduct arm
 - b. Flex elbow
 - c. Support hand near head
 - d. Center palpated scapular area to image receptor approximately 2 inches inferior to coracoid process
 - e. *Respiration:* Quiet breathing
3. *Central ray:* Perpendicular to image receptor at mid-scapular area approximately 2 inches inferior to coracoid process (Figure 5-29)

B. Lateral

1. *Patient position:* Prone oblique or upright (upright preferred when shoulder is tender)
2. Part position
 - a. Place patient in an oblique position with affected scapula centered to image receptor
 - b. Extend affected arm across anterior thorax
 - c. Palpate axillary and vertebral borders of scapula and adjust body rotation so that scapula is lateral and is projected free of rib cage
 - d. *Respiration:* Suspended
3. *Central ray:* Perpendicular to medial border of protruding scapula

Toes

A. AP axial

1. *Patient position:* Supine or seated on table, knees flexed with feet separated
2. *Part position:* Center toes with plantar surface flat against image receptor
3. *Central ray:* 15 degrees cephalad, if positioning wedge is not used; enters the second metatarsophalangeal joint

B. Oblique

1. *Patient position:* Supine or seated on table, knees flexed with feet separated
2. *Part position:* Center patient's toes over image receptor area and medially rotate leg and foot until a 30- to 45-degree angle is formed from image receptor to plantar surface of foot
3. *Central ray:* Perpendicular, entering third metatarsophalangeal joint

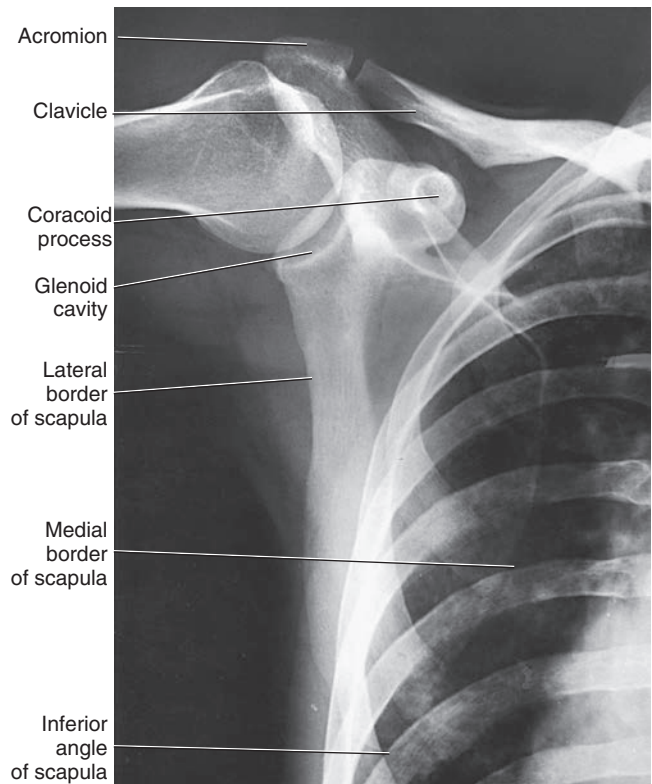
Foot

A. AP axial

1. *Patient position:* Supine or seated on table, knees flexed with feet separated
2. Part position
 - a. Plantar surface firmly resting on image receptor
 - b. Center foot to image receptor
 - c. Adjust midline of foot parallel to long axis of image receptor
3. *Central ray:* 10 degrees toward the heel, entering base of third metatarsal

B. Medial oblique

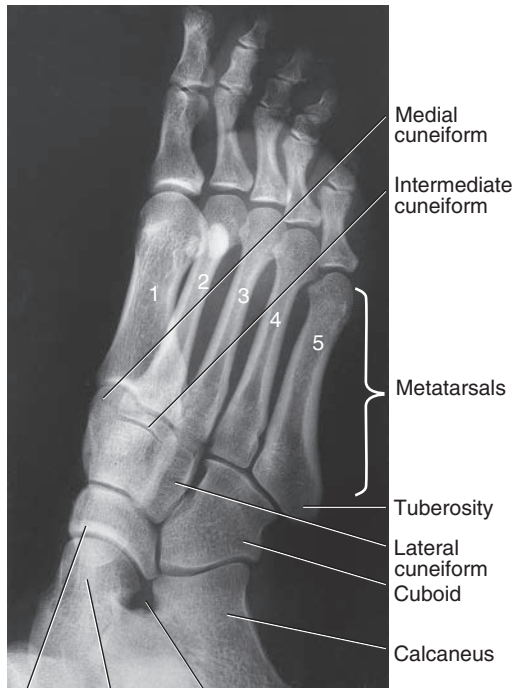
1. *Patient position:* Supine or seated on table, knees flexed with feet separated
2. Part position
 - a. Center foot to image receptor
 - b. Rotate leg medially until plantar surface forms angle of 30 degrees to image receptor
3. *Central ray:* Perpendicular to base of third metatarsal (Figure 5-30)



• Figure 5-29 AP scapula.

C. Lateral (mediolateral)

1. Patient position
 - a. With the patient lying on the affected side, adjust leg and foot in lateral position
 - b. Patella perpendicular to table
2. *Part position*: Center foot and adjust plantar surface perpendicular to image receptor
3. *Central ray*: Perpendicular to midpoint of image receptor, entering base of third metatarsal



• **Figure 5-30** AP oblique foot in medial rotation.

Calcaneus

A. Axial (plantar dorsal)

1. *Patient position*: Supine or seated with leg fully extended
2. Part position
 - a. Center image receptor to ankle
 - b. Draw the plantar surface of foot perpendicular to image receptor
3. *Central ray*: 40 degrees cephalad to long axis of foot, entering midline at level of base of fifth metatarsal

B. Lateral

1. Patient position
 - a. With the patient lying on the affected side, adjust leg and foot in lateral position
 - b. Patella perpendicular to table
2. *Part position*: Center calcaneus to image receptor, about 1 to 1½ inches distal to medial malleolus

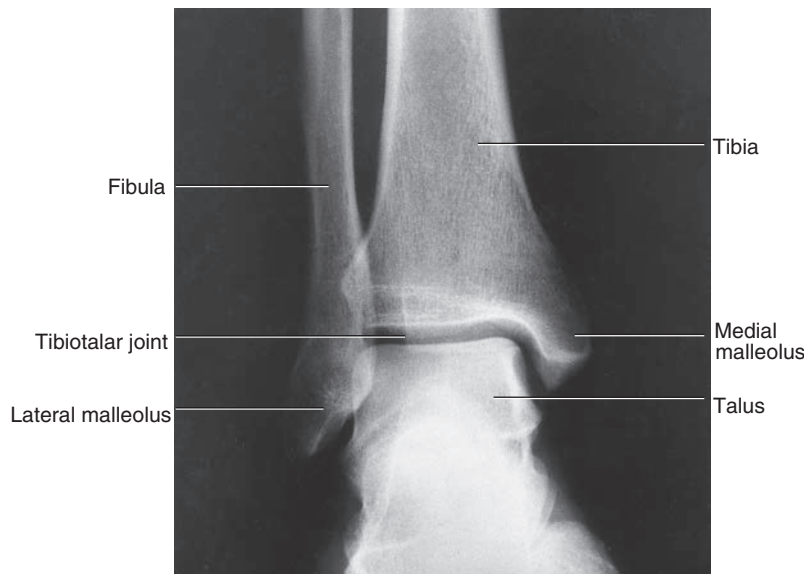
C. *Central ray*: Perpendicular to midportion of calcaneus**Ankle**

A. AP

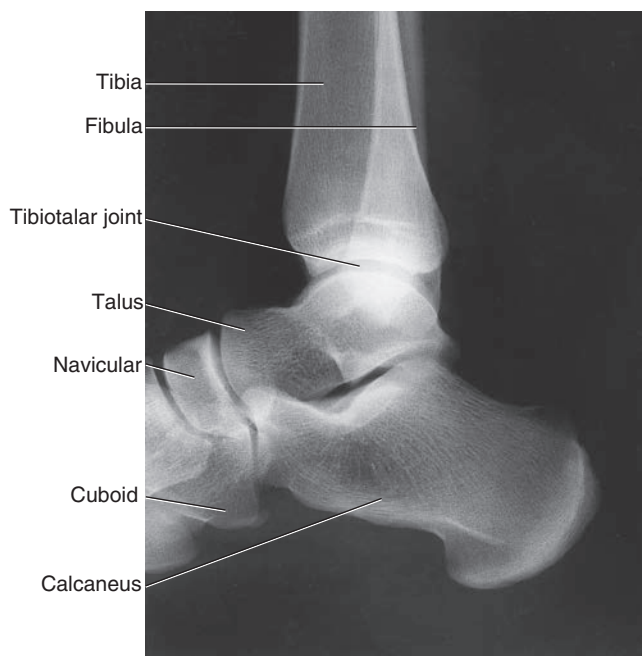
1. *Patient position*: Supine or seated on table with small support under knee
2. Part position
 - a. Center ankle to image receptor
 - b. Dorsiflex foot
 - c. Adjust ankle with toes pointing vertically
3. *Central ray*: Perpendicular to ankle joint midway between malleoli (**Figure 5-31**)

B. Lateral

1. *Patient position*: Supine; roll onto affected side
2. Part position
 - a. Rotate patient's ankle to lateral position
 - b. Adjust foot in lateral position
 - c. Center ankle to image receptor
3. *Central ray*: Vertical through medial malleolus (**Figure 5-32**)



• **Figure 5-31** AP ankle.



• **Figure 5-32** Lateral ankle.

C. Medial oblique

1. *Patient position:* Supine or seated on table
2. Part position
 - a. Rotate patient's leg and foot medially
 - b. Adjust degree of medial rotation
 - (1) *Mortise joint:* Until malleoli are parallel with image receptor (15 to 20 degrees)
 - (2) *Bony structure:* Up to 45 degrees rotation
3. *Central ray:* Vertical midway between malleoli

Leg

A. AP

1. *Patient position:* Supine with leg extended
2. Part position
 - a. Center leg to image receptor
 - b. Adjust leg to AP position
 - c. Both joints should be included
3. *Central ray:* Vertical to midpoint of leg

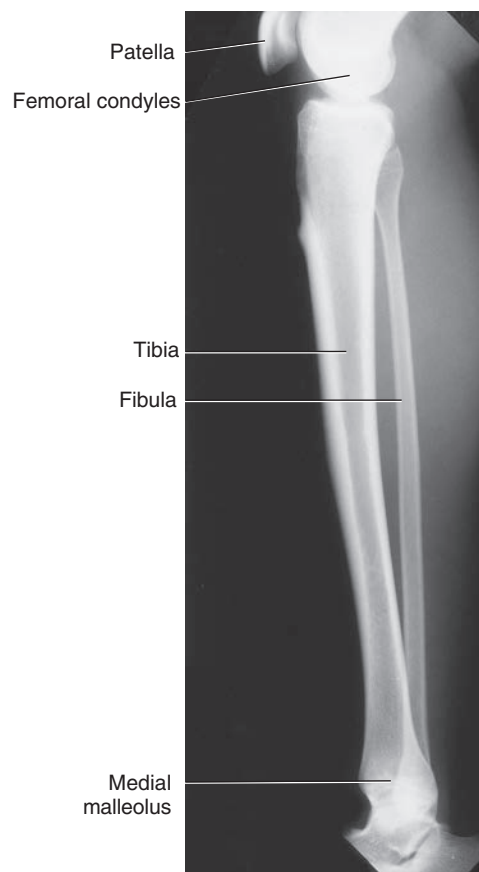
B. Lateral

1. *Patient position:* Supine and roll onto affected side
2. Part position
 - a. Center leg to image receptor
 - b. Adjust leg to lateral position
 - c. Patella perpendicular
 - d. Both joints should be included
3. *Central ray:* Perpendicular to midpoint of leg (**Figure 5-33**)

Knee

A. AP

1. *Patient position:* Supine and with leg extended; adjust patient's body so that pelvis is not rotated
2. Part position



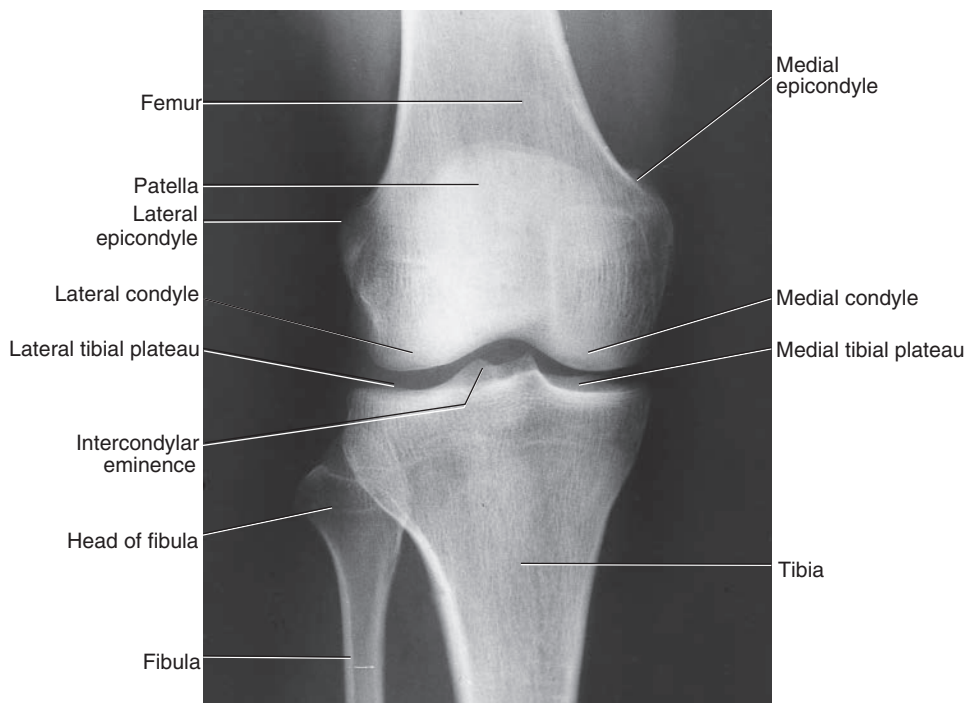
• **Figure 5-33** Lateral tibia and fibula.

- a. Center knee to image receptor
 - b. Adjust leg to AP position
 3. *Central ray:* 5 to 7 degrees cephalad to a point ½ inch inferior to patellar apex (**Figure 5-34**)
- #### B. Lateral
1. *Patient position:* Turn patient onto affected side with knee flexed (usually 20 to 30 degrees)
 2. Part position
 - a. Flex and center knee
 - b. Center image receptor approximately 1 inch distal to medial epicondyle
 - c. Patella perpendicular to image receptor
 3. *Central ray:* 5 degrees cephalad, entering knee joint inferior to medial condyle
- #### C. Intercondylar fossa (tunnel)
1. *Patient position:* Kneeling on radiographic table with affected knee flexed 70 degrees from full extension
 2. Part position
 - a. Center knee to image receptor
 - b. Place at level of patellar apex
 - c. Flex knee 70 degrees from full extension
 3. *Central ray:* Perpendicular to long axis of lower leg, entering midpopliteal area

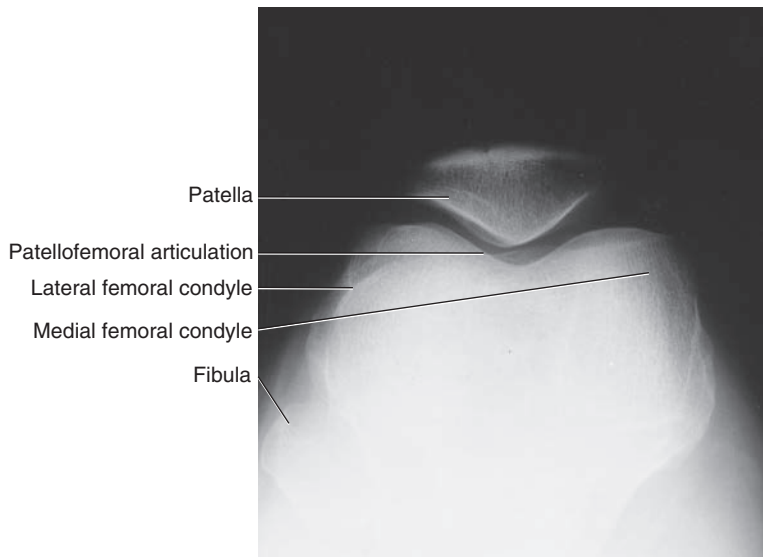
Patella

A. PA

1. *Patient position:* Prone with knee extended



• **Figure 5-34** AP knee.



• **Figure 5-35** Tangential patella (Settegast method).

2. Part position
 - a. Center patella
 - b. Adjust to be parallel with image receptor plane
 - c. Heel generally rotated 5 to 10 degrees laterally
3. *Central ray*: Perpendicular to midpopliteal area
- B. Tangential
 1. *Patient position*: Prone with foot resting on table
 2. *Part position*: Flex affected knee so that tibia and fibula form a 50- to 60-degree angle from table
 3. *Central ray*: 45 degrees cephalad through patellofemoral joint (**Figure 5-35**)
- C. Lateral
 1. *Patient position*: Lying on affected side

2. *Part position*: Flex knee 5 to 10 degrees, femoral epicondyles superimposed
3. *Central ray*: Perpendicular to patella

Femur

- A. AP
 1. *Patient position*: Supine with toes up
 2. Part position
 - a. Center affected thigh to midline of table
 - b. Internally rotate lower limb approximately 15 degrees
 - c. Both joints should be included
 - d. Apply gonadal shielding as appropriate
 3. *Central ray*: Perpendicular to midfemur

B. Lateral

1. *Patient position:* Lying on affected side with knee slightly flexed
2. Part position
 - a. Rotate patient's unaffected hip (including hip joint) posteriorly to prevent superimposition of unaffected hip
 - b. Center femur to midline of table
 - c. Both joints should be included
 - d. Apply gonadal shielding as appropriate
3. *Central ray:* Perpendicular to midfemur

Pelvis

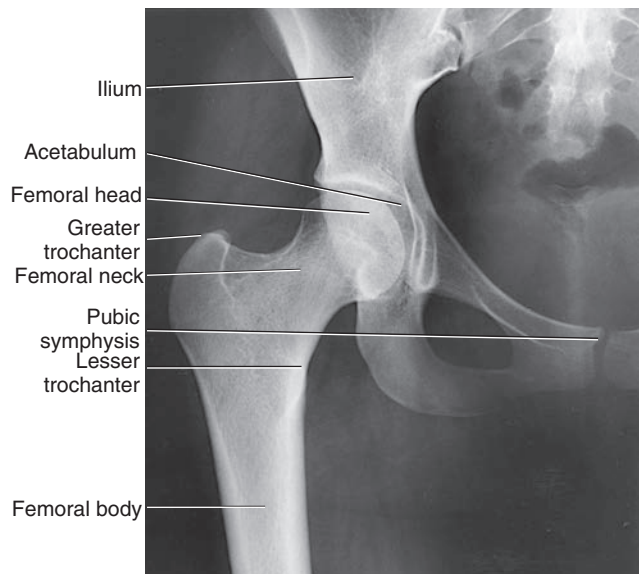
A. AP

1. Patient position: Supine
2. Part position
 - a. Center MSP to table
 - b. Adjust to AP position
 - c. Internally rotate feet and lower limb 15 degrees
 - d. Center image receptor approximately 2 inches superior to level of greater trochanter
 - e. Use gonadal shielding as appropriate
 - f. *Respiration:* Suspended
3. *Central ray:* Perpendicular to midpoint of image receptor 2 inches superior to symphysis pubis

Hip

A. AP

1. Patient position: Supine
2. Part position
 - a. Rotate lower limb 15 degrees medially
 - b. Center hip to image receptor
 - c. *Respiration:* Suspended
3. *Central ray:* Perpendicular to a point 2 inches medial to ASIS and at level of superior margin of greater trochanter (Figure 5-36)



• Figure 5-36 AP hip.

B. Lateral

1. *Patient position:* From supine position, turn patient toward affected side to posterior oblique body position
2. Part position
 - a. Flex affected knee
 - b. Center affected hip to midline of table
 - c. Extend unaffected knee
 - d. *Respiration:* Suspended
3. *Central ray:* Perpendicular to a point midway between ASIS and symphysis pubis

C. Axiolateral

1. *Patient position:* Supine with level of greater trochanter elevated to center of image receptor
2. Part position
 - a. Flex knee and hip of unaffected side
 - b. Elevate and rest on suitable support
 - c. Adjust pelvis to supine position
 - d. Unless it is contraindicated, rotate affected leg 15 to 20 degrees internally
 - e. *Respiration:* Suspended
3. *Central ray:* Perpendicular to long axis of femoral neck and image receptor

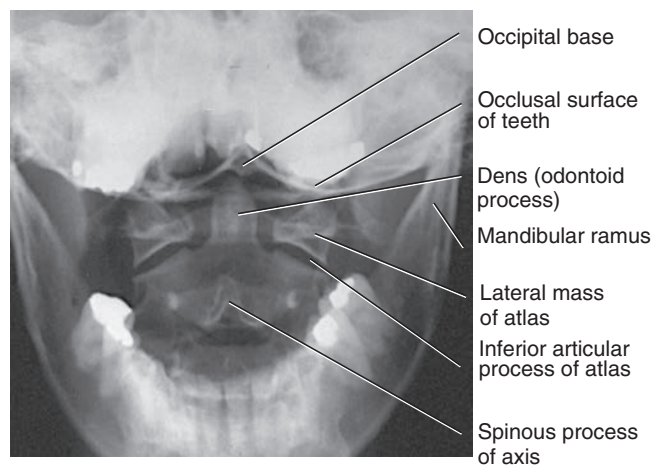
Cervical Vertebrae

A. Atlas and axis

1. *Patient position:* Erect or supine
2. Part position
 - a. MSP centered to image receptor at level of C2
 - b. Arms by sides
 - c. Shoulders in same plane
 - d. Have patient open mouth wide
 - e. Adjust head so that line from lower edge of upper incisors to mastoid process is perpendicular to image receptor
 - f. *Respiration:* Phonate "ah" during exposure
3. *Central ray:* Perpendicular to image receptor, centered to open mouth (Figure 5-37)

B. AP axial

1. *Patient position:* Erect or supine



• Figure 5-37 Open-mouth atlas and axis.

2. Part position
 - a. MSP centered to image receptor
 - b. Arms by sides
 - c. Center image receptor at level of C4
 - d. Adjust a line between upper occlusal plane and mastoid tip, perpendicular to image receptor
 - e. *Respiration:* Suspended
 3. *Central ray:* 15 to 20 degrees cephalad, entering slightly inferior to thyroid cartilage (Figure 5-38)
- C. Lateral
1. *Patient position:* Seated or standing in lateral position
 2. Part position
 - a. Center coronal plane through mastoid tips to image receptor
 - b. Adjust patient's shoulders to same horizontal level and body to true lateral position
 - c. Elevate chin slightly
 - d. Relax shoulders
 - e. Weights may be attached to wrists to help lower shoulders
 - f. Source-to-image receptor distance (SID) recommended—72 inches
 - g. *Respiration:* Expiration
 3. *Central ray:* Perpendicular to image receptor entering C4 (Figure 5-39)
- D. LPO and RPO (AP axial oblique projections)
1. *Patient position:* Seated or standing
 2. Part position
 - a. Rotate body 45 degrees
 - b. Place side of interest farther from image receptor
 - c. Have patient slightly extend chin while looking forward
 - d. Center spine to image receptor

- e. Obtain both oblique projections
- f. *Respiration:* Suspended
3. *Central ray:* 15 to 20 degrees cephalad, entering C4 (Figure 5-40)

Thoracic Vertebrae

A. AP

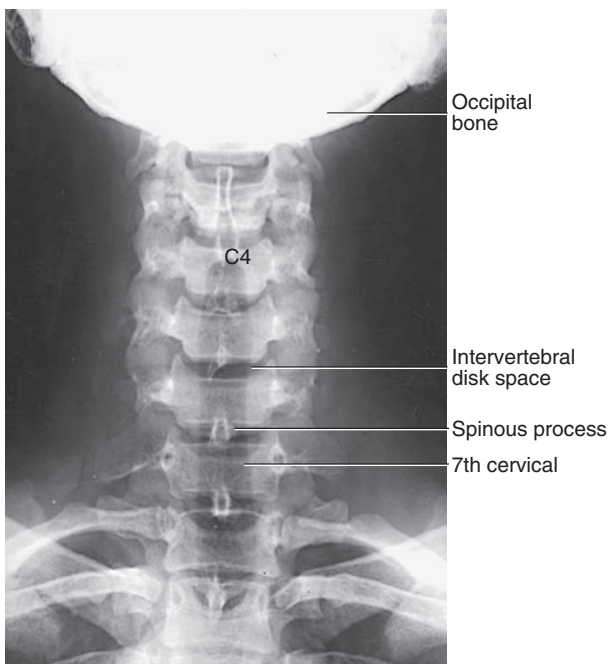
1. *Patient position:* Supine or upright
2. Part position
 - a. MSP centered to image receptor
 - b. Top of image receptor 1½ to 2 inches above shoulders
 - c. Arms by sides
 - d. Shoulders in same plane
 - e. *Respiration:* Shallow or suspended expiration
3. *Central ray:* Perpendicular to T7, 3 to 4 inches distal to jugular (manubrial) notch

B. Lateral

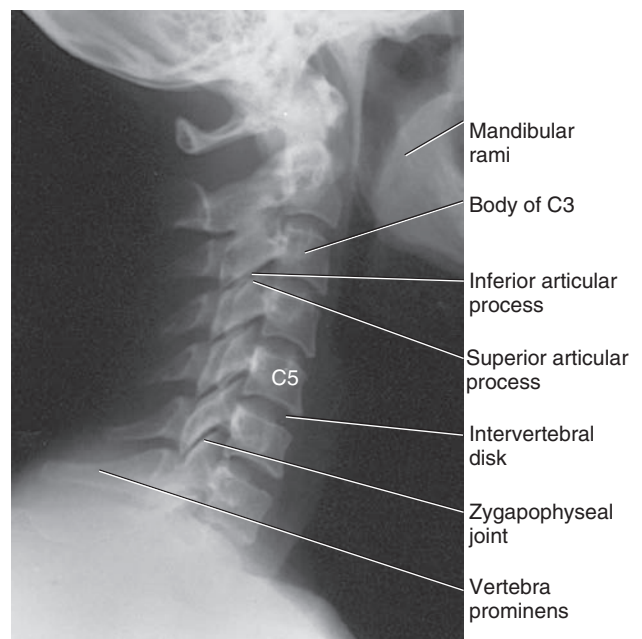
1. *Patient position:* Lateral recumbent or erect
2. Part position
 - a. Elevate head to spine level
 - b. Extend arms forward
 - c. Place radiolucent support under lower thoracic region until spine is horizontal to top of table
 - d. *Respiration:* Shallow or suspended expiration
3. *Central ray:* Perpendicular to image receptor, entering level of T7, approximately 3 to 4 inches below sternal angle (Figure 5-41)

C. Cervicothoracic (twining)

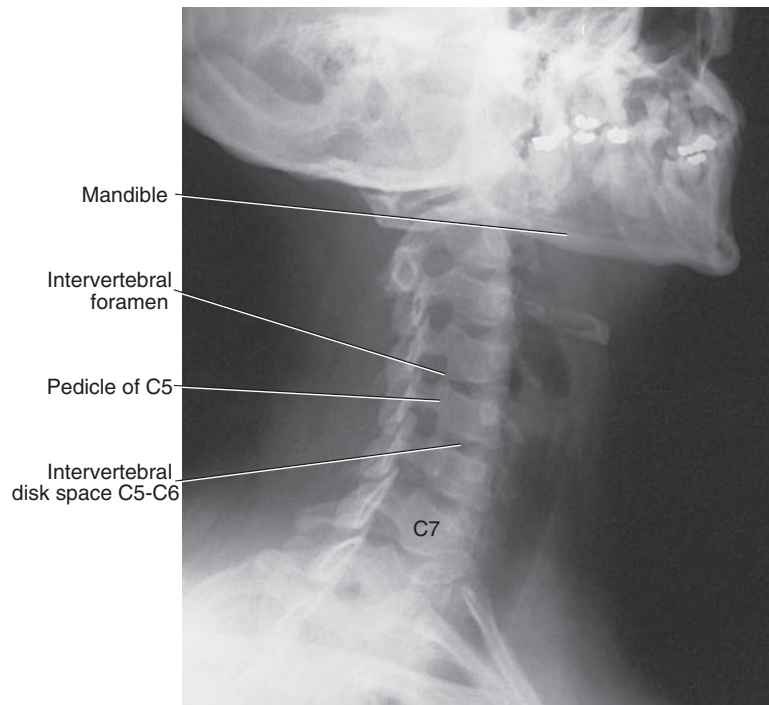
1. *Patient position:* Lateral, seated, or standing
2. Part position
 - a. Center midcoronal plane to grid
 - b. Elevate arm adjacent to Bucky
 - c. Center image receptor to level of T2



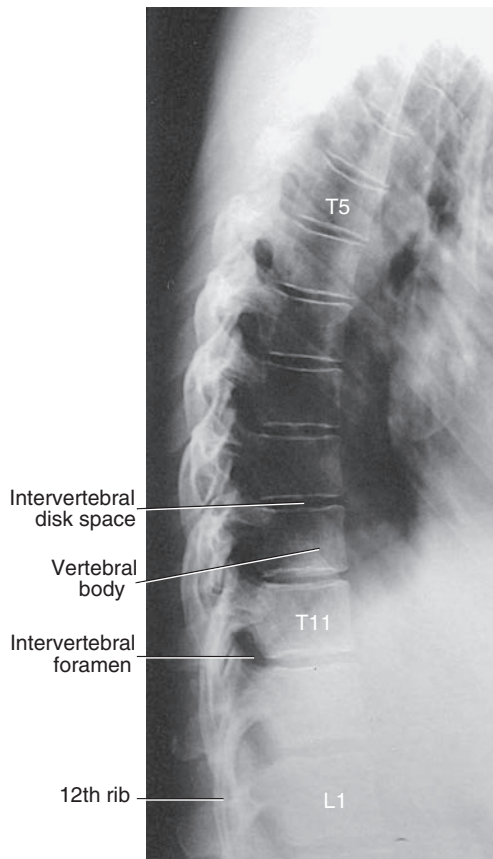
• **Figure 5-38** AP axial cervical vertebrae.



• **Figure 5-39** Lateral cervical vertebrae.



• **Figure 5-40** RAO showing right side.



• **Figure 5-41** Lateral thoracic spine.

- d. Body in true lateral position
- e. *Respiration*: Suspended
3. *Central ray*: Perpendicular to image receptor, entering at level of T2 ([Figure 5-42](#))

Lumbar Vertebrae

A. AP

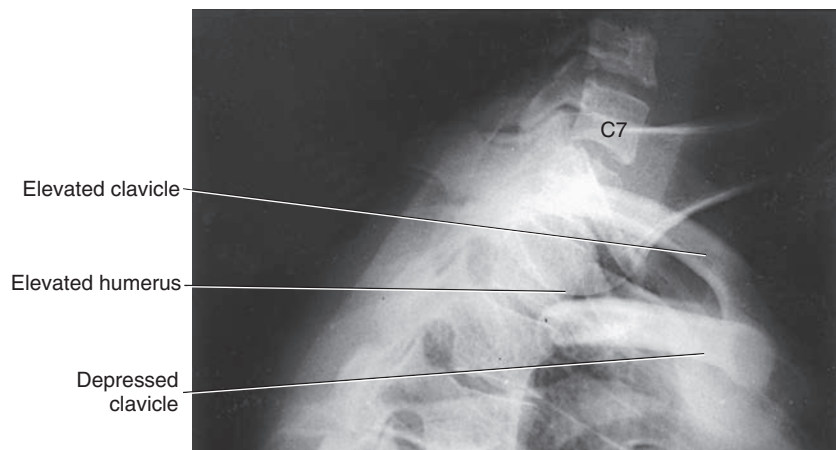
1. *Patient position*: Supine
2. *Part position*
 - a. MSP centered to table
 - b. Flex patient's knees and hips enough to place back in firm contact with table
 - c. Center image receptor at level of iliac crest (L4)
 - d. *Respiration*: Suspended
3. *Central ray*: Perpendicular to midline, entering level of iliac crests ([Figure 5-43](#))

B. Lateral

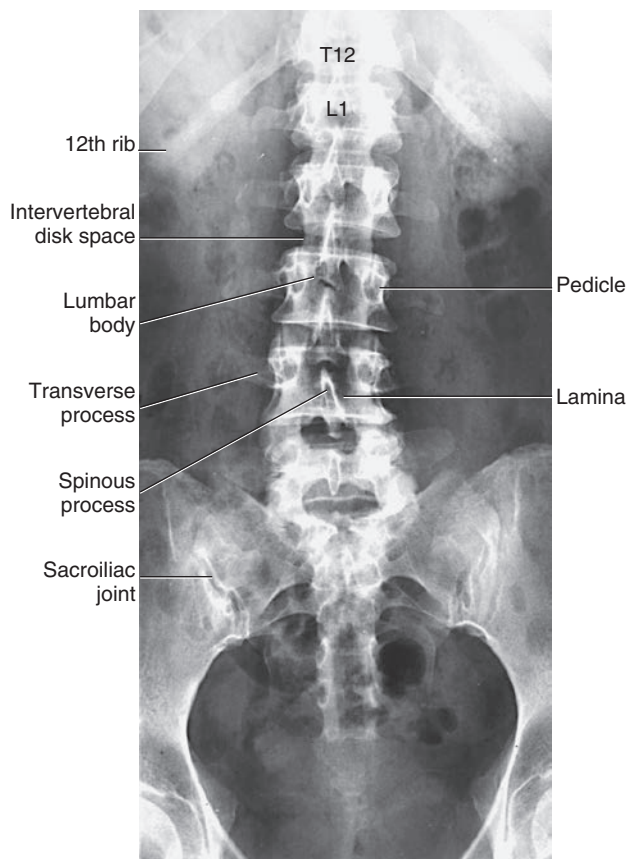
1. *Patient position*: Lateral with hips and knees flexed
2. *Part position*
 - a. Center midaxillary line of body and L4 to table
 - b. Extend arms forward
 - c. Place radiolucent support under lower thorax, and adjust spine parallel to table
 - d. Check for true lateral position
 - e. *Respiration*: Suspended
3. *Central ray*: Perpendicular to image receptor, entering midaxillary line at level of iliac crests ([Figure 5-44](#))

C. Lateral L5 to S1

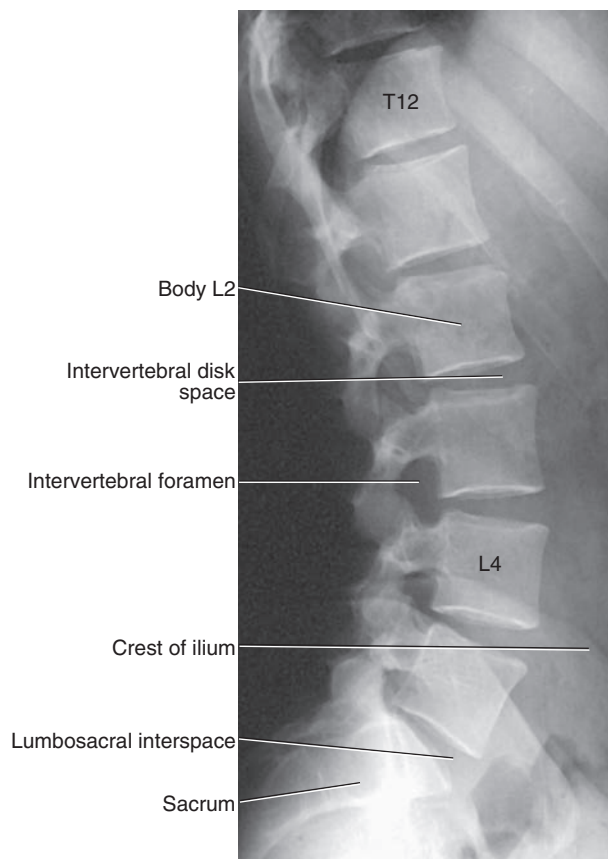
1. *Patient position*: Lateral with hips and knees flexed
2. *Part position*



• **Figure 5-42** Lateral cervicothoracic region (twining method).



• **Figure 5-43** AP lumbar spine.



• **Figure 5-44** Lateral lumbar spine.

- a. Center 1½ inches posterior to midaxillary line and 1½ inches below iliac crest
- b. Extend arms forward
- c. Place radiolucent support under lower thorax, and adjust spine parallel to table
- d. Check for true lateral position
- e. Collimate tightly
- f. *Respiration:* Suspended
3. *Central ray:* Perpendicular to a point 2 inches posterior to ASIS and 1½ inches inferior to iliac crest (if

spine cannot be placed in a true horizontal position, may need to angle central ray caudally—5 degrees in male patients, 8 degrees in female patients)

- D. LPO and RPO (AP oblique projections)
 1. *Patient position:* Posterior oblique; side closest to image receptor is side of interest
 2. Part position
 - a. Adjust and support body obliquity to 45 degrees
 - b. Adjust arms to a comfortable position
 - c. Center spine to midline of table

- d. Center image receptor at level of L3
- e. Obtain oblique projections of both sides
- f. *Respiration*: Suspended
3. *Central ray*: Perpendicular to L3, 1 to 2 inches above level of iliac crest, entering elevated side 2 inches laterally from patient's midline

Sacroiliac Joints

- A. LPO and RPO (AP oblique)
 1. Patient position: Supine
 2. Part position
 - a. Elevate and support side of interest 25 to 30 degrees from table
 - b. Align sagittal plane passing 1 inch medial to ASIS of elevated side centered to image receptor
 - c. Center to table
 - d. Obtain both oblique projections
 - e. *Respiration*: Suspended
 3. *Central ray*: Perpendicular to image receptor, 1 inch medial to elevated ASIS

Sacrum

- A. AP axial
 1. Patient position: Supine
 2. Part position
 - a. Center MSP to center of table
 - b. *Respiration*: Suspended
 3. *Central ray*: 15 degrees cephalad, entering 2 inches superior to symphysis pubis
- B. Lateral
 1. *Patient position*: Lateral with hips and knees flexed
 2. Part position
 - a. Support body to place long axis of spine horizontally
 - b. Align coronal plane, passing 3 inches posterior to median coronal plane
 - c. Center to midline of table
 - d. *Respiration*: Suspended
 3. *Central ray*: Perpendicular to image receptor, entering 3 inches posterior to median coronal plane at level of ASIS

Coccyx

- A. AP axial
 1. Patient position: Supine
 2. Part position
 - a. Center MSP to center of table
 - b. *Respiration*: Suspended
 3. *Central ray*: 10 degrees caudad, entering 2 inches superior to symphysis pubis
- B. Lateral
 1. *Patient position*: Lateral with hips and knees flexed
 2. Part position
 - a. Support body to place long axis of spine horizontally
 - b. Align coronal plane passing approximately 5 inches posterior to median coronal plane
 - c. Center to midline of table
 - d. *Respiration*: Suspended

3. *Central ray*: Perpendicular to image receptor, entering palpated coccyx located approximately 5 inches posterior to median coronal plane

Scoliosis Series

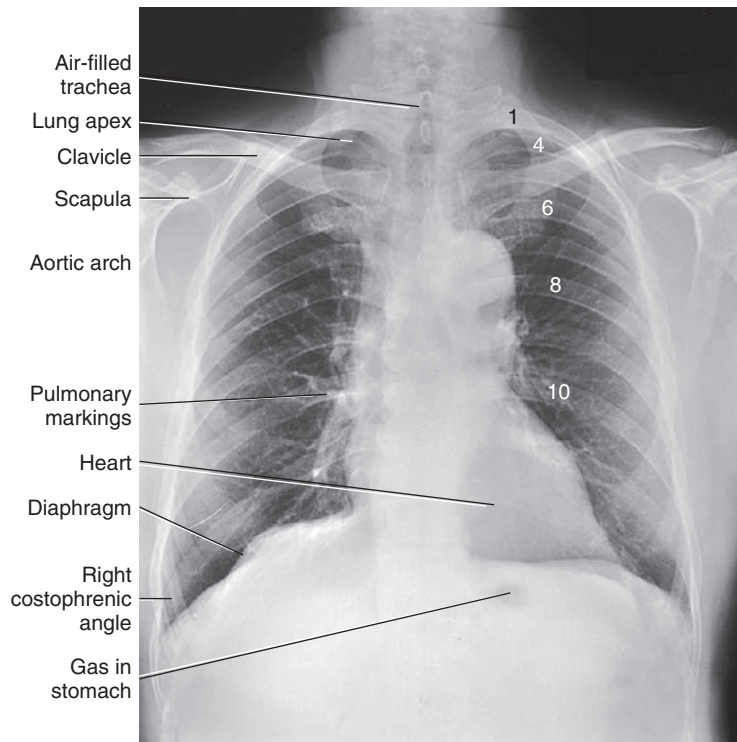
- A. PA (to minimize exposure to breast tissue; AP may be performed with compensating filters)
 1. *Patient position*: Seated or standing
 2. Part position
 - a. *First image*: MSP centered to image receptor; image receptor adjusted to include 1 inch of the iliac crests; arms at sides
 - b. *Second image*: MSP centered to image receptor; elevate hip or foot to convex side of curve 3 or 4 inches on a block
 3. *Central ray*: Perpendicular to the midpoint of the image receptor

Thorax

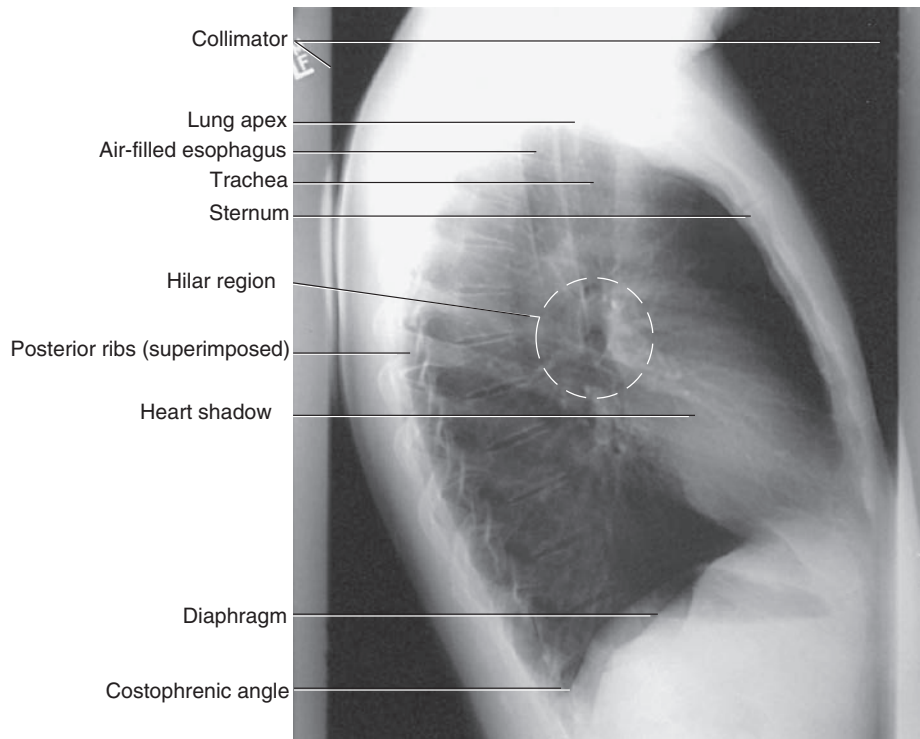
Pathologic Conditions Imaged

- A. Adult respiratory distress syndrome
 1. Acute life-threatening respiratory distress
 2. Large amount of fluid in interstitial and alveolar spaces
 3. Harder to penetrate
- B. Asthma
 1. Pulmonary disorder with increased mucus production in bronchi, causing hyperventilation of the lungs
 2. Bronchi harder to penetrate
 3. Lungs easier to penetrate
- C. Atelectasis
 1. Collapse of lung tissue
 2. Harder to penetrate
- D. Bronchial adenoma
 1. Neoplasm occurring in a bronchus, causing atelectasis and pneumonitis
 2. Harder to penetrate
- E. Bronchiectasis
 1. Dilation and destruction of bronchial walls
 2. Consolidation present
 3. Harder to penetrate
- F. Bronchogenic carcinoma
 1. Lung cancer arising from the bronchial mucosa
 2. Harder to penetrate
- G. Chronic bronchitis
 1. Debilitating pulmonary disease with substantial increase of mucus production in the trachea and bronchi
 2. Harder to penetrate unless evolved into emphysema, which is easier to penetrate
- H. Chronic obstructive pulmonary disease (COPD)
 1. Progressive condition marked by diminished capabilities of inspiration and expiration
 2. Harder to penetrate
- I. Croup
 1. Acute viral infection of respiratory system in infants
 2. Lateral soft tissue neck image taken to show epiglottic narrowing

- J. Cystic fibrosis
1. Inherited pathologic condition of exocrine glands
 2. Marked by increased mucus secretion in lungs and bronchi
 3. Harder to penetrate
- K. Emphysema
1. Overinflation of alveolar walls
 2. Easier to penetrate
 3. Should not be imaged with use of automatic exposure controls (AECs) because minimum reaction time of equipment usually results in overexposure, necessitating repeat exposures
- L. Empyema
1. Pus in the pleural space
 2. Harder to penetrate
- M. Histoplasmosis
1. Infection caused by inhaling fungal spores
 2. Harder to penetrate
- N. Hyaline membrane disease
1. Respiratory distress syndrome of the newborn
 2. Acute lung disease in newborn; characteristics include airless alveoli and rapid respirations
 3. Harder to penetrate
- O. Legionnaires' disease
1. Form of acute bacterial pneumonia
 2. Harder to penetrate
- P. Pleural effusion
1. Accumulation of fluid in intrapleural spaces
 2. Harder to penetrate
- Q. Pneumoconiosis
1. Lung disease caused by inhaling dust (usually mineral dust from the environment or workplace)
 2. *Silicosis*: Caused by prolonged inhalation of silicon dioxide (sand)
 3. *Anthracois*: Caused by prolonged inhalation of anthracite (coal dust)
 4. *Asbestosis*: Caused by prolonged inhalation of asbestos
 5. *Siderosis*: Caused by prolonged inhalation of iron dust
 6. All are harder to penetrate
- R. Pneumonia
1. Acute inflammation of the lungs
 2. Harder to penetrate
- S. Pneumothorax
1. Air in the pleural space that causes the lung to collapse
 2. Easier to penetrate
- T. Pulmonary metastases
1. Spread of cancer into the lungs from a primary site
 2. Harder to penetrate
- U. Tuberculosis
1. Chronic infection of the lungs caused by acid-fast bacillus
 2. More difficult to penetrate
- Chest**
- A. PA
1. Patient position
 - a. Standing or seated erect
 - b. Back of hands on hips
 - c. Top of image receptor 1 to 2 inches above relaxed shoulders
 2. Part position
 - a. MSP centered
 - b. Chin extended and pointing straight ahead
 - c. Roll shoulders forward
 - d. SID recommended—72 inches
 - e. *Respiration*: Full inspiration (expose at end of second inspiration)
 3. *Central ray*: Perpendicular to MSP at level of T7 (Figure 5-45)
- B. Lateral
1. Patient position
 - a. Standing or seated erect
 - b. Left side against image receptor unless otherwise specified
 - c. Top of image receptor 1 to 2 inches above relaxed shoulder
 2. Part position
 - a. MSP parallel to image receptor
 - b. Adjacent shoulder resting against image receptor holder
 - c. Arms raised and crossed over head
 - d. Center thorax to image receptor
 - e. SID recommended—72 inches
 - f. *Respiration*: Full inspiration (expose at end of second inspiration)
 3. *Central ray*: Perpendicular to image receptor, entering patient approximately 2 inches anterior to midaxillary plane at level of T7 (Figure 5-46)
- C. LAO and RAO (PA oblique projections)
1. Patient position
 - a. Standing or seated
 - b. Adjust coronal plane 45 degrees (or 60 degrees) from plane of image receptor
 - c. Top of image receptor 2 inches above shoulders
 - d. Side farther from image receptor is usually side of primary interest
 2. Part position
 - a. Shoulder nearer image receptor rolled posteriorly
 - b. Hand placed on hip
 - c. Arm farther from image receptor placed on top of image receptor holder
 - d. Thorax centered to image receptor
 - e. SID recommended—72 inches
 - f. Both 45-degree oblique projections (or 60-degree oblique projections) may be taken
 - g. *Respiration*: Full inspiration
 3. *Central ray*: Perpendicular at level of T7
- D. AP lordotic
1. Patient position
 - a. Standing approximately 1 foot in front of image receptor
 - b. When patient is properly positioned, top of image receptor should be approximately 3 inches above shoulders

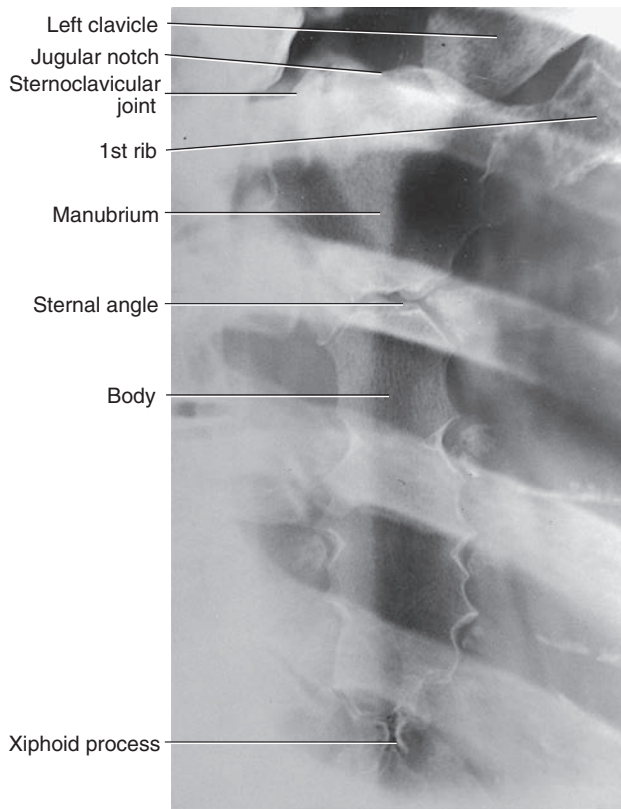


• **Figure 5-45** PA chest.



• **Figure 5-46** Left lateral chest.

2. Part position
 - a. MSP centered with no rotation
 - b. Elbows flexed
 - c. Hands, with palms out, on hips
 - d. Patient leans backward in extreme lordotic position
 - e. SID recommended—72 inches
 - f. *Respiration:* Full inspiration
3. *Central ray:* Perpendicular to image receptor, entering midsternum
- E. Lateral decubitus
 1. *Patient position:* Lateral recumbent



• **Figure 5-47** RAO of sternum.

2. Part position
 - a. Lying on affected or unaffected side, depending on existing condition
 - b. Elevate dependent side on firm pad
 - c. Extend patient's arms above head
 - d. Adjust thorax in true lateral position
 - e. Place top of image receptor approximately 2 inches above shoulders
 - f. *Respiration:* Full inspiration
3. *Central ray:* Horizontal and perpendicular to image receptor, entering T7

Ribs

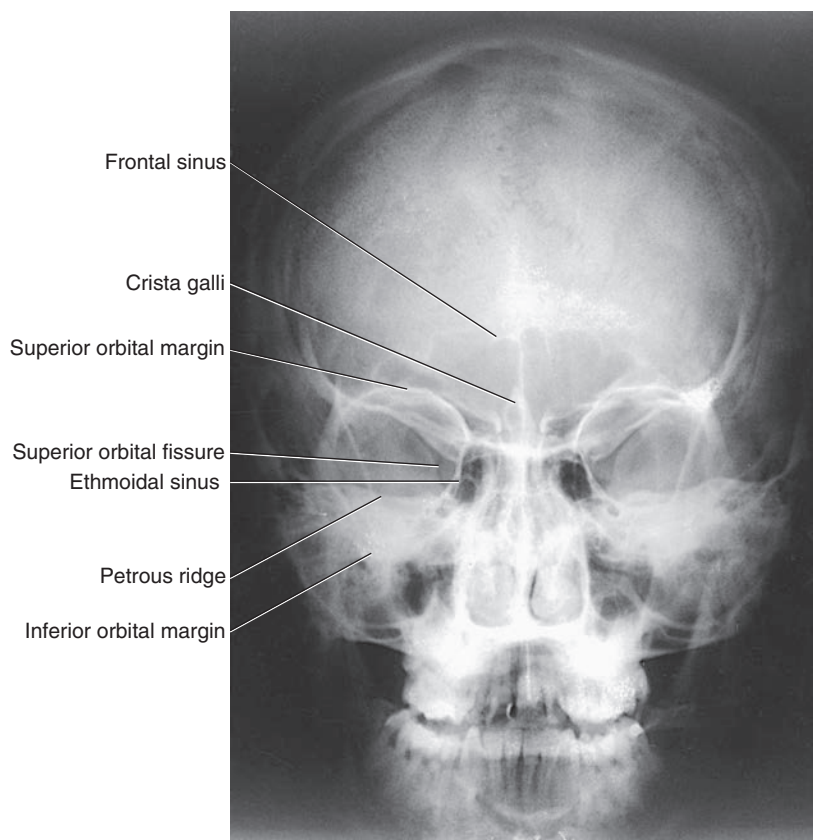
- A. AP
 1. *Patient position:* Erect or recumbent
 2. Part position
 - a. Center midsagittal plane to midline of grid
 - b. *Above diaphragm:* Center to T7; top of image receptor should be 1 to 2 inches above shoulders; shoulders rotated anteriorly
 - (1) *Respiration:* Full inspiration
 - c. *Below diaphragm:* Center thorax with bottom of image receptor at level of iliac crests
 - (1) *Respiration:* Full expiration
 3. *Central ray:* Perpendicular to T7 for upper ribs; perpendicular to T12 for lower ribs (bilateral)
- B. LPO and RPO (AP oblique projections)
 1. *Patient position:* Erect or recumbent
 2. Part position
 - a. Rotate body 45 degrees with affected side toward image receptor
 - b. Center midway between MSP and lateral surface of body to center of grid
 - c. Abduct arm nearer to image receptor
 - d. Place hand on head
 - e. Abduct opposite limb
 - f. Place hand on hip
 - g. *Respiration:* Above diaphragm, full inspiration; below diaphragm, full expiration
 3. *Central ray:* Perpendicular to image receptor; above diaphragm, center at level of T7; below diaphragm, center at level of T10

Sternum

- A. RAO (PA oblique)
 1. *Patient position:* Prone position for RAO (right PA oblique)
 2. Part position
 - a. Center sternum to image receptor
 - b. Rotate body 15 to 20 degrees to prevent superimposition of vertebral and sternal images
 - c. *Respiration:* Shallow breathing or suspended expiration
 3. *Central ray:* Perpendicular, exiting midsternum (Figure 5-47)
- B. Lateral
 1. *Patient position:* Lateral, seated or standing
 2. Part position
 - a. Top of image receptor 1 to 2 inches above jugular notch
 - b. Shoulders and arms rotated posteriorly
 - c. Center sternum to image receptor
 - d. Adjust to true lateral position
 - e. *Respiration:* Full inspiration
 3. *Central ray:* Perpendicular to center of midsternum

Sternoclavicular Joints

- A. PA
 1. *Patient position:* Prone or upright, MSP centered to table
 2. Part position
 - a. Image receptor centered to T3
 - b. Arms on side of body, palms up, shoulders in same plane
 - c. *Bilateral exam:* Head rests on chin, MSP vertical to table
 - d. *Unilateral exam:* Turn head toward affected side, rest cheek on table
 3. *Central ray:* Perpendicular to T3
- B. RAO
 1. *Patient position:* Prone or upright
 2. Part position
 - a. Rotate patient to an oblique position to place vertebral shadow behind sternoclavicular joint nearer to image receptor (10 to 15 degrees)
 - b. Center joint to midline of image receptor
 3. *Central ray:* Perpendicular to affected joint



• **Figure 5-48** PA axial skull (Caldwell method).

Skull

Cranium

A. PA or Caldwell (PA axial) (Figures 5-48 and 5-49)

1. *Patient position:* Prone or seated erect
2. Part position
 - a. Head resting on forehead and nose
 - b. MSP perpendicular to midline of grid device
 - c. OML perpendicular to image receptor
 - d. *Respiration:* Suspended
3. Central ray
 - a. *Caldwell method (PA axial):* Direct central ray 15 degrees caudad to OML, exiting nasion, for survey exam
 - b. *PA:* Perpendicular to image receptor, exiting nasion, to examine frontal bone

B. Lateral (Figure 5-50)

1. *Patient position:* Seated erect or semiprone
2. Part position
 - a. Center a point to the image receptor that is 2 inches superior to the external auditory meatus (EAM)
 - b. MSP parallel to image receptor
 - c. IOML parallel to transverse axis of image receptor
 - d. Interpupillary line (IPL) perpendicular to image receptor
 - e. *Respiration:* Suspended
3. Central ray
 - a. Perpendicular, entering 2 inches superior to EAM for survey exam

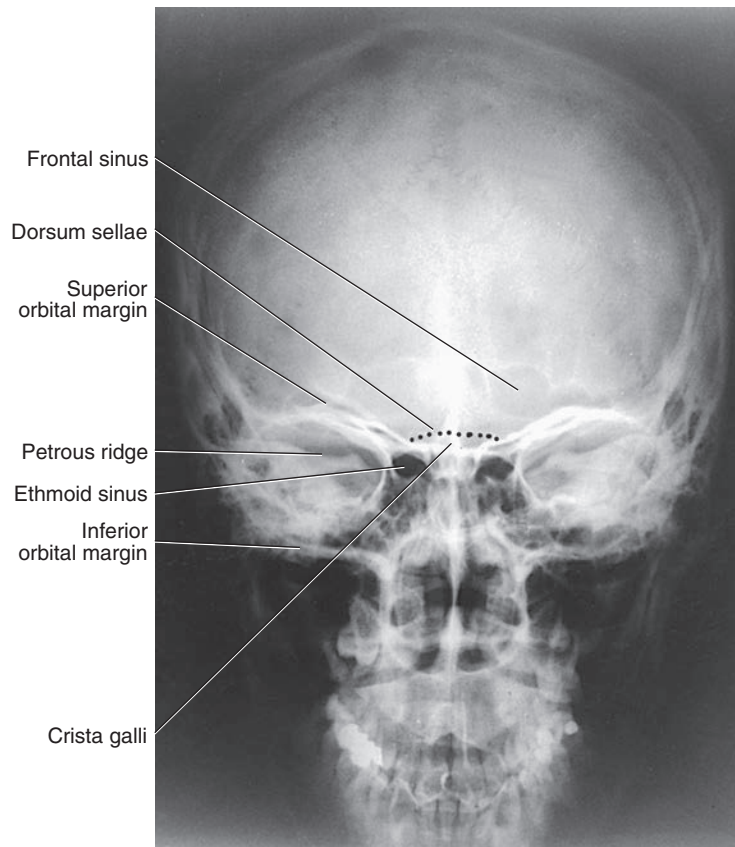
- b. When sella turcica is of primary interest, image receptor is centered, and central ray enters $\frac{3}{4}$ inch superior and $\frac{3}{4}$ inch anterior to EAM

C. AP axial (Towne) (Figure 5-51)

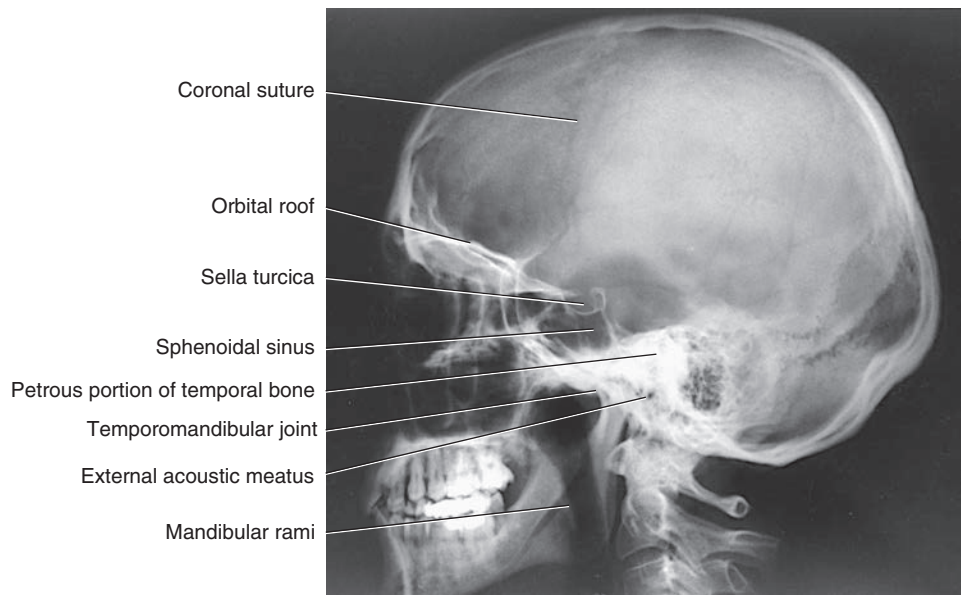
1. *Patient position:* Supine or seated erect
2. Part position
 - a. Center MSP to midline of grid device
 - b. Adjust to be perpendicular
 - c. Flex head and adjust OML perpendicular to image receptor
 - d. Place top of image receptor at level of cranial vertex
 - e. *Respiration:* Suspended
3. Central ray
 - a. Direct through foramen magnum with caudal angle of 30 degrees to OML or 37 degrees to IOML, entering 2 to 2½ inches above the glabella

D. Submentovertex (full basal)

1. *Patient position:* Seated erect at head unit or supine on elevated table support
2. Part position
 - a. Extend neck
 - b. Rest head on vertex
 - c. Center and adjust MSP perpendicular to image receptor
 - d. Adjust IOML parallel to plane of image receptor
 - e. *Respiration:* Suspended
3. *Central ray:* Direct perpendicular to IOML, entering between angles of mandible



• **Figure 5-49** PA skull.



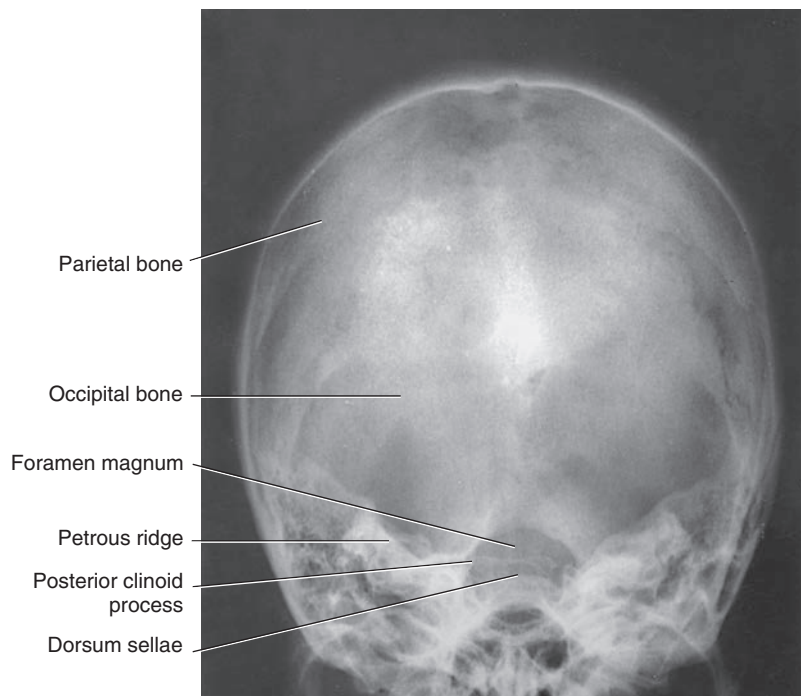
• **Figure 5-50** Lateral skull.

Orbit

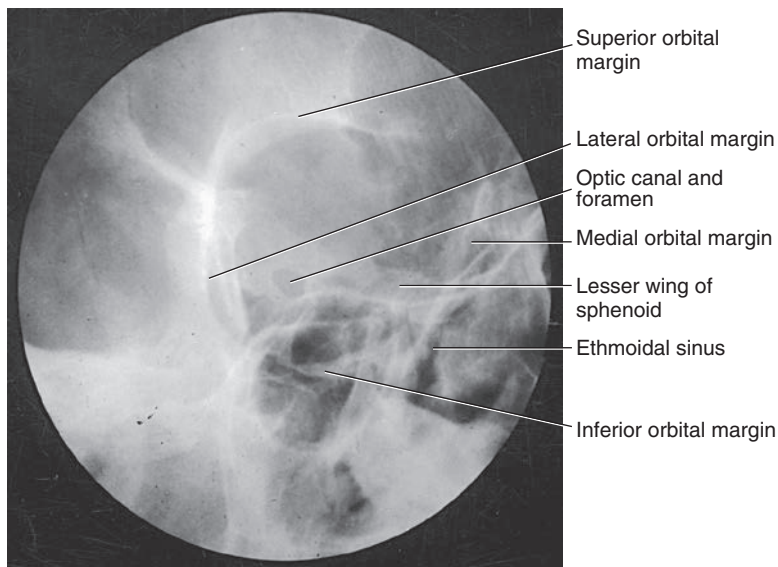
A. Parietoorbital oblique (Rhes) (Figure 5-52)

1. *Patient position:* Prone or seated erect
2. Part position
 - a. Center affected orbit to image receptor
 - b. Rest head on zygoma, nose, and chin

- c. Adjust AML perpendicular to image receptor
- d. Rotate MSP 53 degrees from image receptor
- e. *Respiration:* Suspended
3. *Central ray:* Perpendicular, entering 1 inch superior and posterior to top of ear attachment, exiting affected orbit



• **Figure 5-51** AP axial skull.



• **Figure 5-52** Parietoorbital oblique optic canal (Rhes method).

Facial Bones

A. Lateral (Figure 5-53)

1. *Patient position:* Semiprone or seated erect
2. Part position
 - a. Center zygoma
 - b. Adjust MSP parallel to image receptor
 - c. IOML parallel to transverse axis of image receptor
 - d. IPL perpendicular to image receptor
 - e. *Respiration:* Suspended
3. *Central ray:* Perpendicular, entering lateral surface of zygomatic bone

B. Parietoacanthial (Waters) (Figure 5-54)

1. *Patient position:* Prone or seated erect

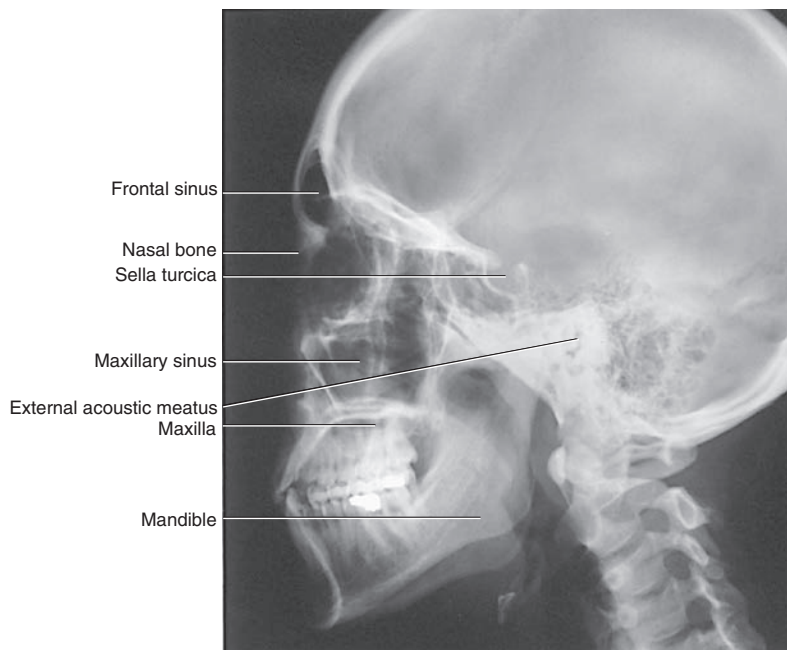
2. Part position

- a. Center and adjust MSP perpendicular to image receptor
- b. Rest patient's head on extended chin
- c. Adjust OML to form a 37-degree angle to image receptor plane
- d. *Respiration:* Suspended
3. *Central ray:* Perpendicular, exiting acanthion

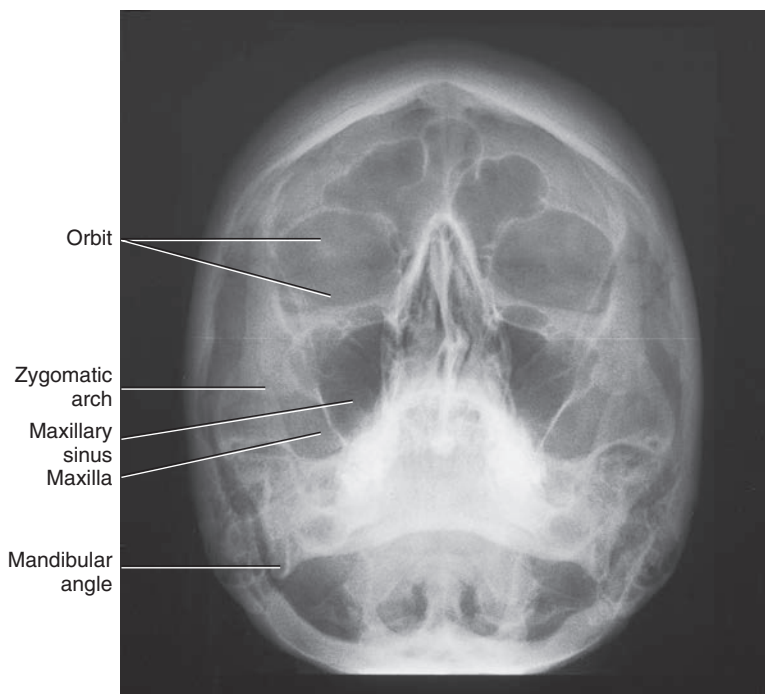
Nasal Bones

A. Lateral (performed as bilateral exam)

1. *Patient position:* Semiprone or seated erect
2. Part position



• **Figure 5-53** Lateral facial bones.



• **Figure 5-54** Parietoacanthial facial bones (Waters method).

- a. Center nasion to image receptor
- b. Adjust MSP parallel to image receptor
- c. IOML parallel to transverse axis of image receptor
- d. IPL perpendicular to image receptor
- e. *Respiration*: Suspended
3. *Central ray*: Perpendicular to the bridge of the nose, entering $\frac{3}{4}$ inch distal to nasion

Zygomatic Arches

- A. Bilateral tangential (basal)
 1. *Patient position*: Seated erect or supine on elevated table support
 2. Part position
 - a. Have patient extend head and rest on vertex
 - b. Center and adjust MSP perpendicular to image receptor

- c. Adjust IOML parallel to image receptor
- d. *Respiration*: Suspended
- 3. *Central ray*: Perpendicular to IOML, entering midway between zygomatic arches, approximately 1 inch posterior to outer canthi
- B. Unilateral tangential (May)
 - 1. *Patient position*: Prone or seated erect at vertical grid device
 - 2. Part position
 - a. Extend neck and rest chin on grid device
 - b. Rotate MSP 15 degrees away from side being examined; if AP, rotate MSP 15 degrees toward side being examined
 - c. Center image receptor 3 inches distal to most prominent point of zygoma
 - d. IOML parallel to plane of image receptor
 - e. *Respiration*: Suspended
 - 3. *Central ray*
 - a. Perpendicular to IOML
 - b. Directed through zygomatic arch 1½ inches posterior to outer canthus

Mandible

- A. PA
 - 1. *Patient position*: Prone or seated erect
 - 2. Part position
 - a. Have patient rest head on nose and chin
 - b. For mandibular body, center image receptor at level of lips
 - c. For rami and temporomandibular joint (TMJ), center to tip of nose
 - d. MSP perpendicular to image receptor
 - e. *Respiration*: Suspended
 - 3. *Central ray*
 - a. For mandibular body, direct perpendicular to image receptor at level of lips
 - b. For rami and condylar processes, direct midway between TMJs at 30-degree cephalad angle
- B. Axialateral oblique (for mandibular body)
 - 1. *Patient position*: Semiprone or seated erect
 - 2. Part position
 - a. Adjust image receptor under affected cheek
 - b. Extend neck to place long axis of mandibular body parallel to image receptor
 - c. Center to first molar region
 - d. Adjust broad surface of mandibular body parallel to image receptor
 - e. *Respiration*: Suspended
 - 3. *Central ray*: Direct slightly posteriorly to mandibular angle farthest from image receptor at a 25-degree cephalad angle
- C. Axialateral oblique (for mandibular ramus)
 - 1. *Patient position*: Semiprone or seated erect
 - 2. Part position
 - a. Center image receptor ½ inch anterior and 1 inch inferior to affected side EAM
 - b. Extend chin

- c. Adjust broad surface of ramus parallel to image receptor
- d. *Respiration*: Suspended
- 3. *Central ray*: Direct 25 degrees cephalad, entering 2 inches distal to the mandibular angle on side farther from image receptor
- D. Submentovertebral (basal)
 - 1. *Patient position*: Seated erect or supine on elevated table support
 - 2. Part position
 - a. Extend neck and rest head on vertex
 - b. Center and adjust MSP perpendicular to image receptor
 - c. Adjust IOML parallel to plane of image receptor
 - d. *Respiration*: Suspended
 - 3. *Central ray*: Perpendicular to IOML, entering midway between mandibular angles

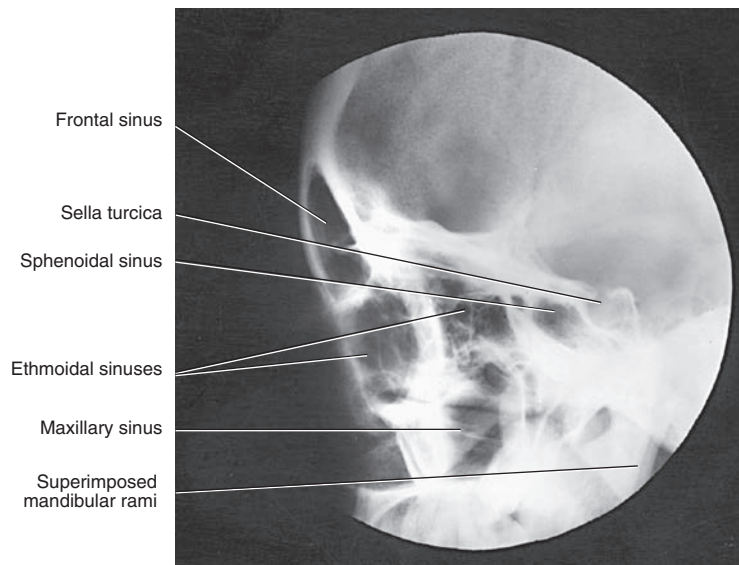
Temporomandibular Articulations

- A. Open-mouth and closed-mouth laterals
 - 1. *Patient position*: Seated erect or semiprone
 - 2. Part position
 - a. Center a point ½ inch anterior and 1 inch inferior to EAM to image receptor
 - b. MSP angled 15 degrees (nose toward image receptor)
 - c. AML adjusted parallel to transverse axis of image receptor
 - d. IPL perpendicular to image receptor
 - e. After first exposure (made with mouth closed and patient completely still), image receptor is changed, and second exposure is made with patient's mouth fully open
 - f. *Respiration*: Suspended
 - 3. *Central ray*: Direct 15 degrees caudad, exiting TMJ against image receptor

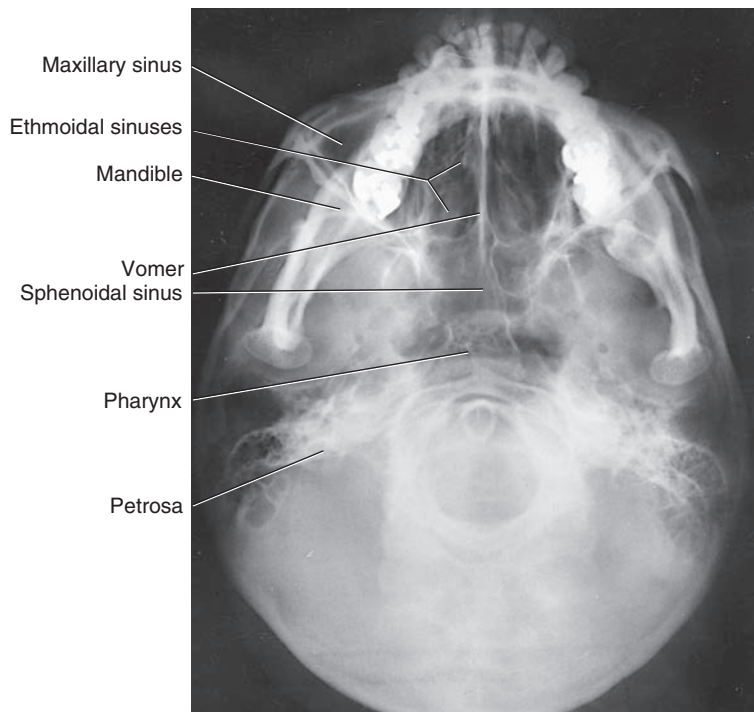
Paranasal Sinuses

- A. Lateral (Figure 5-55)
 - 1. *Patient position*: Seated erect
 - 2. Part position
 - a. Center image receptor ½ to 1 inch posterior to outer canthus
 - b. Adjust head to true lateral position
 - c. MSP parallel and IPL perpendicular to image receptor
 - d. IOML adjusted parallel to transverse axis of image receptor
 - e. *Respiration*: Suspended
 - 3. *Central ray*: Perpendicular, entering ½ to 1 inch posterior to outer canthus
- B. PA axial (Caldwell)
 - 1. *Patient position*: Seated erect at vertical grid device
 - 2. Part position
 - a. Rest head on forehead and nose
 - b. MSP perpendicular to midline of image receptor
 - c. OML perpendicular to image receptor
 - d. *Respiration*: Suspended

3. *Central ray:* Direct to nasion at angle of 15 degrees caudal to the OML
- C. Parietoacanthial (Waters)
1. *Patient position:* Seated erect; use horizontal central ray to demonstrate fluid level
 2. Part position
 - a. Center and adjust MSP perpendicular to image receptor
 - b. Rest head on extended chin
 - c. Adjust OML to form a 37-degree angle to image receptor
 - d. *Respiration:* Suspended
3. *Central ray:* Horizontal and perpendicular to image receptor, exiting acanthion
- D. Submentovertex (basal) (Figure 5-56)
1. *Patient position:* Seated erect at vertical grid device
 2. Part position
 - a. Extend head and rest on vertex
 - b. Center and adjust MSP perpendicular to image receptor
 - c. Adjust IOML parallel to image receptor
 - d. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to IOML through sella turcica, approximately $\frac{3}{4}$ inch anterior to level of EAM



• **Figure 5-55** Lateral sinuses.



• **Figure 5-56** Submentovertical sinuses.

Gastrointestinal System

Pathologic Conditions Imaged

- A. *Acute cholecystitis*: Inflammation of gallbladder
- B. Cancer of the colon and rectum
 - 1. Leading cause of death from cancer in the United States
 - 2. More typical form is annular carcinoma, with classic “apple-core” pattern when imaged using a barium enema
- C. Cancer of the esophagus
 - 1. Malignant neoplasm
 - 2. Imaged during barium study
- D. Cancer of the stomach
 - 1. May appear as gross changes in the stomach wall or as a large mass
 - 2. Imaged during barium study
 - 3. Harder to penetrate
- E. Cholelithiasis
 - 1. Gallstones
 - 2. Harder to penetrate
- F. Crohn disease
 - 1. Chronic inflammation of the bowel
 - 2. Sometimes separated by normal segments of bowel
- G. Diverticulosis
 - 1. Presence of diverticula (pouch-like herniations through the wall of the colon)
- H. Diverticulitis
 - 1. Inflammation of diverticula
- I. Esophageal varices
 - 1. Varicose veins at distal end of esophagus
- J. Esophagitis
 - 1. Inflammation of esophageal mucosal lining
- K. Gastritis
 - 1. Inflammation of the stomach
- L. Hiatal hernia
 - 1. Condition in which a portion of the stomach protrudes through the diaphragm
- M. Ileus
 - 1. Intestinal obstruction
 - 2. *Adynamic ileus*: Ileus caused by immobility of the bowel
 - 3. *Mechanical ileus*: Ileus caused by mechanical obstruction
- N. Intussusception
 - 1. Prolapse of one segment of bowel into another section of bowel
- O. Irritable bowel syndrome
 - 1. Abnormal increase in small and large bowel motility
- P. Large bowel obstruction
 - 1. Characterized by massive accumulation of gas proximal to obstruction
 - 2. Absence of gas distal to obstruction
 - 3. High risk of bowel perforation
 - 4. Extent of obstruction determines ease or difficulty of penetration
- Q. Peptic ulcer disease
 - 1. Loss of mucous membrane in a portion of the gastrointestinal (GI) system
- 2. Imaged using barium study
- 3. Has craterlike appearance
- R. *Pyloric stenosis*: Narrowing of pyloric sphincter
- S. Small bowel obstruction
 - 1. Seen as distended loops of bowel that are filled with gas
 - 2. Bowel proximal to obstruction may be filled with fluid
 - 3. Extent of obstruction determines ease or difficulty of penetration
- T. Ulcerative colitis
 - 1. Severe inflammation of the colon and rectum characterized by ulceration
- U. *Volvulus*: Twisting of bowel on itself, causing an obstruction

General Survey Exams

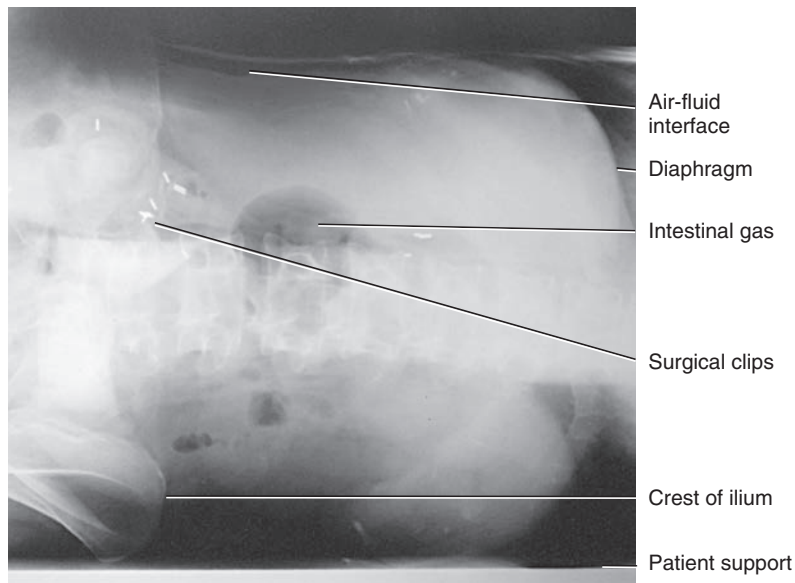
Abdomen

- A. AP (KUB)
 - 1. Patient position: Supine
 - 2. Part position
 - a. Center MSP to table
 - b. Shoulders in same transverse plane
 - c. Support under knees
 - d. Center image receptor at level of iliac crests
 - e. Apply gonadal shielding as appropriate
 - f. *Respiration*: Expiration
 - 3. *Central ray*: Perpendicular to midline at level of iliac crests
- B. AP (upright)
 - 1. Patient position: Erect
 - 2. Part position
 - a. Center MSP to table or upright grid device
 - b. Shoulders in same transverse plane
 - c. Center image receptor 2 to 3 inches above iliac crests to include diaphragm
 - d. Apply gonadal shielding as appropriate
 - e. *Respiration*: Expiration
 - 3. *Central ray*: Horizontal, entering MSP 2 to 3 inches superior to iliac crests
- C. Lateral decubitus (Figure 5-57)
 - 1. Patient position
 - a. Lateral recumbent (usually left side down), lying on pad
 - b. Arms above level of diaphragm
 - c. Knees slightly flexed
 - 2. Part position
 - a. MSP centered to grid device
 - b. Center image receptor at level of iliac crest
 - c. Apply gonadal shielding as appropriate
 - d. *Respiration*: Expiration
 - 3. *Central ray*: Horizontal and parallel to the MSP at level of iliac crest

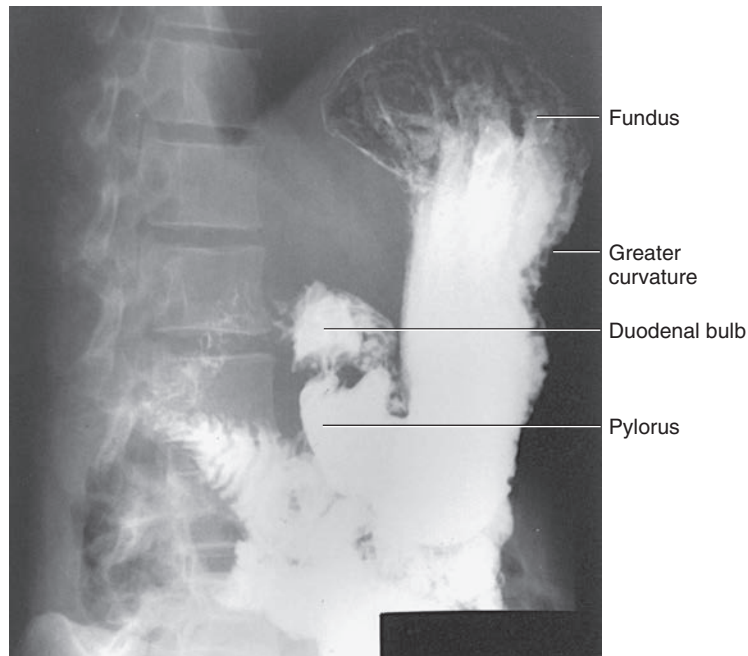
Upper Gastrointestinal System

Esophagus

- A. RAO (PA oblique)
 - 1. *Patient position*: Recumbent with right arm posterior, left arm by head



• **Figure 5-57** AP abdomen. Left lateral decubitus position resulting in air marked by air-fluid interface.



• **Figure 5-58** Single-contrast PA oblique stomach (RAO position).

2. Part position
 - a. Elevate left side to obliquity of 35 to 40 degrees
 - b. Support patient on flexed knee and elbow
 - c. Align esophagus and center at level of T5 or T6
 - d. Feed barium to patient
 - e. *Respiration:* Suspended
3. *Central ray:* Perpendicular to image receptor, entering level of T5 or T6

Stomach

A. PA

1. Patient position: Prone

2. Part position
 - a. Center at level of pylorus (approximately midway between xiphoid process and umbilicus)
 - b. Center halfway between midline and lateral border of abdominal cavity for 10- × 12-inch image receptor or MSP for 14- × 17-inch image receptor
 - c. *Respiration:* Expiration
3. *Central ray:* Perpendicular to image receptor at level of pylorus (L2)

B. RAO (PA oblique) (Figure 5-58)

1. *Patient position:* Recumbent with right arm posterior, left arm by head

2. Part position
 - a. Elevate left side and support patient to obliquity of 40 to 70 degrees
 - b. Longitudinal plane midway between vertebrae and anterior surface of elevated side is centered to image receptor
 - c. Center at level of duodenal bulb
 - d. *Respiration:* Expiration
 3. *Central ray:* Perpendicular to center of image receptor midway between vertebral column and lateral border of abdominal cavity at level of L2
- C. Lateral
1. *Patient position:* Recumbent (right lateral) or erect (left lateral)
 2. Part position
 - a. Center image receptor between midaxillary plane and anterior abdominal surface
 - b. Center at level of pylorus
 - c. Adjust to true lateral
 - d. *Respiration:* Expiration
 3. *Central ray:* Perpendicular to center of image receptor midway between midaxillary line and anterior surface of abdomen at the level of L1 for recumbent position or L3 for upright position

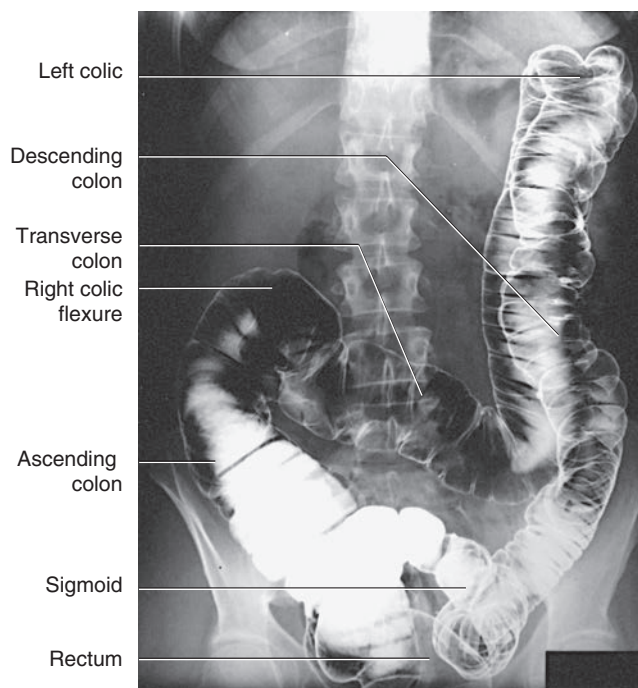
Small Bowel

- A. PA
1. Patient position: Prone
 2. Part position
 - a. MSP centered to table
 - b. Center image receptor at level of iliac crest (may be slightly higher for early time exposures)
 - c. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor entering midline at level of iliac crest (or slightly above)

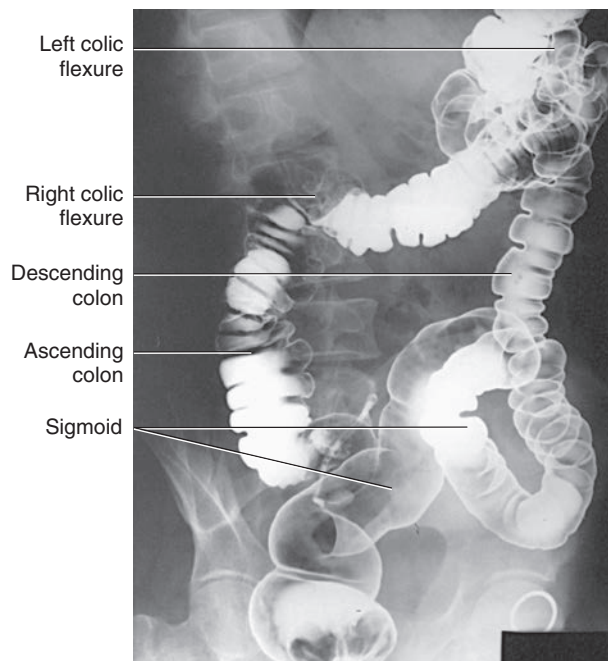
Lower Gastrointestinal System

Colon

- A. PA (Figure 5-59)
1. Patient position: Prone
 2. Part position
 - a. MSP centered to table
 - b. Center image receptor at level of iliac crest
 - c. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor, entering level of iliac crest
- B. PA axial
1. Patient position: Prone
 2. Part position
 - a. MSP centered to table
 - b. Center image receptor at level of iliac crest
 - c. *Respiration:* Suspended
 3. Central ray
 - a. From 30 to 40 degrees caudad
 - b. To show rectosigmoid area using smaller image receptor, central ray enters midline at level of ASIS



• **Figure 5-59** Double-contrast PA large intestine.



• **Figure 5-60** Double-contrast PA oblique large intestine.

- C. LAO and RAO (PA oblique) (Figure 5-60)
1. Patient position: PA oblique
 2. Part position
 - a. Patient rotated 35 to 45 degrees
 - b. Either right or left side up
 - c. Center abdomen to table
 - d. Image receptor centered at level of iliac crest
 - e. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor, entering level of iliac crest

- D. Lateral rectum
1. *Patient position:* Lying on side
 2. Part position
 - a. Adjust patient's body to true lateral position (right or left side down)
 - b. Center midaxillary plane of abdomen to center of table
 - c. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor, entering midaxillary plane at level of ASIS
- E. AP
1. Patient position: Supine
 2. Part position
 - a. MSP centered to table
 - b. Image receptor centered at level of iliac crest
 - c. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor, entering level of iliac crest
- F. AP axial
1. Patient position: Supine
 2. Part position
 - a. MSP centered to table
 - b. Image receptor centered 2 inches above iliac crest
 - c. *Respiration:* Suspended
 3. Central ray
 - a. Cephalad 30 to 40 degrees, entering approximately 2 inches below level of ASIS
 - b. When rectosigmoid is of interest, central ray enters inferior margin of symphysis pubis
- G. Lateral decubitus
1. *Patient position:* Lying on either right or left side, patient's MSP centered to midline of grid
 2. Part position
 - a. Arms above head
 - b. Knees slightly flexed
 - c. Image receptor centered to abdomen at level of iliac crest
 - d. *Respiration:* Suspended
 3. *Central ray:* Horizontal, entering midline at level of iliac crest
- H. LPO and RPO (AP oblique)
1. Patient position: AP oblique
 2. Part position
 - a. Patient rotated 35 to 45 degrees from AP position; either right or left side up
 - b. Center abdomen to table
 - c. Image receptor centered at level of iliac crest
 - d. *Respiration:* Suspended
 3. *Central ray:* Perpendicular to image receptor at level of iliac crest
 - a. Left side of body may be elevated into a 15- to 20-degree oblique angle to prevent bile ducts from being superimposed over the spine
3. *Central ray:* Perpendicular to exposed biliary tract
 4. Procedure notes
 - a. Surgeon directs imaging sequence
 - b. Equipment must be properly cleaned and ready to use
 - c. Radiographer must be in proper operating room attire
 - d. Appropriate radiation protection standards must be maintained for the radiographer and for the operating room staff, using distance and lead shielding
 - e. Exposure times must be as short as possible, with patient respiration controlled by the anesthetist
 5. *Exam evaluation:* Patency of the bile ducts, operation of the sphincter of the hepatopancreatic ampulla, and presence of calculi

Endoscopic Retrograde Cholangiopancreatography (ERCP)

- A. Endoscopic retrograde cholangiopancreatography (ERCP) exam notes
1. Used to evaluate biliary and pancreatic pathologic conditions
 2. Endoscope is passed into duodenum under fluoroscopic control
 3. Contrast medium is injected into the common bile duct or pancreatic duct through a cannula passed through the endoscope
 4. Patient is placed prone for imaging
 5. ERCP may be preceded by ultrasound

Urinary System

Pathologic Conditions Imaged

- A. Carcinoma of the bladder
1. Seen as solid mass arising from the bladder wall
 2. Harder to penetrate
- B. *Cystitis:* Inflammation of bladder and ureters
- C. *Glomerulonephritis:* Inflammation of the glomerulus of the kidney
- D. Polycystic kidney disease
1. Enlarged kidneys containing numerous cysts
 2. Harder to penetrate
- E. *Pyelonephritis:* Inflammation of renal pelvis and parenchyma
- F. Renal calculus
1. Kidney stone
 2. Harder to penetrate stone, but overall technique is not increased to compensate
- G. Renal carcinoma
1. Solid mass cancer that causes renal bulging or enlargement with impact on collecting system
 2. Harder to penetrate
- H. Renal cysts
1. Fluid-filled masses in kidney
 2. Harder to penetrate

Surgical Cholangiogram

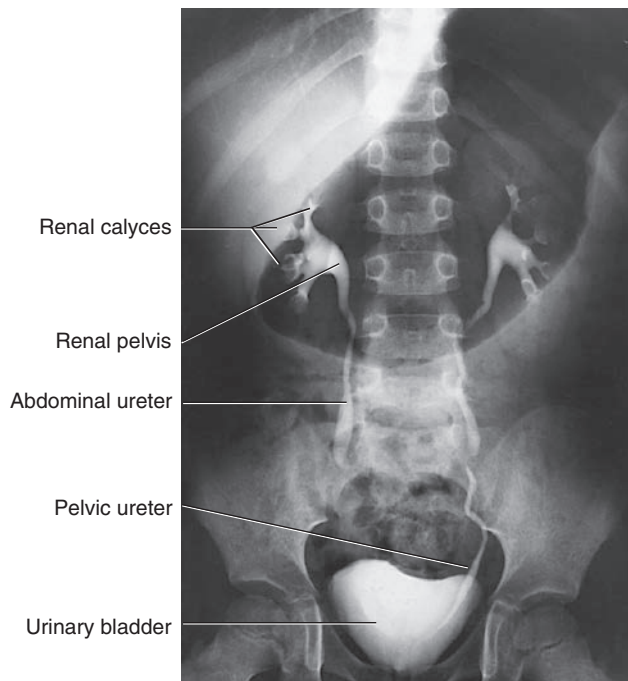
- A. AP or AP oblique
1. *Patient position:* Supine on operating table
 2. Part position
 - a. Right upper quadrant centered to image receptor

- I. Wilms tumor
 1. Malignant cancer of kidney in children
 2. Harder to penetrate

Urinary System Procedures

Intravenous Urography

- A. KUB (AP) (Figure 5-61)
 1. *Patient position:* Supine, centered to the table
 2. Part position
 - a. Spine centered to table
 - b. Include entire renal outlines, bladder, and symphysis pubis; also include prostatic region on older adult male patients
 3. *Central ray:* Perpendicular to image receptor, centered at level of iliac crest
- B. Oblique (RPO, LPO) (Figure 5-62)
 1. Patient position: Supine
 2. Part position: Patient's body rotated to a 30-degree oblique angle; kidney farther from the image receptor is parallel to image receptor, and kidney nearer to the image receptor is perpendicular to image receptor
 3. Central ray: Perpendicular to image receptor at iliac crest
- C. AP bladder
 1. Patient position: Supine
 2. Part position: Supine, centered to image receptor
 3. Central ray: Perpendicular to image receptor, centered at level of ASIS
- D. Intravenous pyelogram (IVP) (intravenous urogram) procedure notes
 1. Patient should be properly prepared with a low-residue diet for 1 to 2 days before the exam and cleansing of GI tract

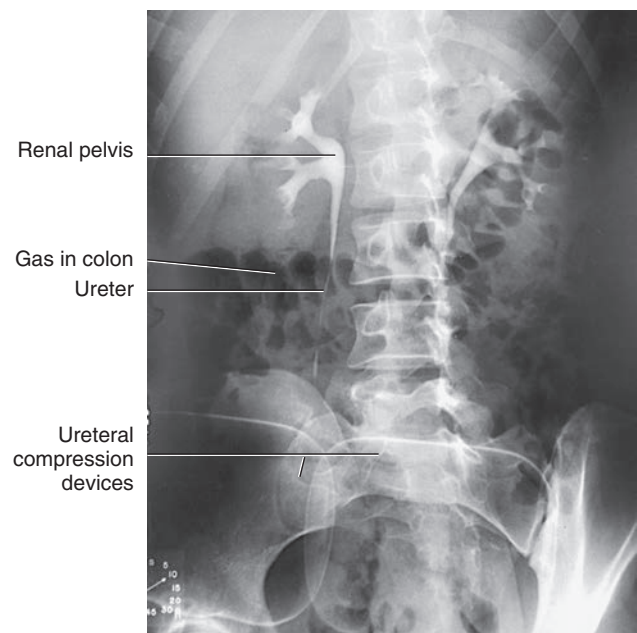


• **Figure 5-61** Urogram from supine position at 15-minute interval with gas-filled stomach.

2. NPO (nothing by mouth) after midnight the day of the exam but not dehydrated
3. Preliminary KUB is performed before contrast agent injection to verify positioning, visualize renal anatomy, or detect the presence of lesions
4. Based on patient weight, 30 to 100 mL of iodinated contrast medium is injected; pelvicalyceal system appears in 2 to 8 minutes, with greatest visualization occurring in 15 to 20 minutes
5. AP and oblique images are obtained at specific intervals after injection of contrast medium
6. All images must be carefully identified using right, left, upright, and “postvoid” markers and numbers indicating postinjection time
7. AP upright positions may be used to show kidney mobility and filled bladder
8. Oblique images may be used to image kidney rotation or localize tumor masses
9. Postvoid images may be taken to image tumor masses or prostatic enlargement
10. Intravenous urography is increasingly being used in conjunction with, or replaced by, computed tomography (CT), eliminating some of above steps

Cystography and Cystourethrography

- A. Positioning
 1. AP axial
 - a. Angle 10 to 15 degrees caudal; only 5 degrees caudal for bladder neck
 - b. Image receptor centered at level 2 to 3 inches above symphysis pubis
 2. Oblique (RPO, LPO)
 - a. Patient rotated 40 to 60 degrees
 - b. Pubic arch closest to table centered to midline of table



• **Figure 5-62** AP oblique urogram 10 minutes after injection.

3. PA of bladder
 - a. Patient centered
 - b. Central ray enters 1 inch distal to tip of coccyx with 10- to 15-degree cephalad angle
 4. Lateral
 - a. Bladder centered to image receptor; image receptor 2 to 3 inches above symphysis pubis
 - b. Central ray centered and perpendicular to image receptor
- B. Procedure notes
1. Bladder is drained with catheter that has been put in place
 2. Bladder is filled with contrast medium through urethral catheter
 3. After bladder is filled, clamp is closed to prevent contrast agent from draining
 4. Imaging follows filling of bladder
 5. Cystourethrography may follow cystogram
 - a. Patient is instructed to void contrast material from bladder while on fluoroscopic table
 - b. Radiologist takes spot images during urination to evaluate urethra and to image reflux

Retrograde Pyelography

- A. Positioning
1. AP
 2. RPO
 3. LPO
- B. Procedure notes
1. Ureters are catheterized to allow filling of the pelvicalyceal system
 2. Urologist performs procedure
 3. Image receptor is placed to include both kidneys and ureters
 4. After catheterization and introduction of contrast material, urologist directs imaging sequence

Table 5-1 lists common additive and destructive diseases and conditions.

Other Radiologic Exams

- A. Myelography
1. Pathologic conditions imaged
 - a. Herniated intervertebral disks
 - b. Degenerative diseases of the CNS
 - c. Space-occupying lesions
 2. Pathologic changes are imaged by displacement of column of contrast material in the subarachnoid space
 3. Lumbar puncture performed by physician at L3-4 interspace allows injection of water-soluble contrast agent into subarachnoid space
 4. Small amount of spinal fluid is withdrawn for laboratory analysis
 5. X-ray table is tilted up and down to distribute contrast medium
 6. Contrast medium should not be allowed to enter cerebral ventricles; head must be kept hyperextended

- to compress cisterna magna when contrast medium is used in cervical region
 7. Images are taken under fluoroscopic control in PA and oblique positions
 8. Cross-table lateral images are taken by radiographer to provide right-angle views
 9. Contrast medium is absorbed by patient's body
- B. Arthrography
1. Contrast exam of an encapsulated joint
 - a. Knee
 - b. Shoulder
 - c. Hip
 - d. Wrist
 - e. TMJ
 2. Pathologic conditions imaged
 - a. Joint trauma
 - b. Meniscal tears
 - c. Capsular damage
 - d. Deformities caused by arthritis
 - e. Rupture of articular ligaments

TABLE 5-1 Common Additive and Destructive Diseases and Conditions by Anatomic Area

Additive Conditions	Destructive Conditions
Abdomen	
Aortic aneurysm	Bowel obstruction
Ascites	Free air
Cirrhosis	
Hypertrophy of some organs (e.g., splenomegaly)	
Chest	
Atelectasis	Emphysema
Congestive heart failure	Pneumothorax
Malignancy	
Pleural effusion	
Pneumonia	
Skeleton	
Hydrocephalus	Gout
Metastases (osteoblastic)	Metastases (osteolytic)
Osteochondroma (exostoses)	Multiple myeloma
Paget disease	Paget disease
Osteoporosis	
Nonspecific sites	
Abscess	Atrophy
Edema	Emaciation
Sclerosis	Malnutrition

From Fauber TL: *Radiographic imaging and exposure*, ed 4, St. Louis, 2012, Mosby.

3. Performed under local anesthetic with use of asepsis
 4. Physician injects contrast material
 5. Joint is manipulated to distribute contrast agent
 6. Fluoroscopic images may be taken
 7. Arthrography is increasingly being replaced by MRI
- C. Hysterosalpingography
1. Pathologies imaged
 - a. Abnormal uterine bleeding
 - b. Amenorrhea
 - c. Cervical stenosis
 - d. Dysmenorrhea
 - e. Fistulae
 - f. Masses
 - g. Neoplasms
 - h. Patency of oviducts (assessment of possible infertility)
 - i. Polyps
 - j. Uterine anomalies
 2. Therapeutic procedures
 - a. Dilate oviducts
 - b. Open oviducts
 - c. Remove kinks
 3. Contraindications include pregnancy, pelvic inflammatory disease, uterine bleeding
4. Preliminary image (AP) centered 2 inches proximal to symphysis pubis
 5. Physician introduces water-soluble iodinated contrast agent through cervix and into uterus
 6. Fluoroscopic or radiographic images (AP) are taken to visualize the uterus and contrast agent flow through the fallopian tubes
 7. Images indicate shape of uterus, presence of pathologies, and patency of oviducts
 8. Other images may be taken in LPO or RPO positions
 9. Contrast agent is absorbed by patient and excreted by urinary system

KEY REVIEW POINTS

Review of Radiography Positioning, Procedures, and Pathology

These three topics are collectively tested as part of one category on the certification exam. These topics constitute the heart of radiographic procedures. Use this review to reinforce what you have learned in class and clinical education. Make use of the labeled radiographs. Be able to define, in words, the pathologic conditions presented.

Review Questions

1. What body type is a slender build?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
2. What body type is a massive build?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
3. What body type has the stomach and gallbladder low, vertical, and near the midline?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
4. What body type is average build, present in about 35% of the population?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
5. What is the most common body habitus, present in about 50% of the population?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
6. What body type has the stomach and gallbladder high and horizontal?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
7. What body type has the thorax narrow and shallow?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
8. What body type has the thorax broad and deep?
 - a. Hypersthenic habitus
 - b. Sthenic habitus
 - c. Hyposthenic habitus
 - d. Asthenic habitus
9. Key points in performing pediatric radiography are:
 - a. Work quickly and impersonally, use gonadal shielding, report suspected child abuse, keep parents in waiting room
 - b. Work quickly, communicate clearly with child and parents, use gonadal shielding, report suspected child abuse
 - c. Work quickly and impersonally, report suspected child abuse, keep parents in waiting room, always use Pigg-O-Stat
 - d. Work quickly and impersonally, use gonadal shielding only on abdominal exams, report suspected child abuse, keep parents in waiting room

10. The most important point to remember when performing trauma radiography is:
 - a. Use gonadal shielding because this patient will be having many follow-up exams
 - b. Work quickly because the injuries may be life-threatening
 - c. Do no additional harm to the patient
 - d. Perform only the projections ordered by the physician
11. When you are performing trauma radiography:
 - a. Splints, bandages, and cervical collars should be removed so that they do not obstruct the anatomy that must be imaged
 - b. Remove cervical collars only under the direction of a radiologist
 - c. Remove cervical collars only under the direction of an emergency department physician or radiologist
 - d. Splints, bandages, and cervical collars should be removed only after preliminary images have been viewed by a physician so that they do not obstruct the anatomy that must be imaged
12. What plane passes transversely across the body?
 - a. Transverse plane
 - b. Midcoronal plane
 - c. Median sagittal plane
 - d. Sagittal plane
13. What plane passes vertically through the midline of the body from front to back?
 - a. Transverse plane
 - b. Midcoronal plane
 - c. Median sagittal plane
 - d. Sagittal plane
14. What plane divides the body into superior and inferior portions?
 - a. Transverse plane
 - b. Midcoronal plane
 - c. Median sagittal plane
 - d. Sagittal plane
15. What plane passes vertically through the midaxillary region of the body and through the coronal suture of the cranium at right angles to the midsagittal plane?
 - a. Transverse plane
 - b. Midcoronal plane
 - c. Median sagittal plane
 - d. Sagittal plane
16. What describes any plane parallel to the midsagittal plane?
 - a. Transverse plane
 - b. Midcoronal plane
 - c. Median sagittal plane
 - d. Sagittal plane
17. What type of joint is the hip?
 - a. Ball-and-socket joint
 - b. Pivot joint
 - c. Hinge joint
 - d. Saddle joint
18. What type of joint has a rounded head of one bone that moves in a cuplike cavity?
 - a. Ball-and-socket joint
 - b. Pivot joint
 - c. Hinge joint
 - d. Saddle joint
19. What type of joint permits motion in one plane only?
 - a. Ball-and-socket joint
 - b. Pivot joint
 - c. Hinge joint
 - d. Saddle joint
20. What type of joint has opposing surfaces that are convex-concave, allowing great freedom of motion?
 - a. Ball-and-socket joint
 - b. Pivot joint
 - c. Hinge joint
 - d. Saddle joint
21. What type of joint permits rotary movement in which a ring rotates around a central axis?
 - a. Ball-and-socket joint
 - b. Pivot joint
 - c. Hinge joint
 - d. Saddle joint
22. The minimum two projections needed for every radiographic exam are:
 - a. Flat and upright
 - b. Two at right angles to one another
 - c. AP and lateral
 - d. Right and left oblique
23. Patient respiration when imaging the lower ribs is:
 - a. Suspended at the end of deep inspiration
 - b. Suspended
 - c. Suspended at the end of second inspiration
 - d. Suspended at the end of expiration
24. Which of the following statements are true regarding contrast arthrography?
 1. Asepsis is required
 2. The exam may be performed on knee, shoulder, TMJ, hip, and wrist
 3. Indications include trauma, capsular damage, meniscal tears, rupture of ligaments, and arthritis
 4. The joint is manipulated by hand to distribute contrast medium
 - a. 1, 2, 3, 4
 - b. 1, 2
 - c. 3, 4
 - d. 2, 3
25. Which of the following statements are true concerning myelography?
 1. Injection is always performed at the L3-4 interspace
 2. Oily, iodinated contrast agent is the medium of choice
 3. Indications include herniated intervertebral disks, space-occupying lesions, and degenerative diseases of the CNS

4. Contrast medium is distributed by manual manipulation of the subarachnoid space
 5. The head must be kept hyperflexed so that the contrast medium does not enter the cerebral ventricles
 6. Spinal fluid may be withdrawn for laboratory analysis
 - a. 1, 2, 4
 - b. 2, 4, 5
 - c. 1, 2, 3, 5
 - d. 3, 6
26. Intravenous urography is being replaced by which imaging modality?
 - a. CT
 - b. MRI
 - c. Nuclear medicine
 - d. Sonography
 27. The proper centering point for a PA projection of the hand is the:
 - a. Third metatarsophalangeal joint
 - b. Third metacarpophalangeal joint
 - c. Midshaft of the third metacarpal
 - d. First metacarpophalangeal joint
 28. For a lateral projection of the wrist:
 - a. The radius and ulna should be superimposed
 - b. The radial surface must be in contact with the image receptor
 - c. The central ray is parallel
 - d. Use the fastest image receptor speed possible
 29. For a lateral projection of the forearm, which of the following statements are true?
 1. The ulnar surface must be in contact with the image receptor
 2. The thumb should be in a relaxed position
 3. The humerus and forearm should be in contact with the table
 4. The elbow should be flexed 45 degrees
 5. The central ray is directed toward the injured joint
 - a. All are true
 - b. 1, 2, 5
 - c. 1, 3
 - d. 2, 4, 5
 30. For an AP projection of the elbow, which of the following statements are true?
 1. The forearm and humerus should be at right angles
 2. The central ray is directed perpendicular to the joint
 3. The forearm and humerus should be parallel to the table
 4. The hand must be pronated
 5. The patient may have to lean laterally to ensure AP alignment
 - a. 1, 2
 - b. 2, 3, 5
 - c. 1, 4
 - d. 2, 3, 4, 5
 31. For a lateral projection of the humerus, which of the following statements are true?
 1. The hand should be pronated
 2. The patient may be upright or supine
 3. The humeral epicondyles are placed perpendicular to the image receptor
 4. The arm should be slightly adducted
 5. The central ray is directed perpendicular to the midshaft
 - a. 2, 3, 5
 - b. 1, 4
 - c. 2, 4
 - d. 1, 2, 3, 5
32. For a scapular Y projection (PA oblique) of the shoulder, which of the following statements are true?
 1. The central ray is directed to the shoulder at a 10-degree cephalad angle
 2. The anterior surface of the affected shoulder is centered to the image receptor
 3. The patient is rotated so that the midcoronal plane forms a 45- to 60-degree angle with the image receptor
 4. The patient continues shallow breathing during exposure
 - a. 1, 2
 - b. 2, 3, 4
 - c. 2, 3
 - d. 1, 2, 3
 33. For an AP projection of the AC joints:
 - a. To show AC separation properly, joints both with and without weights should be shown on one image receptor if possible
 - b. To show AC separation properly, separate images must be acquired with equal weights attached to both wrists and without weights
 - c. The central ray is always directed midway between the AC joints
 - d. The patient should be seated upright and instructed to continue shallow breathing during the exposure
 34. When the clavicle is being radiographed, which of the following statements are true?
 1. PA projection must always be used
 2. A central ray angle of 25 to 30 degrees cephalad is used for the PA axial projection
 3. The patient's head should be turned away from the affected side
 4. AP projection may be used for patient comfort
 5. An erect position may be used for patient comfort
 6. A central ray angle of 25 to 30 degrees caudad is used for the PA axial projection
 - a. 1, 2, 3, 4, 5
 - b. 1, 3, 4, 5
 - c. 2, 3, 4, 5
 - d. 3, 4, 5, 6
 35. For the lateral projection of the scapula, which of the following statements are true?
 1. Patient should be upright to reduce pain
 2. Patient is positioned obliquely with unaffected scapula centered to the image receptor
 3. The body is adjusted by palpating axillary and vertebral borders of the scapula so that the scapula is lateral

4. Scapula must be projected free of the rib cage
- 1, 3, 4
 - 2, 3
 - 3, 4
 - 2, 3, 4
36. What is the name of a fracture of the medial and lateral malleoli of the ankle with ankle joint dislocation?
- Trimalleolar fracture
 - Giant cell myeloma
 - Osteoarthritis
 - Pott fracture
37. What condition involves the posterior portion of the tibia and the medial and lateral malleoli?
- Trimalleolar fracture
 - Giant cell myeloma
 - Osteoarthritis
 - Pott fracture
38. What condition is more commonly seen in elderly patients?
- Trimalleolar fracture
 - Giant cell myeloma
 - Osteoarthritis
 - Pott fracture
39. What is a tumor that arises on bone with a large bubble appearance and may be benign or malignant?
- Trimalleolar fracture
 - Giant cell myeloma
 - Osteoarthritis
 - Pott fracture
40. What condition is characterized by the degeneration of one or several joints?
- Trimalleolar fracture
 - Giant cell myeloma
 - Osteoarthritis
 - Pott fracture
41. For AP radiography of the foot, which of the following statements are true?
- A wedge-compensating filter may be used
 - The dorsal surface rests on the image receptor
 - The central ray is directed 10 degrees toward the heel
 - The central ray is directed at the head of the third metatarsal
- 1, 2, 3, 4
 - 1, 3
 - 2, 4
 - 1, 3, 4
42. When an AP axial projection is performed for the os calcis, which of the following statements are true?
- The leg should be fully extended
 - The plantar surface of the foot should be parallel to the image receptor
 - The central ray is directed 40 degrees cephalad to the long axis of the foot
 - The central ray enters the foot at the head of the fifth metatarsal
 - A cylinder cone may be used for this projection
- 1, 3, 5
 - 2, 4
 - 2, 5
 - 1, 3, 4, 5
43. For a medial oblique position of the ankle, which of the following statements are true?
- The leg and foot are rotated medially
 - The ankle is adjusted to a 90-degree angle
 - The medial rotation is adjusted to 45 degrees to show the mortise joint
 - The medial rotation is adjusted to 15 to 20 degrees to show the bony structure
 - The central ray is directed vertically midway between the malleoli
- 1, 4
 - 1, 5
 - 1, 3, 4, 5
 - 1, 2, 3, 4
44. For a lateral lower leg projection, which of the following statements are true?
- The leg is centered to the image receptor
 - The exam may be performed with the patient on the tabletop or Bucky
 - Roll the patient away from the affected side
 - The patella should be perpendicular to the image receptor
 - Include both joints
 - The tibia and fibula should be superimposed
 - The central ray is directed to the midpoint of the leg
- 1, 2, 3
 - 1, 2, 3, 4, 5, 7
 - 1, 4, 5, 6, 7
 - 1, 2, 4, 5, 7
45. When a lateral knee projection is performed, which of the following statements are true?
- The patient turns onto the affected side
 - The knee is flexed 20 to 30 degrees
 - The patella must be parallel to the image receptor
 - The central ray is directed 5 to 7 degrees caudad
 - The central ray enters the knee joint inferior to the medial epicondyle
- 1, 2, 3
 - 1, 2, 3, 5
 - 1, 2, 5
 - 1, 2, 4, 5
46. For a tangential projection of the patella, which of the following statements are true?
- The patient is prone
 - The affected knee is flexed so that the tibia and fibula form a 50- to 60-degree angle with the table
 - The central ray is directed 45 degrees cephalad through the patellofemoral joint
 - The tangential patella projection may also be performed with the patient supine
- 1, 2, 3, 4
 - 2, 3, 4
 - 1, 2, 3
 - 1, 2, 4

47. For an AP projection of the femur:
- The lower leg should be rotated laterally 15 degrees
 - The central ray is directed toward the affected joint
 - The patient is prone
 - The lower leg is rotated medially 15 degrees
48. The central ray for an AP projection of the hip is:
- Directed parallel to a point 2 inches medial to the ASIS and at the level of the superior margin of the greater trochanter
 - Directed parallel to a point 2 inches lateral to the ASIS and at the level of the superior margin of the greater trochanter
 - Directed parallel to a point 2 inches medial to the ASIS and at the level of the inferior margin of the greater trochanter
 - Directed 2.5 inches distal on a line drawn perpendicular to the midpoint of a line between the symphysis pubis and the ASIS
49. What condition is commonly caused by motor vehicle accidents?
- Jefferson fracture
 - Hangman fracture
 - Spondylolysis
 - Spina bifida
50. What condition is caused by acute hyperextension of the head on the neck and a fracture of the arch of C2?
- Jefferson fracture
 - Hangman fracture
 - Spondylolysis
 - Spina bifida
51. What is a defect of the posterior aspect of the spinal canal caused by failure of the vertebral arch to form properly?
- Jefferson fracture
 - Hangman fracture
 - Spondylolysis
 - Spina bifida
52. What is a defect in the pars interarticularis?
- Jefferson fracture
 - Hangman fracture
 - Spondylolysis
 - Spina bifida
53. What is a comminuted fracture of the ring of the atlas that involves both anterior and posterior arches and causing displacement of the fragments?
- Jefferson fracture
 - Hangman fracture
 - Spondylolysis
 - Spina bifida
54. For a lateral projection of the cervical spine, which of the following statements are true?
- The patient may be upright, seated, or supine, depending on his or her condition
 - SID of 72 inches should be used because of increased object-to-image receptor distance
 - The shoulders should lie in the same plane
 - The cervical collar should be removed so that it does not obstruct pertinent anatomy
 - The chin should be in contact with the chest
 - 1, 2, 4
 - 1, 2, 3
 - 1, 2, 3, 5
 - 1, 2, 4, 5
55. For a lateral projection of the thoracic spine, which of the following statements are true?
- The head and spine should be in the same plane
 - The central ray is directed to T7, at a cephalad angle of 10 degrees
 - The patient should continue shallow breathing during exposure
 - The exam should not be performed in a room with a falling load generator, if possible
 - 1, 2
 - 1, 3
 - 1, 3, 4
 - 1, 2, 3
56. For a lateral projection of L5-S1, which of the following statements are true?
- The patient is in a lateral position
 - The hips and knees are extended
 - The image receptor is centered to the CR
 - A cylinder cone may be used to reduce greatly the production of scatter radiation
 - The central ray is centered on a coronal plane 2 inches posterior to the ASIS and 1½ inches inferior of the iliac crest
 - 1, 2, 3, 4, 5
 - 1, 2
 - 1, 2, 3, 5
 - 1, 3, 4, 5
57. For RPO and LPO positions for sacroiliac joints:
- Image the joint nearest the image receptor
 - The part must be angled at 10 to 15 degrees to coincide with the angle of the joints
 - Image the joint farthest from the image receptor
 - The central ray must be angled 25 degrees cephalad
58. For an AP projection of the coccyx:
- The central ray should be directed 10 degrees caudad, entering 2 inches superior to the symphysis pubis
 - The central ray should be directed 10 degrees cephalad, entering 2 inches superior to the symphysis pubis
 - The central ray should be directed 25 degrees caudad, entering 2 inches superior to the symphysis pubis
 - The central ray should be directed 25 degrees caudad, entering 4 inches superior to the symphysis pubis
59. Which pathologic condition is easy to penetrate?
- Atelectasis
 - Bronchogenic carcinoma

- c. COPD
 - d. Emphysema
60. What condition is a collapse of lung tissue and is harder to penetrate?
- a. Atelectasis
 - b. Bronchogenic carcinoma
 - c. COPD
 - d. Emphysema
61. What condition is characterized by air trapped in the alveoli, which makes the condition very easy to penetrate?
- a. Atelectasis
 - b. Bronchogenic carcinoma
 - c. COPD
 - d. Emphysema
62. What condition should not be imaged with use of an AEC?
- a. Atelectasis
 - b. Bronchogenic carcinoma
 - c. COPD
 - d. Emphysema
63. What is lung cancer arising from bronchial mucosa?
- a. Atelectasis
 - b. Bronchogenic carcinoma
 - c. COPD
 - d. Emphysema
64. What progressive condition is marked by diminished capabilities of inspiration and expiration?
- a. Atelectasis
 - b. Bronchogenic carcinoma
 - c. COPD
 - d. Emphysema
65. For an AP projection of the ribs above the diaphragm, which of the following statements is true?
1. The top of the image receptor is placed 1 to 2 inches above the shoulders
 2. The shoulders are relaxed, and the scapulae are flat against the table
 3. The central ray is directed to T7
 4. Exposure is performed on full expiration to depress the diaphragm
- a. 1, 3
 - b. 1, 2, 3, 4
 - c. 1, 2, 3
 - d. 1, 3, 4
66. For RAO position of the sternum:
- a. The body should be rotated 45 to 60 degrees to prevent superimposition of the sternum and spine
 - b. The patient is supine
 - c. Breathing should be shallow during exposure; a falling load generator should not be used, if possible
 - d. The best image is obtained with suspended breathing
67. For radiography of the sternoclavicular articulations:
- a. PA and lateral projections are required
 - b. RAO or LAO positions are used to eliminate superimposition of joints onto vertebral shadow
 - c. The patient should breathe during exposure; a falling load generator should be used if possible
 - d. An AP projection is used to reduce magnification of joints
68. What condition is characterized by soft bones resulting from deficiency of vitamin D and sunlight?
- a. Hydrocephalus
 - b. Paget disease
 - c. Osteoporosis
 - d. Rickets
69. What condition is a bone disease that causes bone destruction and unorganized bone repair and is generally difficult to penetrate?
- a. Hydrocephalus
 - b. Paget disease
 - c. Osteoporosis
 - d. Rickets
70. What condition is an abnormal demineralization of bone, seen more often in females?
- a. Hydrocephalus
 - b. Paget disease
 - c. Osteoporosis
 - d. Rickets
71. What condition is marked by abnormal accumulation of cerebrospinal fluid in the brain?
- a. Hydrocephalus
 - b. Paget disease
 - c. Osteoporosis
 - d. Rickets
72. What condition is most often seen in elderly patients?
- a. Hydrocephalus
 - b. Paget disease
 - c. Osteoporosis
 - d. Rickets
73. For a direct PA projection of the skull, the central ray is directed:
- a. 15 degrees caudad
 - b. 25 degrees caudad
 - c. Perpendicular to the image receptor
 - d. Perpendicular to the image receptor, exiting the nasion when the OML is perpendicular to the IR
74. When the skull is radiographed in the lateral position:
- a. The MSP must be perpendicular to the IR, the IOML must be parallel to the IR, and the IPL must be parallel to the IR
 - b. The MSP and IOML are parallel to the IR, and the IPL is perpendicular to the IR
 - c. The MSP is perpendicular to the IR, and the IPL is parallel to the IR
 - d. The MSP and IOML are perpendicular to the IR, and the IPL is parallel to the IR
75. Most radiographic imaging of the skull has been replaced by what imaging modality?
- a. Magnetic resonance imaging
 - b. Nuclear medicine
 - c. Angiography
 - d. Computed tomography

76. When a parietoacanthial (Waters) projection is performed for the facial bones:
- The MSP is parallel to the IR
 - The MSP is perpendicular to the IR, the head rests on the chin, and the OML forms a 53-degree angle with the plane of the image receptor
 - The MSP is perpendicular to the IR, the head rests on the chin, and the OML forms a 37-degree angle with the plane of the image receptor
 - The MSP is perpendicular to the image receptor (IR), the head rests on the nose, and the OML forms a 37-degree angle with the plane of the IR
77. For a unilateral tangential (May) projection of the zygomatic arches:
- The IOML is parallel to the plane of the image receptor, the MSP is rotated 15 degrees away from the affected side, the IR is centered 3 inches distal to the most prominent point of the zygoma, and the central ray is directed perpendicular to the IOML through the zygomatic arch 1½ inches posterior to the outer canthus
 - The IOML is parallel to the plane of the image receptor, the MSP is rotated 15 degrees toward the affected side, the IR is centered 3 inches distal to the most prominent point of the zygoma, and the central ray is directed perpendicular to the IOML through the zygomatic arch 1½ inches posterior to the outer canthus
 - The IOML is parallel to the plane of the image receptor, the MSP is rotated 15 degrees away from the affected side, the IR is centered 3 inches distal to the most prominent point of the zygoma, and the central ray is directed perpendicular to the zygomatic arch 1½ inches posterior to the outer canthus
 - The IOML is parallel to the plane of the image receptor, the MSP is rotated 25 degrees away from the affected side, the IR is centered 3 inches distal to the most prominent point of the zygoma, and the central ray is directed perpendicular to the IOML through the zygomatic arch 1½ inches posterior to the outer canthus
78. When the mandibular body is radiographed with the patient in the SMV position:
- The head and neck are extended and resting on the chin
 - The MSP is parallel with the IR.
 - The IOML is perpendicular with the plane of the image receptor, the head and neck are resting on the vertex, and the MSP is perpendicular to the IR
 - The IOML is parallel with the plane of the image receptor, the head is resting on the vertex, and the MSP is perpendicular to the IR
79. The best survey study of the paranasal sinuses is obtained by use of what projection?
- Lateral
 - Parietoacanthial (Waters)
 - Upright lateral
 - SMV
80. What is a condition in which a portion of the stomach protrudes through the diaphragm?
- Annular carcinoma
 - Crohn disease
 - Hiatal hernia
 - Ileus
81. What condition involves an intestinal obstruction?
- Annular carcinoma
 - Crohn disease
 - Hiatal hernia
 - Ileus
82. What condition involves chronic inflammation of portions of the bowel?
- Annular carcinoma
 - Crohn disease
 - Hiatal hernia
 - Ileus
83. What condition may be adynamic or mechanical?
- Annular carcinoma
 - Crohn disease
 - Hiatal hernia
 - Ileus
84. What condition appears in an “apple-core” pattern on a barium enema exam?
- Annular carcinoma
 - Crohn disease
 - Hiatal hernia
 - Ileus
85. What condition is visualized by performing an upper GI series?
- Diverticula
 - Ulcerative colitis
 - Pyloric stenosis
 - Adynamic ileus
86. What describes a bowel obstruction caused by immobility of the bowel?
- Diverticula
 - Ulcerative colitis
 - Pyloric stenosis
 - Adynamic ileus
87. What condition is characterized by pouch-like herniations of the colonic wall?
- Diverticula
 - Ulcerative colitis
 - Pyloric stenosis
 - Adynamic ileus
88. What condition causes a narrowing of the sphincter at the distal end of the stomach?
- Diverticula
 - Ulcerative colitis
 - Pyloric stenosis
 - Adynamic ileus
89. What condition is a severe inflammation of the colon and rectum with loss of mucosal lining?
- Diverticula
 - Ulcerative colitis
 - Pyloric stenosis
 - Adynamic ileus

90. For RAO position of the esophagus:
- The patient is rotated obliquely by elevation of the right side 35 to 40 degrees, and the esophagus is centered to the image receptor at the level of T5 or T6
 - The patient is rotated obliquely by elevation of the left side 35 to 40 degrees, and the esophagus is centered at the level of T5 or T6
 - The patient is rotated obliquely by elevation of the right side 55 to 60 degrees, and the esophagus is centered to the image receptor at the level of T5 or T6
 - The patient is rotated obliquely by elevation of the left side 55 to 60 degrees, and the esophagus is centered to the image receptor at the level of T5 or T6
91. For a PA projection of the stomach:
- Center midway between the xiphoid process and the umbilicus
 - Center halfway between the midline and lateral border of the abdominal cavity
 - Center midway between the manubrium and the umbilicus and halfway between the midline and lateral border of abdominal cavity
 - Center midway between the xiphoid process and the umbilicus and halfway between the midline and lateral border of the abdominal cavity
92. For the LPO or RPO positions for the colon:
- The patient is prone, rotated 35 to 45 degrees, with the central ray at the level of the iliac crest
 - The patient is supine, rotated 55 to 60 degrees, with the central ray at the level of ASIS
 - The patient is supine, rotated 35 to 45 degrees from AP, with the central ray at the level of the iliac crest
 - The patient is prone, rotated 55 to 60 degrees, with the central ray at the level of the iliac crest
93. For a lateral decubitus position of the colon:
- The patient is lying on one side, the image receptor is centered to the iliac crest, and the central ray is horizontal to the midline at the level of the iliac crest
 - The patient is prone, the image receptor is centered to the iliac crest, and the central ray is horizontal to the midline at the level of the iliac crest
 - The patient is lying on one side, the image receptor is centered 3 inches above the iliac crest, and the central ray is horizontal 3 inches above the iliac crest
 - The patient is prone, the image receptor is centered to L1, and the central ray is horizontal to L1
94. A procedure used to evaluate biliary and pancreatic pathologic conditions with an endoscope is:
- Ultrasound
 - MRI
 - ERCP
 - IVP
95. What condition is characterized by fluid-filled masses in the kidney?
- Polycystic kidney disease
 - Renal calculus
 - Wilms tumor
 - Renal cysts
96. Which of the following is a malignant cancer of the kidney?
- Polycystic kidney disease
 - Renal calculus
 - Wilms tumor
 - Renal cysts
97. What condition includes enlarged kidneys containing numerous cysts?
- Polycystic kidney disease
 - Renal calculus
 - Wilms tumor
 - Renal cysts
98. Which of the following conditions is seen primarily in children?
- Polycystic kidney disease
 - Renal calculus
 - Wilms tumor
 - Renal cysts
99. Which of the following describes a kidney stone?
- Polycystic kidney disease
 - Renal calculus
 - Wilms tumor
 - Renal cysts
100. For RPO and LPO positions of the kidneys:
- The patient is prone, the body is rotated obliquely 30 degrees, the kidney farther from the image receptor is imaged in profile, the kidney nearer the image receptor is imaged in its entirety, and the central ray is perpendicular to the IR
 - The patient is supine, the body is rotated obliquely 45 degrees, the kidney farther from the image receptor is imaged in profile, the kidney nearer the image receptor is imaged in its entirety, and the central ray is perpendicular to the IR
 - The patient is supine, the body is rotated obliquely 30 degrees, the kidney farther from the image receptor is imaged parallel to the image receptor, the kidney nearer the image receptor is imaged perpendicular to the image receptor, and the central ray is perpendicular to the IR
 - The patient is supine, the body is rotated obliquely 30 degrees, the kidney nearer the image receptor is imaged in profile, the kidney farther from the image receptor is imaged in its entirety, and the central ray is perpendicular to the IR

6

Challenge Tests

The review tests in this chapter are constructed using the same proportion of questions contained on the radiography certification exam. The computer-based certification exam asks you questions at random; however, these printed tests are sorted by category.

After you complete your review work and take these challenge tests, you are ready to move on to the online questions. There you will find hundreds of additional questions presented randomly in 200-question blocks, sectioned to simulate the actual American Registry of Radiologic Technologists (ARRT) examination. The online questions are your best practice and preparation. You will be answering questions on a computer at random, just as you will when you take the ARRT exam. There are enough questions to give you many different exams with countless combinations of questions, always according to ARRT test specifications. By drilling yourself using this test bank, you will be as prepared as possible for test day.

Challenge Test Number 1

ARRT Exam Categories: Safety, Image Production, Procedures, Patient Care

Read each question and the answer choices carefully. Choose the best, most complete answer for each item. Use the results of this test to assess your strengths and weaknesses. Do not look up any of the answers until you have completed the entire test. Correct the test using the answer key in the back of the book. Then compute your scores using Table 6-1 to see where you are strong and where you need additional review. Refer to the appropriate chapter in this book for review of the questions you miss.

Safety (Questions 1-53)

1. Attenuation:
 - a. Is radiation that emerges from the patient
 - b. Describes changes in the x-ray beam as it travels through the patient
 - c. Produces only scatter radiation
 - d. Occurs only at doses used in radiation therapy
2. Which photon-tissue interaction makes radiography possible because of its creation of contrast?

- a. Compton
 - b. Coherent
 - c. Photoelectric
 - d. Pair production
3. Which photon-tissue interaction produces radiation that may expose others in the room during fluoroscopy?
 - a. Compton
 - b. Coherent
 - c. Photoelectric
 - d. Pair production
 4. The unit of radiation absorbed in air is the:
 - a. Sv
 - b. Gy_a
 - c. Bq
 - d. Gy_t
 5. The unit of radioactivity is the:
 - a. Becquerel
 - b. Gray_t
 - c. Sievert
 - d. Gray_a
 6. The unit of effective dose is the:
 - a. Becquerel
 - b. Gray_t
 - c. Sievert
 - d. Gray_a
 7. Linear energy transfer:
 - a. Is the same for all types of radiation
 - b. Is the same for wave and particulate radiations used in diagnosis and treatment
 - c. Occurs only during x-ray procedures
 - d. Varies for different types of radiation
 8. The unit of Bq would be used in what imaging modality?
 - a. Radiography
 - b. CT
 - c. MRI
 - d. Nuclear medicine
 9. Graphs that show the relationship between radiation received and the organism's response are called:
 - a. Response curves
 - b. Exposure curves
 - c. Dose-response curves
 - d. Radiation-threshold curves

10. Medical x-rays are an example of:
 - a. Natural background radiation
 - b. Artificially produced radiation
 - c. Nonionizing radiation
 - d. Ionizing, natural background radiation
11. Cataractogenesis does not occur at low levels of radiation exposure; it is best expressed by which of the following dose-response relationships?
 - a. Threshold
 - b. Nonthreshold
 - c. Low dose
 - d. Occupational dose
12. Increased dose equals increased probability of effects best describes which of the following?
 - a. Stochastic effects
 - b. Deterministic effects
 - c. Direct effect
 - d. Indirect effect
13. The cumulative occupational exposure for a 22-year-old radiographer is:
 - a. 220 mSv
 - b. 22 mSv
 - c. 11 mSv
 - d. 110 mSv
14. The annual effective dose limit for the general public, assuming frequent exposure, is:
 - a. 0.5 mSv
 - b. 500 mSv
 - c. 0.05 mSv
 - d. 1.0 mSv
15. The secondary protective barrier used in room shielding must be at least how thick?
 - a. $\frac{1}{32}$ -inch Al equivalent
 - b. $\frac{1}{16}$ -inch Al equivalent
 - c. $\frac{1}{16}$ -inch Pb equivalent
 - d. $\frac{1}{32}$ -inch Pb equivalent
16. The intensity of the scattered beam is $\frac{1}{1000}$ the intensity of the primary beam at a _____ angle 1 m from the patient.
 - a. 45-degree
 - b. 25-degree
 - c. 90-degree
 - d. 10-degree
17. If the air kerma measured 6 feet from the x-ray table is 5 Gray_a, what is the air kerma measured at a distance of 3 feet?
 - a. 20 Gray_a
 - b. 10 Gray_a
 - c. 1.25 Gray_a
 - d. 2.5 Gray_a
18. The minimum source-to-skin distance for fixed fluoroscopes is:
 - a. 15 inches
 - b. 12 inches
 - c. 10 inches
 - d. 18 inches
19. The use of gonadal shielding on female patients may reduce gonad dose by:
 - a. 50%
 - b. 75%
 - c. 85%
 - d. 95%
20. Cells that are oxygenated are more susceptible to radiation damage; this describes:
 - a. Target theory
 - b. Direct effect
 - c. Doubling dose
 - d. Oxygen enhancement ratio
21. The blood count is depressed after a whole-body dose equivalent of at least how many rads?
 - a. 10 Sv
 - b. 0.25 Sv
 - c. 5 Sv
 - d. 0.01 Sv
22. Highly reactive ions that have unpaired electrons in the outer shell are called:
 - a. Electrified
 - b. Radiolytic
 - c. Hydrogen peroxide
 - d. Free radicals
23. The master molecule that directs cell activities is:
 - a. RNA
 - b. Hydrogen peroxide
 - c. A free radical
 - d. DNA
24. The process of somatic cell division is called:
 - a. Mitosis
 - b. Spermatogenesis
 - c. Organogenesis
 - d. Cytogenesis
25. The most common effect from exposure to ionizing radiation is:
 - a. Mutations
 - b. Ionization of atoms in the cells
 - c. Cell death
 - d. Nothing
26. Most radiation-induced damage to cells occurs:
 - a. At diagnostic levels of radiation
 - b. During fluoroscopy
 - c. At doses of radiation much higher than doses used in radiography
 - d. From background radiation
27. Radiation doses up to _____ are considered relatively low risk to the embryo and fetus.
 - a. 5 mSv
 - b. 10 mSv
 - c. 0.01 mSv
 - d. 0.20 mSv
28. A concept of radiologic practice that encourages radiation users to adopt measures that keep the dose to the patient and themselves at minimum levels is called:
 - a. LET
 - b. RBE

- c. MPD
d. ALARA
29. Which of the following is (are) relatively insensitive to radiation?
a. Nerve tissue
b. Reproductive cells
c. Epithelial tissue
d. Immature sperm cells
30. Somatic effects of radiation:
a. Are common
b. Are caused when a large dose of high-LET radiation is received by a large area of the body
c. Are caused after exposure of DNA
d. Include genetic mutations
31. The best way to keep the radiation dose to the patient low is:
a. Distance
b. Shielding
c. Time
d. Avoidance of repeat exposures
32. X-rays may remove electrons from atoms in the body by a process called:
a. Electrification
b. Exposure
c. Ionization
d. Radicalizing
33. Ionization may cause:
a. Stable atoms
b. Production of high-energy x-rays
c. Formation of new molecules beneficial to the cell
d. Unstable atoms
34. Cell damage may be exhibited as:
a. Loss of function or abnormal function
b. Nothing
c. Enhanced function
35. Damage to the cell being irradiated is called:
a. Genetic
b. Exposed cell
c. Somatic
d. Molecular
36. Radiation effects that show up in the next generation are called:
a. Genetic
b. Exposed cell
c. Somatic
d. Molecular
37. Radiation that is contained in the environment is called:
a. Man-made
b. Artificial
c. Natural background
d. Artificial background
38. Background radiation is the source of approximately what percent of human exposure?
a. 95%
b. 82%
c. 50%
d. 35%
39. The annual effective dose per person from natural background radiation is approximately:
a. 1.0 mSv
b. 3.0 mSv
c. 50 mSv
d. 9.0 mSv
40. The greatest source of natural background radiation to humans is:
a. X-rays
b. Delta rays
c. Radon
d. Radium
41. According to NCRP Report #160, the increase in total exposure is primarily attributed to increased use of:
a. MRI
b. Diagnostic medical ultrasound
c. Fluoroscopy and interventional procedures
d. CT
42. What barrier must be at least 1/16-inch lead equivalent?
a. Lead apron
b. Primary protective barrier
c. Bucky slot cover
d. Secondary protective barrier
43. CT accounts for approximately what percent dose to the population (NCRP Report #160)?
a. 24%
b. 50%
c. 15%
d. 80%
44. Meiosis describes the process of division of what type of cells?
a. Somatic
b. Cancer
c. Muscle
d. Germ
45. What is the most important reason for collimating and using gonadal shielding?
a. To prevent mutations from occurring in the human population
b. To prevent ionization of water molecules in the body
c. To control somatic effects of ionizing radiation exposure
d. To increase contrast in the radiographic image
46. What refers to the lifetime accumulated occupational dose?
a. Annual accumulated effective dose
b. Cumulative effective dose
c. Common effective dose
d. Common medical effective dose
47. Exposure times longer than ____ minutes can lead to skin effects.
a. 5
b. 10

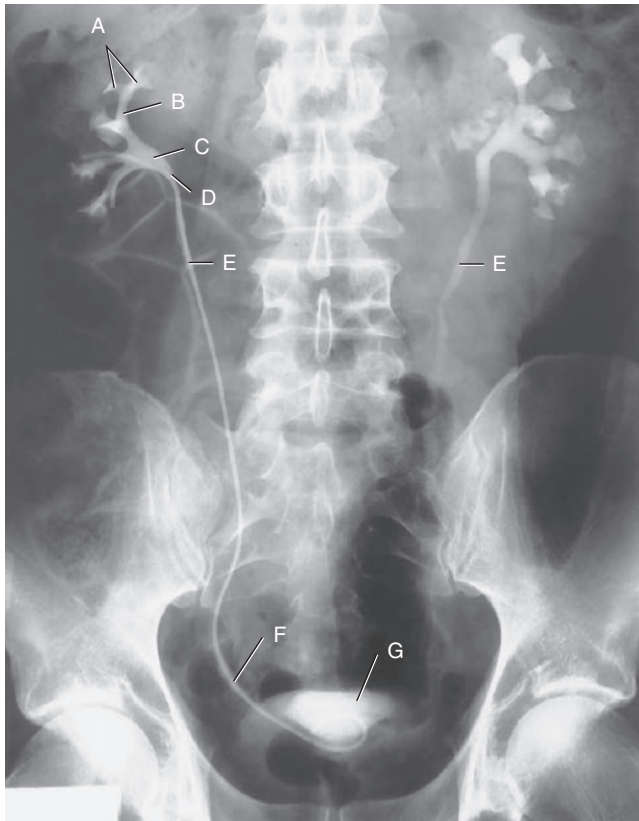
- c. 20
d. 30
48. What provides an approximate skin dose where the x-ray beam is entering the patient?
a. Sievert
b. Becquerel
c. Air kerma
d. Effective dose
49. Two of the following are sources of exposure to natural background radiation. Choose both.
a. Medical x-rays
b. Radon
c. Certain consumer products
d. Microwave ovens
e. Dental x-rays
f. Exposure during air travel
50. The *preferred* term for radiation exposure is:
a. Coulombs per kilogram
b. Gray
c. Sievert
d. Air kerma
51. Effective dose limits may be found in what published material?
a. Dose limit reports
b. NCRP reports
c. Environment Protection Agency reports
d. Health and Human Services reports
52. Photon-cell interactions occur:
a. Predictably
b. By chance
c. Seldom
d. Only at high radiation doses
53. Calipers are used to measure:
a. Radiation dose
b. Patient part thickness
c. Patient BMI
d. Patient body thickness
- Image Production (Questions 54-103)**
54. The smallest particle of an element that retains the characteristics of the element is a(n):
a. Element
b. Atom
c. Molecule
d. Neutron
55. Atomic mass refers to:
a. The number of protons plus the number of neutrons
b. The number of electrons
c. The number of electron shells
d. The number of protons
56. X-rays travel as bundles of energy called:
a. Protons
b. Phasers
c. Particles
d. Photons
57. The height of a sine wave is called:
a. Wavelength
b. Altitude
c. Amplitude
d. Frequency
58. The transformer that operates on the principle of self-induction is the:
a. Step-up transformer
b. Step-down transformer
c. Induction transformer
d. Autotransformer
59. Electronic timers used in x-ray equipment allow for exposure times of:
a. $\frac{1}{100}$ second
b. $\frac{1}{1000}$ second
c. 1 μ s
d. There is no limit to how short the exposure can be
60. To ensure consistency of radiographic quality from one exposure to the next, what device may be used?
a. Electronic timer
b. Automatic collimation
c. Automatic exposure control
d. Falling load generator
61. An x-ray machine that uses a continually decreasing mA for the shortest times possible uses a(n):
a. Ionization chamber
b. Phototimer
c. AEC
d. Falling load generator
62. Devices in the x-ray circuit that operate on the principle of mutual induction are called:
a. Rectifiers
b. Generators
c. Timers
d. Transformers
63. The high-voltage section of the x-ray circuit makes use of what type of transformer?
a. Step-up
b. Autotransformer
c. Step-down
d. Falling load
64. The device in the x-ray circuit that changes AC to DC is the:
a. Autotransformer
b. Step-up transformer
c. Rectifier
d. Falling load generator
65. What type of current is required for proper operation of the x-ray tube?
a. Direct
b. Falling load
c. Alternating
d. Fluctuating
66. The result of thermionic emission is a(n):
a. Recoil electron
b. Electron cloud

- c. Scattered photon
 - d. Characteristic photon
67. The focusing cup is located at the:
- a. Cathode
 - b. Anode
 - c. X-ray tube window
 - d. Control panel
68. An interaction that produces x-rays at the anode as a result of outer shell electrons filling holes in the K-shell is called:
- a. Characteristic
 - b. Photoelectric
 - c. Compton
 - d. Brems
69. In digital fluoroscopy, the image should be viewed on what device to take advantage of the digital capabilities?
- a. Digital viewbox
 - b. High-resolution monitor
 - c. High-definition TV
 - d. Plasma TV
70. A primary advantage of digital fluoroscopy is:
- a. Postprocessing manipulation of the image
 - b. No radiation dose to the patient
 - c. No fluoroscopist required
 - d. Lower cost
71. In digital fluoroscopy and computed radiography, the energy must be changed to digital form by a(n):
- a. Digital-to-analog converter
 - b. Flux capacitor
 - c. Analog-to-digital converter
 - d. DVD-ROM
72. An algorithm is:
- a. A mathematical hypothesis used in imaging
 - b. A mathematical formula used to reconstruct the image in digital imaging
 - c. An advanced imaging procedure
 - d. The mathematical basis for film-screen imaging
73. In computed radiography, each pixel corresponds to a shade of gray representing an area in the patient known as a(n):
- a. Pathology
 - b. Density
 - c. Voxel
 - d. Artifact
74. Lightness and darkness of the image in computed radiography may be adjusted by:
- a. Doubling the kVp
 - b. Adjusting the window level
 - c. Adjusting the window width
 - d. Using digital fluoroscopy
75. The window level in computed radiography is the:
- a. Area of the patient being irradiated
 - b. Amount of radiation needed to obtain the image
 - c. Midpoint of densities
 - d. Top of the midpoint of densities
76. Radiographic contrast in computed radiography may be adjusted by changing the:
- a. Window level
 - b. Window width
 - c. Area of the patient being irradiated
 - d. Imaging plate
77. The amount of receptor exposure is controlled primarily by:
- a. kVp
 - b. Focal spot size
 - c. AEC
 - d. mAs
78. The visible image may also be called the:
- a. Manifest image
 - b. Image-in-waiting
 - c. Preprocessed image
 - d. Latent image
79. The quantity of x-rays produced is directly controlled by:
- a. kVp
 - b. OID
 - c. SID
 - d. mAs
80. The rule or law that governs changing technique using kVp is the:
- a. Inverse square law
 - b. Density maintenance law
 - c. Reciprocity law
 - d. 15% rule
81. If SID is halved, what may be said about receptor exposure?
- a. Receptor exposure doubles
 - b. Receptor exposure is reduced by half
 - c. Receptor exposure is reduced by one-half of the mAs
 - d. Receptor exposure is quadrupled
82. Distortion that affects the size of the object as represented on the radiographic image is called:
- a. Minification
 - b. Foreshortening
 - c. Elongation
 - d. Magnification
83. Shape distortion may take the form of:
- a. Magnification and minification
 - b. Size and shape distortion
 - c. Elongation and foreshortening
 - d. Magnification and elongation
84. A longer than usual OID may cause:
- a. Elongation
 - b. Foreshortening
 - c. Minification
 - d. Magnification
85. CR cassettes *should* be erased at least:
- a. Every 24 hours
 - b. Every 48 hours
 - c. Every 3 months
 - d. Weekly

86. The equation H/D describes:
- Grid radius
 - Contrast
 - Grid ratio
 - Reciprocity law
87. If the exposure field is not accurately recognized, the histogram:
- Narrows
 - Widens
 - Remains the same
88. Noise increases with an increase in:
- mAs
 - Speed class
 - SID
 - OID
89. Edge enhancement provides:
- Artificial increase in display contrast at an edge of the image
 - Artificial increase in display brightness at an edge of the image
 - Artificial increase in spatial resolution at an edge of the image
90. Which of the following grid errors would result in an image that shows normal exposure in the middle but decreased exposure on the sides and may follow removal and replacement of the grid?
- Upside down
 - Off-level
 - Lateral decentering
 - Grid-focus decentering
91. Grid frequency is described as the:
- Height of the lead strips divided by the distance between the lead strips
 - Distance between the lead strips divided by the height of the lead strips
 - Number of lead strips per inch or centimeter
 - SID at which the grid may be used
92. When working with CR and DR, one must be aware that their response to scatter radiation is:
- Very sensitive
 - Minimally sensitive
 - Irrelevant
93. The images on radiologists' monitors appear:
- The same as on radiographers' monitors
 - In greater detail than on radiographers' monitors
 - In less detail than on radiographers' monitors
94. A histogram analysis error may be caused by:
- Excessive mAs
 - Pixel unresponsiveness
 - Inappropriate collimation
 - Excessive kVp
95. Smoothing provides:
- Higher spatial resolution
 - Equalization
 - Evenness in brightness
 - Higher contrast resolution
96. Consistency of image appearance is achieved through the use of:
- Higher speed class
 - Uniform processing codes
 - More effective postprocessing
 - Lower exposure index numbers
97. Which of the following sets of exposure factors would produce an image with the poorest spatial resolution?
- 60 mAs, 80 kVp, 40-inch SID, 4-inch OID
 - 30 mAs, 92 kVp, 40-inch SID, 4-inch OID
 - 120 mAs, 92 kVp, 20-inch SID, 4-inch OID
 - 15 mAs, 100 kVp, 40-inch SID, 4-inch OID
98. Which of the following sets of exposure factors would produce an image with the best spatial resolution?
- 60 mAs, 80 kVp, 72-inch SID, 4-inch OID
 - 30 mAs, 92 kVp, 40-inch SID, 4-inch OID
 - 120 mAs, 92 kVp, 20-inch SID, 4-inch OID
 - 15 mAs, 100 kVp, 40-inch SID, 4-inch OID
99. Beam restriction has the following effect on contrast:
- Decreases contrast
 - Longer scale of contrast
 - Shorter scale of contrast
 - No effect on contrast
100. As kVp increases, there is an increased production of:
- Long wavelengths
 - Low-energy waves
 - Short wavelengths
 - Electrons
101. The relationship between kVp and receptor exposure is:
- Indirect
 - Directly proportional
 - Direct, although not proportional
 - Inverse
102. Grids that have strips angled to coincide with divergence of the x-ray beam are called:
- Parallel
 - Crosshatch
 - Focused
 - Rhombic
103. In digital imaging, the radiographer must be aware that:
- mAs is the primary controlling factor
 - The image is determined by the total exposure
 - Speed class is the primary controlling factor
 - kVp is the primary controlling factor

Procedures (Questions 104-167)

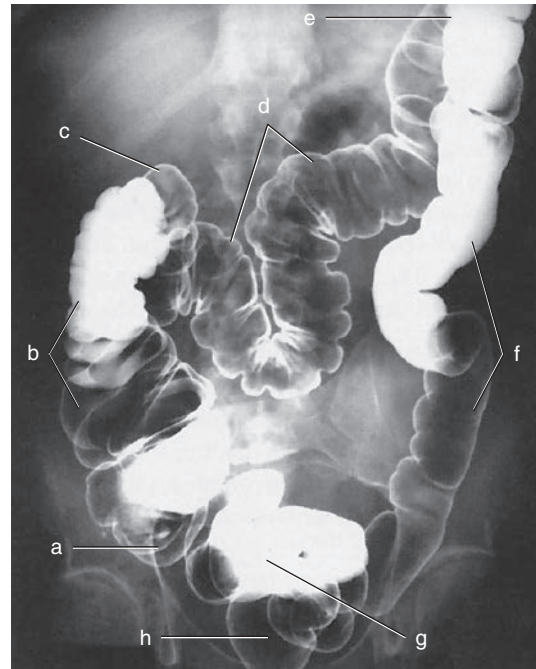
Using **Figure 6-1**, identify the radiographic anatomy of the urinary system.



• **Figure 6-1** Retrograde pyelogram.

104. Structure *A* is the:
 a. Renal pelvis
 b. Ureter
 c. Minor calyces
 d. Major calyces
105. Structure *B* is the:
 a. Renal pelvis
 b. Urethra
 c. Minor calyces
 d. Major calyces
106. Structure *C* is the:
 a. Renal pelvis
 b. Ureter
 c. Urethra
 d. Renal pyramids

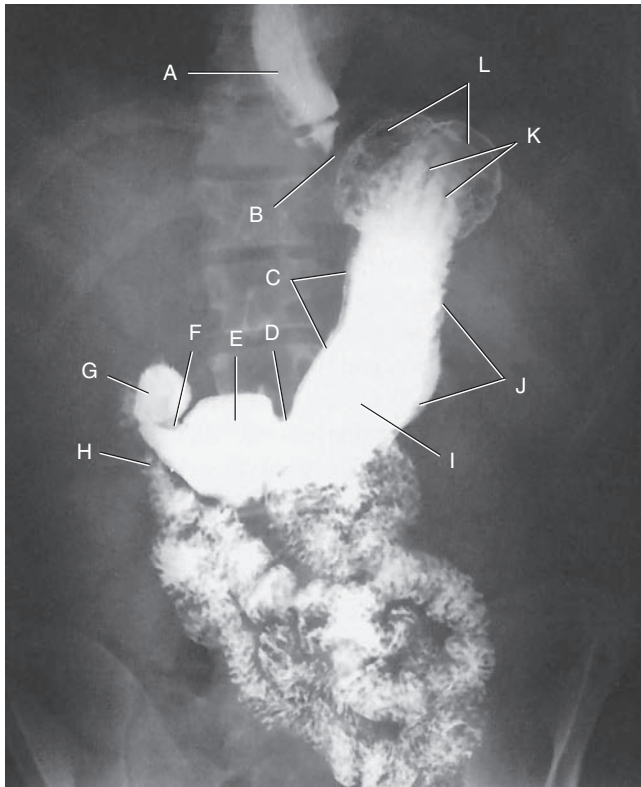
Using **Figure 6-2**, identify the radiographic anatomy of the colon.



• **Figure 6-2** AP projection, barium enema (double-contrast enema).

107. Structure *b* is the:
 a. Transverse colon
 b. Ascending colon
 c. Hepatic flexure
 d. Descending colon
108. Structure *c* is the:
 a. Transverse colon
 b. Ascending colon
 c. Hepatic flexure
 d. Splenic flexure
109. Structure *d* is the:
 a. Transverse colon
 b. Splenic flexure
 c. Hepatic flexure
 d. Descending colon
110. Structure *f* is the:
 a. Jejunum
 b. Ascending colon
 c. Hepatic flexure
 d. Descending colon

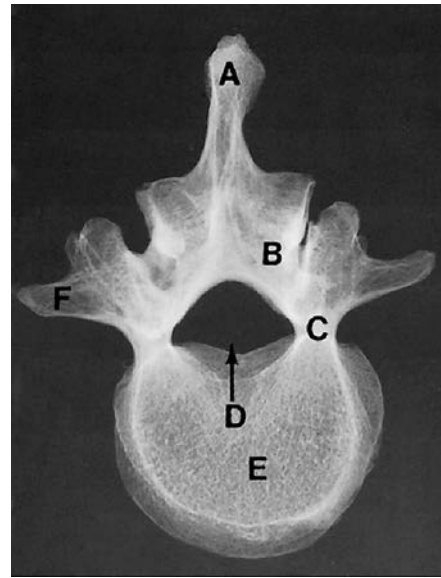
Using **Figure 6-3**, identify the radiographic anatomy visualized during an upper GI series.



• **Figure 6-3** PA projection of the stomach.

111. Structure *D* is the:
- Rugae
 - Haustra
 - Pylorus
 - Incisura angularis
112. Structure *E* is the:
- Rugae
 - Fundus
 - Pylorus
 - Cardiac sphincter
113. Structure *K* is the:
- Rugae
 - Haustra
 - Pylorus
 - Incisura angularis
114. Structure *L* is the:
- Rugae
 - Fundus
 - Pylorus
 - Incisura angularis

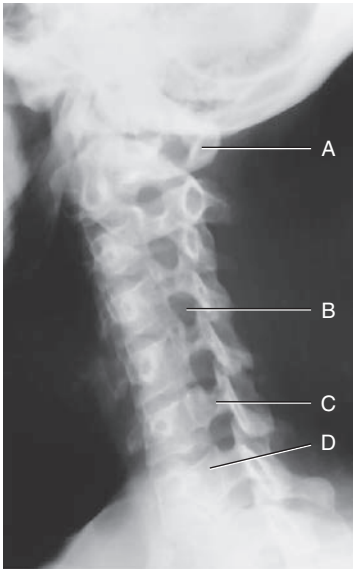
Using **Figure 6-4**, identify the anatomy of a lumbar vertebra.



• **Figure 6-4** Lumbar vertebra (superoinferior projection).

115. Structure *A* is the:
- Pedicle
 - Spinous process
 - Transverse process
 - Lamina
116. Structure *B* is the:
- Pedicle
 - Spinous process
 - Coracoid process
 - Lamina
117. Structure *C* is the:
- Pedicle
 - Coronoid process
 - Transverse process
 - Lamina
118. Structure *F* is the:
- Pedicle
 - Spinous process
 - Transverse process
 - Lumbar angle

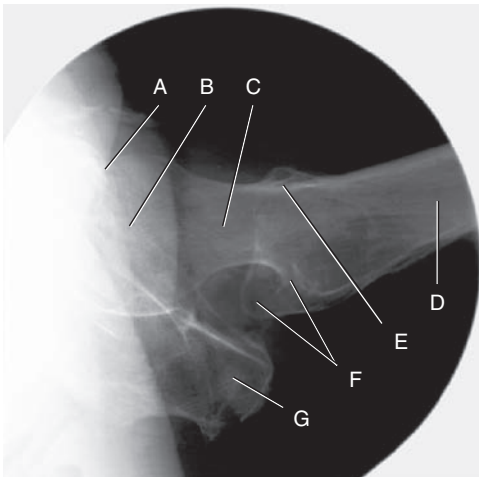
Using [Figure 6-5](#), identify the radiographic anatomy of the cervical spine.



• **Figure 6-5** Oblique cervical spine.

119. Structure *B* is the:
- Intervertebral foramen
 - Spinous process
 - Pedicle
 - Lamina
120. Structure *C* is the:
- Intervertebral foramen
 - Spinous process
 - Pedicle
 - Lamina

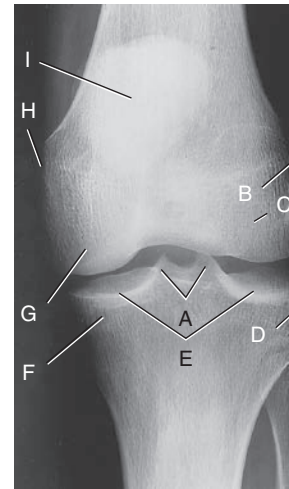
Using [Figure 6-6](#), identify the radiographic anatomy of the hip.



• **Figure 6-6** Lateral hip, inferosuperior projection.

121. Structure *E* is the:
- Acetabulum
 - Ischial tuberosity
 - Greater trochanter
 - Lesser trochanter
122. Structure *F* is the:
- Obturator foramen
 - Ischial tuberosity
 - Greater trochanter
 - Lesser trochanter
123. Structure *G* is the:
- Acetabulum
 - Ischial tuberosity
 - Greater trochanter
 - Lesser trochanter

Using [Figure 6-7](#), identify the radiographic anatomy of the knee.



• **Figure 6-7** AP knee.

124. Structure *B* is the:
- Medial condyle
 - Lateral epicondyle
 - Lateral condyle
 - Lateral plateau
125. Structure *D* is the:
- Medial condyle
 - Lateral epicondyle
 - Lateral condyle
 - Tibial plateau
126. Structure *E* is the:
- Tibial condyle
 - Lateral epicondyle
 - Lateral condyle
 - Tibial plateau
127. Structure *G* is the:
- Medial condyle
 - Lateral epicondyle
 - Lateral condyle
 - Tibial plateau

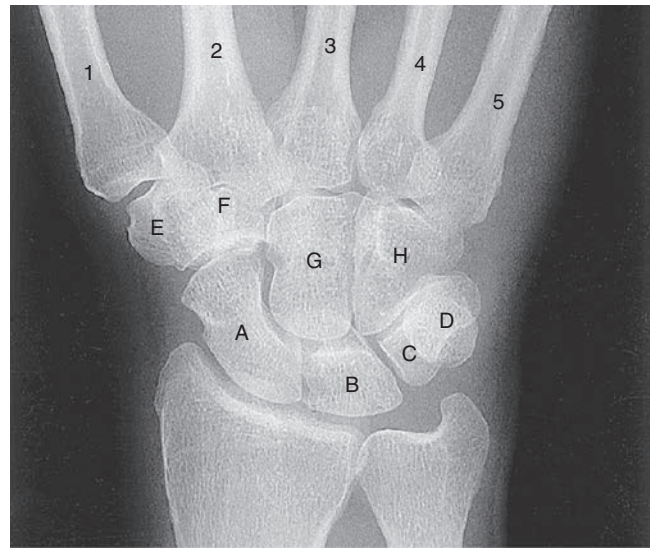
Using **Figure 6-8**, identify the radiographic anatomy of the hand.



• **Figure 6-8** PA radiograph of right hand.

128. Structure *A* is the:
- First proximal interphalangeal joint
 - First carpometacarpal joint
 - Second distal interphalangeal joint
 - Second metacarpophalangeal joint
129. Structure *G* is the:
- Second proximal interphalangeal joint
 - First carpometacarpal joint
 - Second distal interphalangeal joint
 - Second metacarpophalangeal joint
130. Structure *I* is the:
- Second proximal interphalangeal joint
 - First carpometacarpal joint
 - Second distal interphalangeal joint
 - Second metacarpophalangeal joint
131. Structure *K* is the:
- Second proximal interphalangeal joint
 - First carpometacarpal joint
 - Second distal interphalangeal joint
 - Second metacarpophalangeal joint

Using **Figure 6-9**, identify the radiographic anatomy of the wrist.

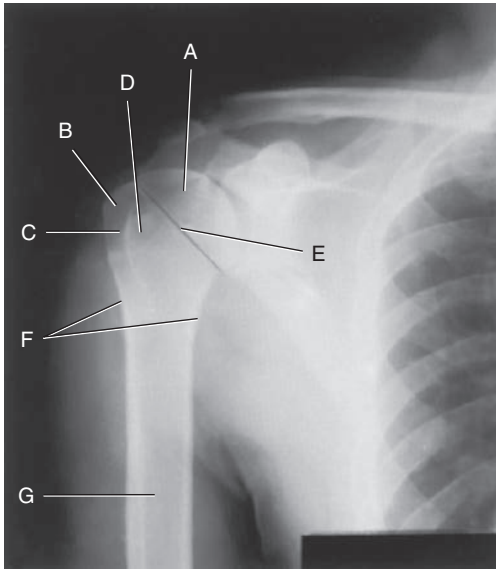


• **Figure 6-9** PA wrist.

132. Structure *A* is the:
- Pisiform
 - Hamate
 - Triquetral
 - Scaphoid
133. Structure *B* is the:
- Hamate
 - Lunate
 - Triquetral
 - Scaphoid
134. Structure *C* is the:
- Pisiform
 - Lunate
 - Triquetral
 - Trapezium
135. Structure *D* is the:
- Pisiform
 - Lunate
 - Triquetral
 - Hamate
136. Structure *E* is the:
- Hamate
 - Trapezium
 - Trapezoid
 - Capitate
137. Structure *F* is the:
- Hamate
 - Trapezium
 - Trapezoid
 - Capitate
138. Structure *G* is the:
- Hamate
 - Trapezium

- c. Trapezoid
 - d. Capitate
139. Structure *H* is the:
- a. Hamate
 - b. Trapezium
 - c. Trapezoid
 - d. Capitate

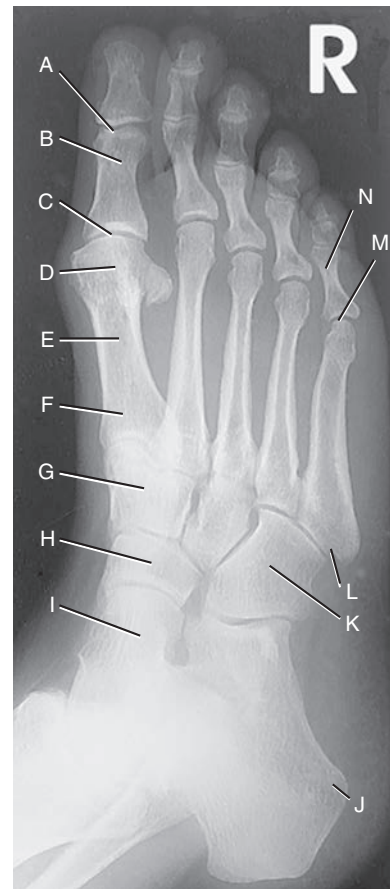
Using Figure 6-10, identify the radiographic anatomy of the shoulder.



• Figure 6-10 AP shoulder in external rotation.

140. Structure *B* is the:
- a. Surgical neck
 - b. Glenoid fossa
 - c. Anatomical neck
 - d. Greater tubercle
141. Structure *D* is the:
- a. Surgical neck
 - b. Lesser tubercle
 - c. Scapula
 - d. Greater tubercle
142. Structure *E* is the:
- a. Surgical neck
 - b. Lesser tubercle
 - c. Anatomical neck
 - d. Greater tubercle
143. Structure *F* is the:
- a. Surgical neck
 - b. Semilunar notch
 - c. Anatomical neck
 - d. Greater tubercle

Using Figure 6-11, identify the radiographic anatomy of the foot.



• Figure 6-11 Oblique right foot.

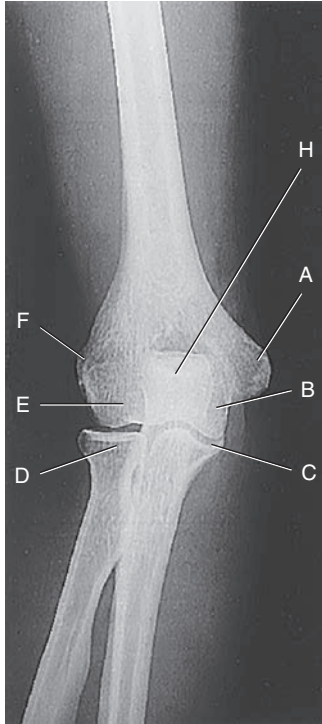
144. Structure *G* is the:
- a. Talus
 - b. Navicular
 - c. Cuboid
 - d. Second or intermediate cuneiform
145. Structure *H* is the:
- a. Talus
 - b. Navicular
 - c. First or intermediate cuneiform
 - d. Second or intermediate cuneiform
146. Structure *I* is the:
- a. Talus
 - b. Navicular
 - c. Tuberosity
 - d. Second or intermediate cuneiform
147. Structure *J* is the:
- a. Talus
 - b. Tuberosity of the calcaneus
 - c. Cuboid
 - d. Second or intermediate cuneiform
148. Structure *K* is the:
- a. Fifth metatarsophalangeal joint
 - b. Navicular

- c. Cuboid
- d. Second or intermediate cuneiform

149. Structure *M* is the:

- a. Talus
- b. Navicular
- c. Cuboid
- d. Fifth metatarsophalangeal joint

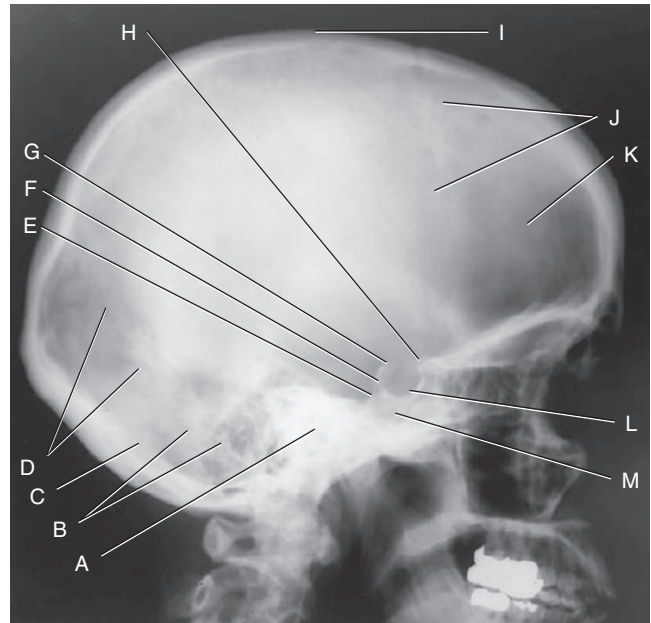
Using Figure 6-12, identify the radiographic anatomy of the elbow.



• Figure 6-12 AP elbow.

- 150. Structure *A* is the:
 - a. Lateral epicondyle
 - b. Olecranon process
 - c. Radial head
 - d. Medial epicondyle
- 151. Structure *D* is the:
 - a. Capitulum
 - b. Olecranon process
 - c. Radial head
 - d. Ulnar head
- 152. Structure *E* is the:
 - a. Capitulum
 - b. Olecranon process
 - c. Radial head
 - d. Medial epicondyle
- 153. Structure *H* is the:
 - a. Ulnar head
 - b. Olecranon process
 - c. Radial head
 - d. Medial epicondyle

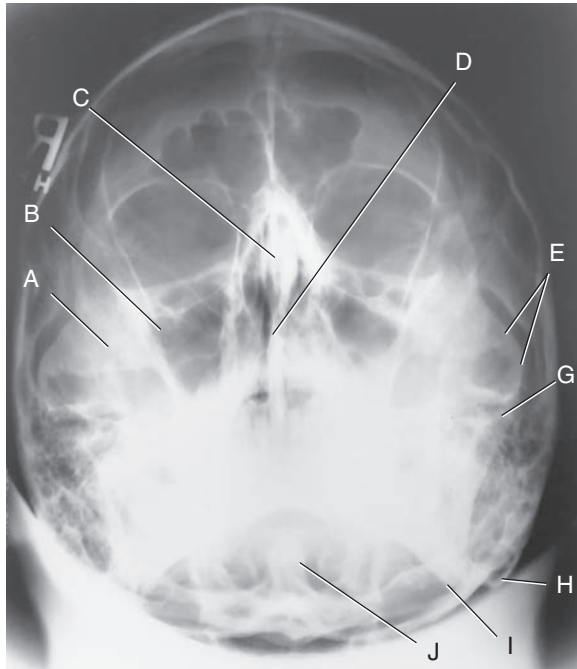
Using Figure 6-13, identify the radiographic anatomy of the skull.



• Figure 6-13 Lateral projection of skull.

- 154. Structure *C* is the:
 - a. Body of sphenoid
 - b. Occipital bone
 - c. Dorsum sellae
 - d. Anterior clinoid process
- 155. Structure *F* is the:
 - a. Body of sphenoid
 - b. Occipital bone
 - c. Dorsum sellae
 - d. Sella turcica
- 156. Structure *H* is the:
 - a. Sella turcica
 - b. Occipital bone
 - c. Dorsum sellae
 - d. Anterior clinoid process
- 157. Structure *M* is the:
 - a. Body of sphenoid (sphenoid sinus)
 - b. Occipital bone
 - c. Dorsum sellae
 - d. Anterior clinoid process

Using [Figure 6-14](#), identify the radiographic anatomy of the facial bones.



• **Figure 6-14** Parietoacanthial (Waters) projection of facial bones.

158. Structure *B* is the:
- Zygomatic arch
 - Foramen magnum
 - Bony nasal septum (perpendicular plate of ethmoid and vomer)
 - Body of maxilla (contains the maxillary sinuses)
159. Structure *C* is the:
- Zygomatic arch
 - Foramen magnum
 - Bony nasal septum (perpendicular plate of ethmoid and vomer)
 - Body of maxilla (contains the maxillary sinuses)
160. Structure *D* is the:
- Zygomatic arch
 - Anterior nasal spine
 - Bony nasal septum (perpendicular plate of ethmoid and vomer)
 - Angle of mandible
161. Structure *E* is the:
- Zygomatic arch
 - Foramen magnum
 - Bony nasal septum (perpendicular plate of ethmoid and vomer)
 - Body of maxilla (contains the maxillary sinuses)
162. Beam-part-image receptor alignment is critical in providing:
- A distortion-free image
 - Lower patient dose
 - Higher overall contrast
 - Lower spatial resolution
163. BMI can have an important impact on diagnostic imaging. What does BMI stand for?
- Below measurable index
 - Body mass in imaging
 - Body mass index
 - Body measurement index
164. Which of the following anatomic structures is not demonstrated on a KUB?
- Bone structure of the pelvis
 - Inferior ribs
 - Psoas muscles
 - Minor calyces
165. Radial deviation is synonymous with:
- Radial flexion
 - Radial deviation
 - Ulnar flexion
 - Dorsiflexion
166. Which of the following structures is most distal?
- Ascending colon
 - Cecum
 - Descending colon
 - Sigmoid
167. Rugae may be found in the:
- Esophagus
 - Stomach
 - Small intestine
 - Large intestine
- Patient Care (Questions 168-200)**
168. An IR can be a source of infection through:
- Droplet transmission
 - Indirect contact
 - Direct contact
 - Airborne transmission
169. Anywhere organisms can thrive is the definition of:
- Infection control
 - Infectious waste
 - Universal contamination
 - The reservoir of infection
170. The abbreviation that stands for a stroke is:
- hx
 - Bx
 - CVA
 - MI
171. The prefix that means “false” is:
- Retro-
 - Endo-
 - Pseudo-
 - Epi-
172. The prefix that means “above” is:
- Hypo-
 - Ex-
 - Ect-
 - Hyper-
173. Infectious waste is placed in containers:
- Made of lead
 - Properly labeled with the type of waste therein

- c. That are incinerated
d. Made of plastic only
174. Needles and syringes must be disposed of:
a. Capped
b. Weekly
c. Uncapped
d. Monthly
175. Causing a patient to become apprehensive of being injured is called:
a. Assault
b. Battery
c. False imprisonment
d. Invasion of privacy
176. Violation of confidentiality defines:
a. Assault
b. Battery
c. False imprisonment
d. Invasion of privacy
177. Neglect or omission of reasonable care defines:
a. Respondeat superior
b. Res ipsa loquitur
c. Gross negligence
d. Unintentional misconduct
178. Bradycardia indicates a pulse of:
a. More than 100 beats per minute
b. Fewer than 60 beats per minute
c. Greater than 90 beats per minute
d. Less than 50 beats per minute
179. Which of the following contains all equipment and drugs needed during respiratory arrest?
a. Crash cart
b. Suction unit
c. Defibrillator
d. Sphygmomanometer
180. Which of the following is used to measure blood pressure?
a. Crash cart
b. Suction unit
c. Defibrillator
d. Sphygmomanometer
181. A positive contrast agent that may be administered to a patient when barium sulfate is contraindicated is called:
a. Barium thiosulfate
b. Iodine
c. Air
d. Aqueous iodine compound
182. Flushing, urticaria, and nausea are symptoms of what type of contrast agent reaction?
a. Local irritation
b. Cardiovascular shock
c. Anaphylactic shock
d. Psychogenic shock
183. What is the type of infection control in which microorganisms have been eliminated as much as possible by the use of water and chemical disinfectants?
a. Medical asepsis
b. Surgical asepsis
c. Standard precautions
d. Gas sterilization
184. The abbreviation that means “history” is:
a. hx
b. bx
c. hs
d. MI
185. The abbreviation that means “heart attack” is:
a. hx
b. HA
c. CVA
d. MI
186. When scheduling radiographic examinations:
a. Schedule barium studies first to get them over with
b. Schedule special studies for the afternoon
c. Schedule barium studies last
d. Always schedule a scout CT scan first
187. Infectious waste must be handled according to which of the following?
a. Radiation protection guidelines
b. Radiology department rules
c. CDC guidelines
d. The condition of the patient
188. Normal adult respiration is measured by:
a. Counting breaths
b. Thermometer
c. Sphygmomanometer
d. Digital BP cuff
189. What item is used to administer oxygen through the nose?
a. Crash cart
b. Suction unit
c. Defibrillator
d. Nasal cannula
190. What type of infection transmission is defined as being spread primarily on contaminated items, food, or water?
a. Contact transmission
b. Airborne transmission
c. Droplet transmission
d. Common vehicle transmission
191. Which of the following is used to restore a normal heartbeat?
a. Crash cart
b. Suction unit
c. Defibrillator
d. Sphygmomanometer

192. Shock is indicated when the diastolic blood pressure is:
- Greater than 100 mm Hg
 - Less than 60 mm Hg
 - Greater than 90 mm Hg
 - Less than 50 mm Hg
193. The law governing patient confidentiality is abbreviated:
- CDC
 - HHS
 - ALARA
 - HIPAA
194. The type of shock that occurs secondary to heart failure is called:
- Hypovolemic shock
 - Septic shock
 - Neurogenic shock
 - Cardiogenic shock
195. Needles and syringes must be disposed of in:
- Lead containers
 - Sharps containers

- ectomy
- megaly

200. The suffix that means “puncture” is:
- centesis
 - otomy
 - genic
 - osis

Scoring

Traditionally you have probably focused on how many questions you miss on a test. As you prepare for the certification exam, I encourage you to focus on how many you answer correctly. Use [Table 6-1](#) to calculate the percentage of questions you answered correctly in each category and on the test as a whole. Remember, a score of less than 75% on any topic or on an entire test is an indication that more review is needed on that topic. Now go back and concentrate on the items that were missed and figure out the reason why. Then go on to Challenge Test Number 2.

TABLE 6-1 Calculating Your Score for Challenge Test Number 1

Topic	Percentage Calculation	Your Score
Safety	Number correct _____ × 100, ÷ 53 =	
Image Production	Number correct _____ × 100, ÷ 50 =	
Procedures	Number correct _____ × 100, ÷ 64 =	
Patient Care	Number correct _____ × 100, ÷ 33 =	
<i>Total</i>	Number correct _____ × 100, ÷ 200 =	

- Plastic bags
 - Metal pans
196. Used bandages and dressings must be placed into:
- Lead containers
 - Waterproof bags and sealed
 - Plastic bags
 - Metal pans
197. Infectious waste must be discarded:
- Immediately
 - Monthly
 - And burned
 - With other hospital waste
198. Toxic chemicals may:
- Be poured down the drain if they do not enter the public water supply
 - Never be poured down the drain
 - Be poured down the same drain as the processing water
 - Be poured down the drain in the restroom only
199. The suffix that means “pain” is:
- itis
 - algia

Challenge Test Number 2

ARRT Exam Categories: Safety, Image Production, Procedures, Patient Care

Read each question and the answer choices carefully. Choose the best, most complete answer for each item. Use the results of this test to assess your strengths and weaknesses. Do not look up any of the answers until you have completed the entire test. Correct the test using the answer key in the back of the book. Then compute your scores using [Table 6-2](#) to see where you are strong and where you need additional review. Refer to the appropriate chapter in this book for review of the questions you miss.

Safety (Questions 1-53)

- The amount of radiation deposited per unit length of tissue traversed by incoming photons is called:
 - Tissue exposure
 - Linear deposition of energy
 - Linear energy transfer
 - Effective dose limit

2. Cataractogenesis, life span shortening, embryologic effects, and carcinogenesis are examples of:
 - a. Short-term somatic effects
 - b. Genetic effects
 - c. Acute radiation syndrome
 - d. Long-term somatic effects
3. Compton interaction:
 - a. Increases contrast in the radiographic image
 - b. Results in scattering of the incident electrons
 - c. Decreases recorded detail in the radiographic image
 - d. Decreases contrast in the radiographic image
4. Gray_t multiplied by a radiation weighting factor equals:
 - a. Air kerma
 - b. Becquerel
 - c. Sievert
 - d. Gray_a
5. Effective dose limit (Efd):
 - a. Is the level of radiation that an organism can receive and probably sustain no appreciable effects
 - b. Is a safe level of radiation that can be received with no effects
 - c. Should be absorbed annually to maintain proper immunity to radiation
 - d. Is 500 mSv per year for the general public
6. Radiation with a high LET:
 - a. Has low ionization
 - b. Is highly ionizing
 - c. Carries a low quality factor
 - d. Equates with a low RBE
7. Radiation protection is based on which dose-response relationship?
 - a. Linear-threshold
 - b. Nonlinear-nonthreshold
 - c. Linear-nonthreshold
 - d. Nonlinear-threshold
8. Which of the following states that the radiosensitivity of cells is directly proportional to their reproductive activity and inversely proportional to their degree of differentiation?
 - a. Inverse square law
 - b. Law of Bergonié and Tribondeau
 - c. Reciprocity law
 - d. Ohm's law
9. Which of the following causes about 95% of the cellular response to radiation?
 - a. Direct effect
 - b. Law of Bergonié and Tribondeau
 - c. Target theory
 - d. Indirect effect
10. When radiation strikes DNA, which of the following occurs?
 - a. Direct effect
 - b. Law of Bergonié and Tribondeau
 - c. Target theory
 - d. Indirect effect
11. The amount of radiation that causes the number of genetic mutations in a population to double is called the:
 - a. Threshold dose
 - b. Doubling dose
 - c. Mutagenic dose
 - d. Genetic dose
12. The SI units of equivalent dose, activity, air kerma, and absorbed dose are, respectively:
 - a. Roentgen, rad, rem, curie
 - b. Rad, coulomb per kilogram, curie, becquerel
 - c. Rem, curie, roentgen, rad
 - d. Sievert, becquerel, gray_a , gray_t
13. Medical x-rays are an example of:
 - a. Natural background radiation
 - b. Artificially produced radiation
 - c. Nonionizing radiation
 - d. Ionizing, natural background radiation
14. The effective dose limit for a fetus for the entire gestational period is:
 - a. 5.0 mSv
 - b. 0.5 mSv
 - c. 0.05 mSv
 - d. 50 mSv
15. The photoelectric effect:
 - a. Results in absorption of the incident photon
 - b. Results in absorption of the incident electron
 - c. Produces contrast fog on the radiographic image
 - d. Is the same as brems radiation
16. The annual effective dose limit for radiographers is:
 - a. 10 mSv
 - b. 100 mSv
 - c. 50 mSv
 - d. 100 mSv
17. The average dose to active bone marrow as an indicator of somatic effects on a population is called:
 - a. Doubling dose
 - b. Bone dose
 - c. GSD
 - d. Mean marrow dose
18. A radiation dose that if received by the entire population would cause the same genetic injury as the total of doses received by the members actually being exposed is called:
 - a. Genetically significant dose
 - b. Doubling dose
 - c. Mean marrow dose
 - d. Genetic dose
19. A lead apron of at least what thickness *should* be worn while being exposed to scatter radiation?
 - a. 0.25-mm Pb equivalent
 - b. 0.50-mm Pb equivalent
 - c. 0.50-mm Al equivalent
 - d. 0.10-mm Al equivalent
20. Use of a thyroid shield of at least what thickness should be used for fluoroscopy?
 - a. 0.10-mm Pb equivalent
 - b. 0.50-mm Pb equivalent

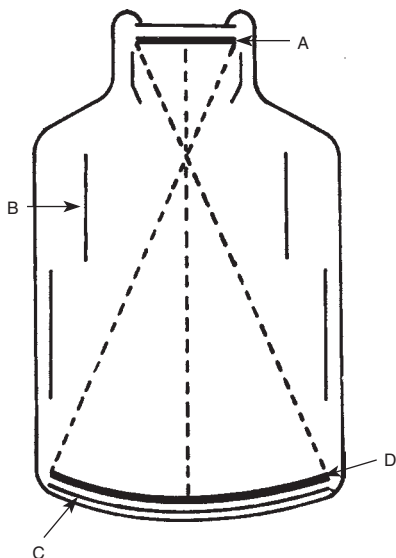
- c. 0.50-mm Al equivalent
d. 0.10-mm Al equivalent
21. How thick are primary protective barriers?
a. $\frac{1}{32}$ -inch lead equivalent
b. $\frac{1}{16}$ -inch aluminum equivalent
c. $\frac{1}{32}$ -inch concrete
d. $\frac{1}{16}$ -inch lead equivalent
22. Primary protective barriers, if in the wall, must extend to a height of at least:
a. 5 feet
b. 6 feet
c. 7 feet
d. 10 feet
23. Secondary protective barriers must extend to a height of:
a. 5 feet
b. 6 feet
c. The ceiling
d. 10 feet
24. The protective curtain hanging from the fluoroscopy tower must be at least:
a. 0.50-mm Pb equivalent
b. 0.25-mm Al equivalent
c. 0.10-mm Pb equivalent
d. 0.25-mm Pb equivalent
25. The Bucky slot cover must be at least:
a. 0.50-mm Pb equivalent
b. 0.25-mm Al equivalent
c. 0.10-mm Pb equivalent
d. 0.25-mm Pb equivalent
26. Filters made of aluminum and copper are placed in the film badge to measure x-ray:
a. Quantity
b. Source
c. Energy
d. Type
27. Film badges are changed:
a. Quarterly
b. Weekly
c. Yearly
d. Monthly
28. Thermoluminescent dosimeters use what type of crystals to record dose?
a. Dilithium crystals
b. Lithium fluoride
c. Flux capacitors
d. Bromide crystals
29. TLDs are heated and release what type of energy to indicate dose?
a. Laser
b. Visible light
c. X-rays
d. Gamma rays
30. Optically stimulated luminescence (OSL) dosimeters provide readings as low as:
a. 1 μSv
b. 10 μSv
c. 50 μSv
d. 100 μSv
31. The recording material in an OSL dosimeter is:
a. Dilithium
b. Lithium fluoride
c. Aluminum oxide
d. Silver halide
32. The energy stored in an OSL dosimeter is released when the dosimeter is exposed to:
a. Heat
b. White light
c. Laser
d. Ultrasound
33. OSL dosimeters may be worn for:
a. 1 month
b. 1 week
c. 3 months
d. 1 year
34. OSL dosimeters may be scanned and reanalyzed:
a. Only once
b. Monthly
c. Five times
d. An unlimited number of times
35. The most commonly used gonadal shield is the:
a. Shadow shield
b. Collimator
c. Contact shield
d. Filter
36. For optimal radiation protection, what type of exposure technique should be used?
a. Low kVp, high mAs
b. Small focal spot
c. All manual technique
d. High kVp, low mAs
37. For optimal radiation protection, what speed of IR should be used?
a. Slow
b. Speed has no impact on dose
c. Analog
d. Fast
38. The minimum source-to-skin distance for portable radiography is:
a. At least 12 inches
b. At least 15 inches
c. At least 72 inches
d. At least 40 inches
39. How often is added filtration adjusted by the radiographer?
a. After several exposures
b. Daily
c. As part of weekly quality control
d. Never
40. What report does a radiographer consult and initial to verify occupational dose received?
a. PACS
b. Dosimeter

- c. Radiation
d. Annual dose report
41. What are radiation effects that manifest themselves in the person being irradiated?
a. Genetic
b. Exposed cell
c. Somatic
d. Molecular
42. What type of background radiation is radon?
a. Man-made
b. Radioactive water
c. Natural
d. Natural form of electromagnetic waves
43. The photoelectric effect is responsible for:
a. The brightness of the image
b. Producing scatter radiation
c. Differential absorption of the x-ray beam by the body
d. Spatial resolution
44. The unit of measurement that is determined by measuring ions produced in air as radiation passes through it is the:
a. Becquerel
b. Gray
c. Air kerma
d. Sievert
45. One (1) is the radiation weighting factor (W_R) for:
a. Neutrons
b. Gamma rays
c. Cosmic rays
d. Radon
46. Atomic number is represented by the letter:
a. M
b. A
c. Z
d. Q
47. Atomic mass is represented by the letter:
a. M
b. A
c. Z
d. Q
48. The primary purpose of filtering the x-ray beam is to:
a. Increase contrast
b. Improve radiation protection
c. Soften the beam for proper imaging
d. Remove short-wavelength rays
49. Considering probability, x-ray photons will probably strike:
a. The nucleus
b. RNA
c. DNA
d. Water
50. X-ray photons depositing their energy in the water of the cytoplasm may cause:
a. Electrolysis
b. Radiolysis
c. Radioactivity
d. Pair production
51. Free radicals may recombine to form:
a. DNA
b. Hydrogen peroxide
c. Sulfuric acid
d. New cytoplasm
52. What is the thickness of a thyroid shield that should be worn during fluoroscopy?
a. 0.10-mm lead equivalent
b. 0.50-mm lead equivalent
c. 0.50-mm aluminum equivalent
d. 0.10-mm aluminum equivalent
53. For shielding purposes, what is the x-ray control booth considered?
a. Secondary protective barrier
b. Primary protective barrier
c. Equivalent to a lead apron
d. A tertiary protective barrier

Image Production (Questions 54-103)

54. An ionization chamber circuit places:
a. A photomultiplier tube between the IR and the patient
b. An ionization chamber beneath or behind the IR
c. An ionization chamber between the patient and the x-ray tube
d. An ionization chamber between the IR and the patient
55. Full-wave rectification uses:
a. A single semiconductor
b. Four silicone-based semiconductors
c. The x-ray tube as a semiconductor
d. Four silicon-based semiconductors
56. A full-wave rectified, three-phase, 12-pulse x-ray machine produces approximately ____% more average photon energy than a full-wave rectified, single-phase x-ray machine.
a. 35
b. 50
c. 41
d. 100
57. According to the anode heel effect, the intensity of radiation is greater at the _____ side of the x-ray tube.
a. Anode
b. Central x-ray
c. Neither side; the beam is of uniform intensity
d. Cathode
58. The amount of time needed for an AEC to terminate the exposure is called:
a. Exposure latitude
b. Minimum reaction time
c. Chamber response time
d. Electronic time

Using Figure 6-15, answer questions 59 through 62.



• Figure 6-15

59. Where is the electron beam focused?
- A
 - B
 - C
 - D
60. Where is light energy converted to electrons?
- A
 - B
 - C
 - D
61. From where is the visible image distributed to viewing or recording media?
- A
 - B
 - C
 - D
62. Where is x-ray energy converted to visible light?
- A
 - B
 - C
 - D
63. A particular x-ray room is "shooting dark." The problem arises when a change is made from 200 to 300 mA using fixed kVp techniques at 0.16 second. Which of the following would lead to an accurate diagnosis of the problem?
- Resolution test pattern
 - Measurement of HVL
 - Use of a digital dosimeter to determine exposure reproducibility
 - Use of a digital dosimeter to determine exposure linearity
64. An outpatient radiographic room is used primarily for tabletop radiography of the extremities. On a particularly busy afternoon, the radiographers find that similar exposure techniques on successive patients result in substantially different radiographs. Which of the following would lead to an accurate diagnosis of the problem?
- Contrast test pattern
 - Measurement of HVL
 - Use of a digital dosimeter to determine exposure reproducibility
 - Use of a digital dosimeter to determine exposure linearity
65. X-ray beam quality is expressed in terms of:
- Half-value layer
 - Exposure linearity
 - Exposure reproducibility
 - mAs
66. The accuracy of collimation at a 40-inch SID must be:
- ± 4 inches
 - $\pm \frac{1}{10}$ inch
 - ± 1 inch
 - $\pm \frac{1}{10}$ inch
67. The accuracy of kVp at 80 kVp must be:
- Within 5%
 - Within 10%
 - Within 15%
 - Within 20%
68. The apparent size of the focal spot as viewed by the image receptor is called the:
- Actual focal spot
 - Target angle spot
 - Anode heel effect
 - Effective focal spot
69. Which of the following interactions is the primary source of diagnostic x-rays?
- Photoelectric effect
 - Bremsstrahlung
 - Compton
 - Pair production
70. Which set of exposure factors would produce the greatest receptor exposure?
- 100 mAs, 70 kVp, 0.5-mm focal spot, 60-inch SID
 - 200 mAs, 60 kVp, 1.2-mm focal spot, 60-inch SID
 - 100 mAs, 70 kVp, 1.2-mm focal spot, 60-inch SID
 - 300 mAs, 90 kVp, 0.5-mm focal spot, 60-inch SID
71. Which set of exposure factors would produce the lowest receptor exposure?
- 80 mAs, 85 kVp, 40-inch SID, 1.2-mm focal spot
 - 40 mAs, 60 kVp, 40-inch SID, 0.5-mm focal spot
 - 160 mAs, 70 kVp, 40-inch SID, 1.2-mm focal spot
 - 160 mAs, 90 kVp, 40-inch SID, 0.5-mm focal spot
72. The components of a grid are:
- Pb strips and Pb interspacers
 - Al strips and Pb interspacers
 - Pb strips and Al interspacers
 - Pb strips and cardboard interspacers

73. Which of the following lists of substances that make up the human body best places them in increasing order of density?
- Air, fat, water, muscle, bone
 - Bone, muscle, water, fat, air
 - Air, fat, muscle, water, bone
 - Air, fat, water, muscle, bone, tooth enamel
74. Bit depth describes:
- The available gray scale of an imaging system
 - Window level
 - Spatial resolution
 - Optimum exposure needed for an imaging system
75. If it is necessary to reduce exposure by half, and it is impossible to do so by changing mAs, the radiographer may:
- Reduce SID by half
 - Double SID
 - Decrease kVp by 15%
 - Decrease kVp by 50%
76. The dynamic range for digital imaging is:
- Wide
 - Narrow
 - Unrelated to diagnostic imaging
77. Dynamic range is defined as:
- The range of exposures over which a detector can acquire image data
 - Exposure latitude
 - Window width
 - Window level
78. Modulation transfer function (MTF) is:
- The controlling factor of contrast resolution
 - A measure of the ability of the imaging system to preserve signal contrast as a function of the spatial resolution
 - A function of exposure
 - A function of pixel density
79. 2^n (where n equals the number of bits) defines:
- Pixel density
 - Shades of gray
 - Bit depth
 - Detector element size
80. A scintillator:
- Absorbs x-ray energy and emits part of that energy as visible light
 - Absorbs x-ray energy and emits that energy as electrons
 - Converts visible light into electrons
 - Converts electrons into visible light
81. The magnitude of the signal differences in the remnant beam refers to:
- Subject contrast
 - IP contrast
 - Window level
 - Spatial resolution
82. A term used to describe the mathematical formula used by the computer to reconstruct the image is:
- Bit depth
 - Algorithm
 - Mathematical function
 - Exposure equation
83. When speed is essential in completing an imaging examination, the preferred IR is:
- CR
 - DR
 - Wireless DR plate
84. Pixel is an acronym meaning:
- Detector element
 - Picture element
 - Volume element
 - Bit element
85. Improper use of grids with a digital imaging system may cause an artifact known as:
- Moiré pattern
 - Grid cutoff
 - Motion artifact
 - Quantum mottle
86. An integrated system of images and information is called:
- DICOM
 - DDR
 - CR/DDR
 - PACS
87. Image noise may be described as:
- Undesirable fluctuations in brightness
 - Undesirable fluctuations in contrast
 - Inadequate spatial resolution
 - A function of mAs
88. The measurement of the luminance of a monitor is called:
- Density
 - Contrast
 - Brightness
 - Detail visibility
89. Grid radius is:
- The total amount of lead in a grid
 - The range of SIDs that may be used with a focused grid
 - The objective plane
 - H/D
90. Visibility of an object's edge may be limited by:
- Speed class
 - Modulation transfer function
 - Contrast resolution
 - Quantum noise
91. Detective quantum efficiency indicates:
- Patient dose
 - Potential speed class
 - Spatial resolution
 - Contrast resolution

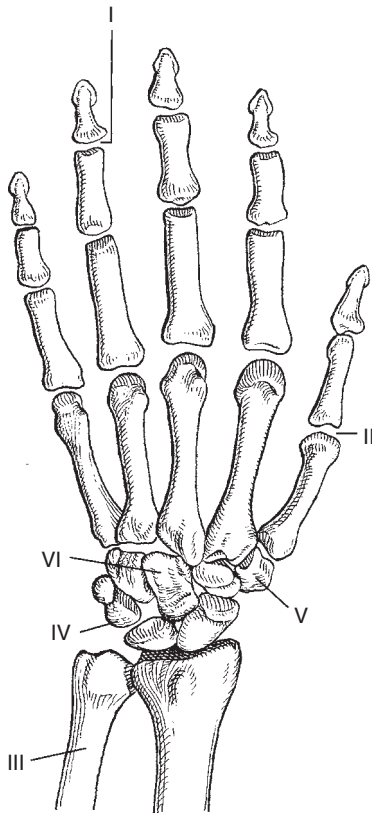
92. Digital receptors have what kind of response to exposure?
- Nonlinear
 - Linear
 - Curvilinear
 - Hyperlinear
93. If the angle on the anode is decreased, what effect is there on spatial resolution?
- Increases
 - Decreases
 - No appreciable effect
94. If mAs is increased four times, what is the effect on receptor exposure?
- Increases
 - Decreases
 - No appreciable effect
95. If SID is increased, what is the effect on IR exposure?
- Increases
 - Decreases
 - No appreciable effect
96. If OID is decreased, what is the effect on spatial resolution?
- Increases
 - Decreases
 - No appreciable effect
97. A photodiode converts:
- AC to DC
 - Light into a charge
 - Electrons into light
 - MRI signal into PACS data
98. If kVp is increased, what happens to attenuation of the beam in the patient?
- Increase
 - Decrease
 - No appreciable effect
99. In a conversion from a nongrid to a 12:1 grid, what happens to image contrast?
- Increases
 - Decreases
 - No appreciable effect
100. If SID is decreased from 60 inches to 30 inches, what happens to magnification?
- Increases
 - Decreases
 - No appreciable effect
101. If the IR is moved from tabletop to Bucky, what happens to spatial resolution?
- Increases
 - Decreases
 - No appreciable effect
102. If there is a decrease in source-to-object distance, what happens to spatial resolution?
- Increases
 - Decreases
 - No appreciable effect
103. The amount of lead in a grid is referred to as:
- Grid frequency
 - Grid ratio
 - Grid radius
 - Grid cleanup ability

Procedures (Questions 104-167)

104. For the parietoacanthial projection (Waters) for the sinuses, the OML forms an angle of how many degrees with the cassette?
- 53
 - 45
 - 25
 - 37
105. For the PA axial projection for the colon, the central ray is angled caudad how many degrees?
- 10 to 20
 - 20 to 30
 - 30 to 40
 - 25 to 45
106. The carpal bones are arranged in two rows as follows:
- Proximal row (scaphoid, lunate, triquetral, pisiform) and distal row (trapezium, trapezoid, capitate, hamate)
 - Distal row (scaphoid, lunate, triquetral, pisiform) and proximal row (trapezium, trapezoid, capitate, hamate)
 - Proximal row (scaphoid, triquetral, capitate, pisiform) and distal row (trapezium, trapezoid, lunate, hamate)
 - The carpals are not arranged in rows
107. The prominent point of the elbow is called the:
- Olecranon, part of the radius
 - Semilunar notch
 - Trochlea
 - Olecranon, part of the ulna
108. Imaging of what pathologic condition would require radiography of the cervical spine?
- Talipes
 - Colles fracture
 - Ankylosing spondylitis
 - Jefferson fracture
109. Imaging of what pathologic condition would require radiography of the hand?
- Talipes
 - Colle fracture
 - Boxer fracture
 - Ankylosing spondylitis
110. Imaging of what pathologic condition would require radiography of the distal forearm?
- Talipes
 - Colle fracture
 - Boxer fracture
 - Ankylosing spondylitis

111. Imaging of what pathologic condition would require radiography of the feet?
- Talipes
 - Colle fracture
 - Boxer fracture
 - Ankylosing spondylitis
112. Imaging of what pathologic condition would require radiography of the entire spine?
- Talipes
 - Colle fracture
 - Boxer fracture
 - Ankylosing spondylitis

Using Figure 6-16, answer questions 113 through 118.



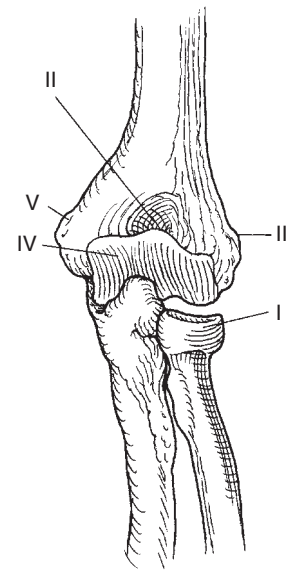
• Figure 6-16

113. The structure designated as *I* is the:
- Carpometacarpal joint
 - Interphalangeal joint
 - Proximal phalanx
 - Distal interphalangeal joint
114. The structure designated as *II* is the:
- Carpometacarpal joint
 - Interphalangeal joint
 - Proximal phalanx
 - Metacarpophalangeal joint
115. The structure designated as *III* is the:
- Ulna
 - Metacarpal

- Radius
- Humerus

116. The structure designated as *IV* is the:
- Lunate
 - Triquetral
 - Capitate
 - Pisiform
117. The structure designated as *V* is the:
- Lunate
 - Scaphoid
 - Trapezium
 - Trapezoid
118. The structure designated as *VI* is the:
- Lunate
 - Triquetrum
 - Capitate
 - Scaphoid

Using Figure 6-17, answer questions 119 through 123.

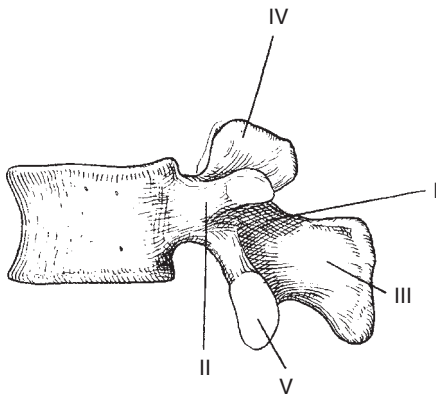


• Figure 6-17

119. The structure designated as *I* is the:
- Head of ulna
 - Radial head
 - Medial epicondyle
 - Lateral epicondyle
120. The structure designated as *II* is the:
- Coronoid fossa
 - Olecranon
 - Semilunar notch
 - Radial head
121. The structure designated as *III* is the:
- Head of the ulna
 - Radial head
 - Medial epicondyle
 - Lateral epicondyle

122. The structure designated as *IV* is the:
- Medial epicondyle
 - Trochlea
 - Lateral epicondyle
 - Ulnar head
123. The structure designated as *V* is the:
- Medial epicondyle
 - Trochlea
 - Lateral epicondyle
 - Ulnar head

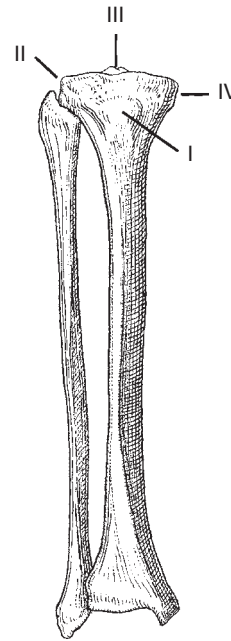
Using [Figure 6-18](#), answer questions 124 through 128.



• **Figure 6-18**

124. The structure designated as *I* is the:
- Pedicle
 - Superior vertebral notch
 - Inferior vertebral notch
 - Lamina
125. The structure designated as *II* is the:
- Pedicle
 - Superior vertebral notch
 - Inferior vertebral notch
 - Spinous process
126. The structure designated as *III* is the:
- Lamina
 - Spinous process
 - Superior articular process
 - Pedicle
127. The structure designated as *IV* is the:
- Superior vertebral notch
 - Superior articular process
 - Transverse process
 - Spinous process
128. The structure designated as *V* is the:
- Lamina
 - Spinous process
 - Inferior vertebral notch
 - Inferior articular process

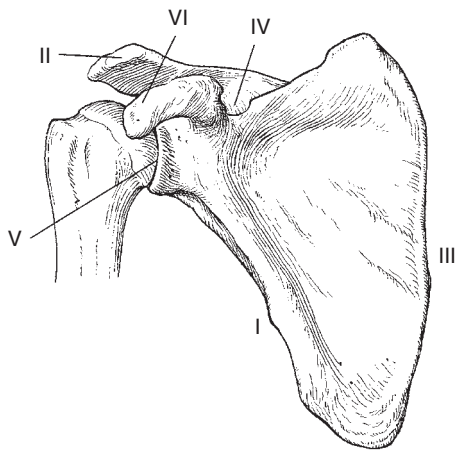
Using [Figure 6-19](#), answer questions 129 through 132.



• **Figure 6-19**

129. The structure designated as *I* is the:
- Head of the fibula
 - Head of the tibia
 - Tuberosity
 - Styloid process
130. The structure designated as *II* is the:
- Medial condyle
 - Lateral condyle
 - Intercondylar eminence
 - Head of the fibula
131. The structure designated as *III* is the:
- Tubercle
 - Lateral condyle
 - Medial condyle
 - Intercondylar eminence
132. The structure designated as *IV* is the:
- Tubercle
 - Lateral condyle
 - Medial condyle
 - Intercondylar eminence

Using Figure 6-20, answer questions 133 through 138.



• Figure 6-20

133. The structure designated as *I* is the:
- Vertebral border
 - Scapular notch
 - Body
 - Axillary border
134. The structure designated as *II* is the:
- Humeral head
 - Acromion
 - Coracoid process
 - Coronoid process
135. The structure designated as *III* is the:
- Vertebral border
 - Scapular notch
 - Body
 - Subscapular fossa
136. The structure designated as *IV* is the:
- Coracoid process
 - Coronoid process
 - Scapular notch
 - Glenoid fossa
137. The structure designated as *V* is the:
- Glenoid fossa
 - Acromion
 - Coronoid process
 - Coracoid process
138. The structure designated as *VI* is the:
- Glenoid fossa
 - Acromion
 - Coronoid process
 - Coracoid process

139. Critique Figure 6-21.
- Radiograph is unacceptable; radius and ulna should be superimposed
 - Radiograph is unacceptable; tibia and fibula should be superimposed
 - Radiograph is acceptable, but only one joint is needed
 - Radiograph is acceptable



• Figure 6-21

140. The radiograph in [Figure 6-22](#) illustrates what region?
- Genitourinary
 - Cardiovascular
 - Hepatobiliary
 - Gastrointestinal



• **Figure 6-22**

141. Critique [Figure 6-23](#).
- Radiograph unacceptable; arm rotated
 - Radiograph acceptable for medial oblique
 - Radiograph acceptable for lateral oblique
 - Radiograph unacceptable; humerus and forearm must be in same plane



• **Figure 6-23**

142. Critique [Figure 6-24](#).
- Radiograph was taken with interpupillary line parallel to IR
 - Radiograph was taken with MSP perpendicular to IR
 - Radiograph was taken with interpupillary line perpendicular to IR
 - Radiograph was taken with MSP parallel to central ray



• **Figure 6-24**

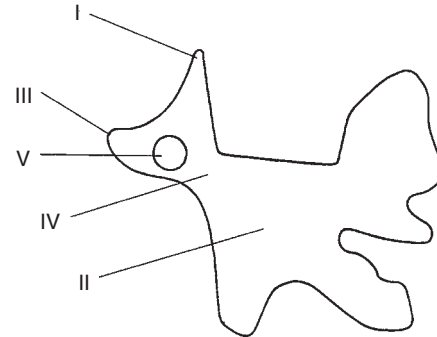
143. Critique **Figure 6-25**.
- Radiograph was taken with central ray angled 15 degrees caudad
 - Radiograph was taken with central ray angled 0 degrees
 - Radiograph was taken with central ray angled 15 degrees cephalad
 - Radiograph was taken with MSP perpendicular to central ray



• **Figure 6-25**

Using **Figure 6-26**, answer questions 144 through 148.

144. The structure designated as *I* is the:
- Pars interarticularis
 - Superior articular process
 - Pedicle
 - Lamina



• **Figure 6-26**

145. This illustrates which type of vertebra?
- thoracic
 - cervical
 - lumbar
146. The structure designated as *III* is the:
- Spinous process
 - Transverse process
 - Pedicle
 - Inferior articular process
147. The structure designated as *IV* is the:
- Spinous process
 - Transverse process
 - Pedicle
 - Pars interarticularis
148. The structure designated as *V* is the:
- Spinous process
 - Transverse process
 - Pedicle
 - Inferior articular process
149. The lateral transthoracic humerus, oblique sternum, and lateral thoracic spine may be imaged best by using:
- Short exposure time
 - Breathing technique
 - Image intensifier
 - CT

150. A patient unable to supinate the hand for an antero-posterior (AP) projection of the forearm:
- Should be made to do so to provide a diagnostic radiograph
 - Probably has a fracture of the radial head and must be handled carefully
 - Probably has a low pain tolerance and must be handled carefully
 - May require radiographs with and without weights
151. When a posteroanterior (PA) axial projection of the clavicle is performed, the central ray should be angled:
- 15 degrees cephalad
 - 15 degrees caudad
 - 25 to 30 degrees cephalad
 - 25 to 30 degrees caudad
152. When a lateral projection of the knee is performed, the knee should be:
- Extended 20 to 30 degrees
 - Flexed to a 90-degree angle
 - Flexed 20 to 30 degrees
 - Fully extended
153. When a tangential projection of the patella is performed with the patient prone, the central ray should be angled:
- 15 degrees cephalad
 - 15 degrees caudad
 - 25 degrees cephalad
 - 45 degrees cephalad
154. Use of which of the following would provide an improved image of the femur?
- Wedge filter
 - Anode heel effect
 - Short SID
 - Long OID
155. When an AP projection of the hip is performed, the central ray is directed:
- Perpendicular to a point 2 inches medial to the anterior superior iliac spine (ASIS) at the level of the superior margin of the greater trochanter
 - Parallel to a point 2 inches medial to the ASIS at the level of the superior margin of the greater trochanter
 - At a 15-degree cephalad angle
 - To the level of the ASIS
156. When an AP oblique projection is performed for the cervical vertebrae, the central ray is directed:
- 25 to 30 degrees cephalad
 - 15 to 20 degrees caudad
 - 5 to 10 degrees cephalad
 - 15 to 20 degrees cephalad
157. When the AP oblique projection is performed for the lumbar vertebrae, the side of interest is:
- Farthest from the image receptor
 - Closest to the image receptor
 - Rotated 30 degrees
 - Rotated 20 degrees
158. When the PA oblique projection for the sacroiliac joints is performed, the side of interest is:
- Farthest from the image receptor
 - Closest to the image receptor
 - Rotated 10 degrees
 - Rotated 45 degrees
159. Routine chest radiography is performed:
- At the end of full inspiration
 - At the end of full expiration
 - At the end of the second full inspiration
 - With the patient supine or upright
160. The primary purpose of performing oblique projections of the ribs is:
- To image the axillary portion of the ribs
 - To image the ribs above the diaphragm
 - To image the ribs below the diaphragm
 - To determine the extent of the patient's pain tolerance
161. When the PA projection of the skull is performed to image the frontal bone:
- The central ray is directed perpendicular to the IR
 - The OML is perpendicular to the IR
 - The central ray exits at the glabella
 - MSP is parallel to the cassette
- All are true
 - 1, 2
 - 1, 3, 4
 - 1, 3
162. Which of the following bones has (have) no body?
- Atlas
 - Axis
 - Thoracic vertebrae
 - Lumbar vertebrae
163. This forms the medial part of the anterior chest wall:
- Manubrium
 - Floating
 - Xiphoid
 - Sternum
164. Which of the following is (are) located just below the head of the humerus?
- Greater and lesser tubercles
 - Bicipital groove
 - Capitulum
 - Trochlea
165. Blood vessels, the bronchial tree, and nerves enter the lungs at this point:
- Trachea
 - Left lung
 - Right lung
 - Hilus
166. The narrow distal end of the stomach that connects with the small intestine is called the:
- Rugae
 - Pylorus
 - Fundus
 - Greater curvature

167. The part of the urinary system located between the renal pelvis and the bladder is called the:
- Cortex
 - Medulla
 - Nephron
 - Ureter

Patient Care (Questions 168-200)

168. The first tier of transmission-based isolation precautions is called:
- Universal precautions
 - Standard precautions
 - Infection control
 - Liner, nonthreshold
169. The first step in pouring liquids into containers in a sterile field is to:
- Allow the liquid to drop onto the sterile field
 - Pour a small amount into a waste receptacle to cleanse the lip of the bottle
 - Carefully determine the contents of the container
 - Immediately pour the solution when requested to do so
170. What is usually used to perform medical asepsis?
- Water and chemicals
 - Complete sterilization procedure
 - Surgical suite procedures
 - Soap and water
171. The suffix that means “condition” is:
- pathy
 - itis
 - osis
 - tomy
172. The suffix that means “disease” is:
- osis
 - pathy
 - rhaphy
 - scopy
173. Bradycardia indicates a pulse of:
- Greater than 100 beats per minute
 - Greater than 60 beats per minute
 - Greater than 90 beats per minute
 - Less than 60 beats per minute
174. Normal adult respiration is:
- Greater than 100 beats per minute
 - Less than 60 beats per minute
 - 12 to 16 breaths per minute
 - 12 to 16 beats per minute
175. The radiographer must be proficient in the use of which of the following medical instruments?
- Angiography catheter
 - Sphygmomanometer
 - Thermometer
 - Oxygen administration equipment
176. A tube used to feed a patient or to perform gastric suction is called a:
- Tracheostomy tube
 - Tracheotomy tube
 - Nasogastric tube
 - Ventilator tube
177. Nosocomial infections are acquired:
- In radiology
 - Through the nose
 - During cold and flu season
 - In the health care setting
178. During movement and transfer of patients, urinary catheter bags should be:
- Safely placed on the patient’s abdomen
 - Kept below the level of the urinary bladder
 - Kept below the level of the x-ray table
 - Kept on the cart or wheelchair
179. The first task that must be performed when beginning a radiographic examination of a patient is to:
- Verify patient identity
 - Determine accuracy of physician’s orders
 - Verify the examination to be performed
 - Remove radiopaque objects from the area of interest
180. Which of the following is *not* required for valid consent?
- Patient must be of legal age
 - Patient must be adequately informed and sign a consent form
 - Patient must be mentally competent
 - Consent must be offered voluntarily
181. The prefix that means “around” is:
- Poly-
 - Peri-
 - Retro-
 - Trans-
182. The prefix that means “many” is:
- Peri-
 - Poly-
 - Hemi-
 - Epi-
183. A system that uses barriers between individuals and assumes all patients are infectious is called:
- Standard precautions
 - Whole-body isolation
 - Sterile technique
 - Surgical asepsis
184. When you are performing patient care in radiology:
- Hands should be washed after each procedure
 - Gowns and gloves should always be worn
 - Hands should be washed only after you care for obviously infectious patients
 - Gloves should be worn only when you perform gastrointestinal procedures or venipuncture
185. Patient transfer from cart to x-ray table should be performed:
- Alone when working evenings or nights
 - By radiographers working in pairs at all times
 - Alone when the department is busy or has a staff shortage
 - In pairs only when other radiographers are available to assist

186. Your best source for the latest information regarding standard precautions is the:
- Radiology administrator
 - Radiology purchasing manager
 - Infection control department
 - Radiologist
187. After all radiographic or fluoroscopic procedures, the radiographer should use _____ to clean surfaces with which the patient was in contact.
- Alcohol
 - Surgical asepsis
 - Soap and water
 - Medical asepsis
188. When sterile fields are prepared, damp packages:
- Are always considered contaminated
 - Are always considered sterile because the dampness confirms they were cleaned
 - Should be unwrapped first and placed in the center of the sterile field
 - Are always considered sterile; the dampness is a remnant of the gassing process
189. When mobile radiography is performed, the mobile unit:
- Does not have to be cleaned because it is never in contact with sterile fields
 - Must be cleaned before and after each use
 - Must be cleaned before it is brought into surgical areas or reverse isolation units
 - Must be cleaned before it is brought into surgical areas or reverse isolation units and after its removal from most isolation units
190. When radiography is performed on patients in isolation, the IR:
- Should be placed in a protective covering only if the patient is in reverse isolation
 - Must always be placed in a protective covering
 - Should be placed in a protective covering to keep it free of microbes
 - Should be placed in a protective covering so that no microbes leave the room
191. Which of the following procedures should a radiographer be prepared to assist with at any time?
- Cardiac massage
 - Defibrillation
 - Feeding tube insertion
 - CPR
192. In addition to performing radiography on a trauma victim, the radiographer should be:
- Assessing the patient's condition continually
 - Interpreting the images for the emergency department physician
 - Taking additional projections as indicated by the patient's condition or preliminary images
 - Keeping all other health care workers out of the room because of radiation protection standards
5. Providing comfort and communicating quietly with the patient, whether the patient is conscious or unconscious
- 1, 3
 - 4, 5
 - 1, 3, 5
 - 1, 3, 4, 5
193. For a barium enema, the contrast agent should be mixed with:
- Cold water
 - Water at or below body temperature
 - Water at approximately 120° F
 - Water at approximately 100° F
194. All iodinated contrast media used today contain:
- Iodine and free ions
 - Free ions
 - Only iodine
 - Salts of organic iodine compounds
195. The highest incidence of contrast agent reactions occurs with the use of:
- Negative contrast media
 - Ionic iodinated contrast media
 - Nonionic iodinated contrast media
 - Barium sulfate
196. It is important for the radiographer to obtain the recent history of radiographic examinations performed on a patient so that:
- An overdose of iodinated contrast media does not occur from examinations recently performed
 - An overdose of radiation is not administered
 - Unnecessary examinations may be avoided
 - Costs may be contained
197. For a patient who has a history of intravenous urography and no contrast agent reactions:
- The radiographer may assume there would be no reaction on subsequent intravenous urograms
 - The radiographer must assume there is a chance of a reaction on other contrast examinations
 - The radiographer must assume there is a chance of a reaction on subsequent intravenous urograms
 - There is no chance of reactions on subsequent intravenous urograms
198. A negative contrast agent used in chest radiography and some arthrography is:
- Barium sulfate
 - Iodine
 - Perforated ulcers or ruptured appendix
 - Air
199. A positive contrast agent administered to the patient who is going to surgery is:
- Barium sulfate
 - Iodine
 - Perforated ulcers or ruptured appendix
 - Aqueous iodine compound

TABLE 6-2 Calculating Your Score for Challenge Test Number 2

Topic	Percentage Calculation	Your Score
Safety	Number correct _____ $\times 100, \div 53 =$	
Image Production	Number correct _____ $\times 100, \div 50 =$	
Procedures	Number correct _____ $\times 100, \div 64 =$	
Patient Care	Number correct _____ $\times 100, \div 33 =$	
Total	Number correct _____ $\times 100, \div 200 =$	

- 200.** In an attempt to maintain the quality of patient care at the highest level possible over time, proof of continuing education is mandatory for renewal of certification with:
- State licensing boards in all 50 states
 - American Society of Radiologic Technologists
 - The Joint Commission
 - ARRT

Scoring

Use Table 6-2 above to calculate the percentage of questions you answered correctly in each category and on the test as a whole. Remember, a score of less than 75% on any topic or the entire test is an indication that more review is needed on that topic. Now go back and concentrate on which items were missed and the reason why. When you are done reviewing, go on to Challenge Test Number 3.

Challenge Test Number 3

ARRT Exam Categories: Safety, Image Production, Procedures, Patient Care

Read each question and the answer choices carefully. Choose the best, most complete answer for each item. Use the results of this test to assess your strengths and weaknesses. Do not look up any of the answers until you have completed the entire test. Correct the test using the answer key in the back of the book. Then compute your scores using Table 6-3 to see where you are strong and where you need additional review. Refer to the appropriate chapter in this book for review of the questions you miss.

Safety (Questions 1-53)

For the following questions, choose the single best answer.

- Radiation that exits the x-ray tube from the anode is called:
 - Remnant radiation
 - Gamma radiation

- Nonionizing radiation
 - Primary radiation
- The photon-tissue interaction in diagnostic radiography that results in the total absorption of an x-ray photon and the production of contrast in the radiographic image is:
 - Compton
 - Coherent
 - Photoelectric
 - Pair production
 - Which photon-tissue interaction produces a recoil electron and a scattered photon in diagnostic radiography?
 - Compton
 - Coherent
 - Photoelectric
 - Pair production
 - The SI unit of exposure in air is the:
 - Air kerma
 - Gray
 - Becquerel
 - Sievert
 - The SI unit of absorbed dose is the:
 - LET
 - Gray
 - Curie
 - Sievert
 - The SI unit of equivalent dose is the:
 - Sievert
 - Gray
 - Radiation weighting factor
 - LET
 - The SI unit of effective dose is the:
 - Sievert
 - Gray
 - Radiation weighting factor
 - LET
 - The SI unit of radioactivity is the:
 - Becquerel
 - Gray
 - Quality factor
 - Curie

9. _____ refers to energy per unit mass absorbed by an object.
 - a. Bq
 - b. Gy_a
 - c. W_R
 - d. Gy_t
10. The amount of radiation deposited per unit length of tissue traversed by incoming photons is called:
 - a. REM
 - b. RADS
 - c. LET
 - d. RPU
11. The weighting factor related to radiation effects in organs and tissues is:
 - a. W_R
 - b. Gy_a
 - c. Gy_t
 - d. W_T
12. Compton interaction:
 - a. Produces poorer recorded detail in the radiographic image
 - b. Results in absorption of the incident photon
 - c. May produce higher contrast on the radiograph
 - d. May produce a gray fog on the image, lowering contrast
13. The radiation weighting factor for x-rays is:
 - a. 10
 - b. 1
 - c. 20
 - d. 5
14. Mutations are examples of:
 - a. Short-term somatic effects
 - b. Genetic effects
 - c. Acute radiation syndrome
 - d. Long-term somatic effects
15. Effective dose limit is:
 - a. The level of radiation that an organism can receive before formation of cancer
 - b. Age \times 1 mSv for occupationally exposed individuals
 - c. 50 mSv per month for occupationally exposed individuals
 - d. 50 mSv per year for occupationally exposed individuals
16. What agency publishes radiation protection recommendations?
 - a. ICRP
 - b. NCRP
 - c. NRC
 - d. ASRT
17. Radiation safety standards assume what relationship between dose and response?
 - a. Linear-threshold
 - b. Nonlinear-nonthreshold
 - c. Linear-nonthreshold
 - d. Nonlinear-threshold
18. Which of the following would be applicable to radiation therapy?
 - a. Inverse square law
 - b. Law of Bergonié and Tribondeau
 - c. Reciprocity law
 - d. Ohm's law
19. Which of the following causes about 5% of the cellular response to radiation?
 - a. Direct effect
 - b. Law of Bergonié and Tribondeau
 - c. Target theory
 - d. Indirect effect
20. When radiation strikes the cytoplasm, which of the following occurs?
 - a. Direct effect
 - b. Law of Bergonié and Tribondeau
 - c. Target theory
 - d. Indirect effect
21. The equivalent dose limit for the embryo-fetus is:
 - a. 500 mSv per year
 - b. 0.5 mSv per month
 - c. 0.05 rem per month
 - d. 0.5 mSv during gestation
22. The effective dose limit for radiographers for localized areas of skin is:
 - a. 50 mSv per year
 - b. 500 mSv per year
 - c. 0.5 mSv monthly
 - d. 10 mSv monthly
23. The cumulative occupational exposure for a 48-year-old radiographer is:
 - a. 48 mSv
 - b. 480 mSv
 - c. 24 mSv
 - d. 0.48 mSv
24. The annual effective dose limit for the general public, assuming infrequent exposure, is:
 - a. 5 mSv
 - b. 500 mSv
 - c. 0.5 mSv
 - d. 50 mSv
25. The upper boundary dose that can be absorbed that carries a negligible risk of somatic or genetic damage to the individual defines:
 - a. Maximum permissible dose
 - b. ALARA
 - c. Law of Bergonié and Tribondeau
 - d. Effective dose limit
26. Compared with OSL and TLD badges, film badges are:
 - a. more sensitive
 - b. less sensitive
 - c. the same sensitivity

27. The exposure switch on a portable x-ray machine must be attached to a cord that is at least how many feet long?
- 3
 - 6
 - 12
 - 2
28. Under what conditions can the radiographer be exposed to the primary beam?
- When performing mobile radiography, as long as the exposure is low
 - Never, under any conditions
 - When performing cross-table projections, if needed to hold the cassette in place
 - When assisting with fluoroscopy
29. For purposes of radiation protection, the x-ray beam is filtered. X-ray tubes operating above 70 kVp must have total filtration of:
- At least 0.25-mm aluminum equivalent
 - At least 0.25-mm lead equivalent
 - No more than 2.5-mm aluminum equivalent
 - At least 2.5-mm aluminum equivalent
30. Gonadal shielding should be used:
- On every examination performed
 - Whenever it does not obstruct the area of clinical interest
 - Only on children and women of childbearing age
 - Only during pregnancy
31. The secondary protective barrier must overlap the primary protective barrier by at least:
- $\frac{1}{10}$ inch
 - 1 inch
 - 1 foot
 - $\frac{1}{2}$ inch
32. The x-ray control booth is considered a:
- Secondary protective barrier
 - Primary protective barrier
 - Mobile barrier
 - Nonbarrier
33. The exposure switch must keep the radiographer behind the:
- Primary protective barrier
 - Secondary protective barrier
 - X-ray tube
 - Door
34. Areas for the general public, such as waiting rooms and stairways, are considered:
- Controlled areas
 - Uncontrolled areas
 - Off-limits areas
 - Radiation areas
35. An uncontrolled area must be kept under what dose weekly?
- 5 μSv
 - 10 μSv
 - 15 μSv
 - 20 μSv
36. Areas occupied by persons trained in radiation safety and wearing personnel monitoring devices are called:
- Controlled areas
 - Uncontrolled areas
 - Off-limits areas
 - Radiation areas
37. Which of the following takes into account the volume and types of examinations performed in the room?
- Use factor
 - Shielding factor
 - Volume factor
 - Workload
38. How is workload factor measured?
- Half-value layer
 - Amount of time the beam is on
 - mA minutes per week
 - Average kVp per week
39. The amount of time the beam is on and directed at a particular barrier is called:
- Use factor
 - Shielding factor
 - Occupancy
 - Workload
40. Leakage radiation from a diagnostic x-ray tube may not exceed:
- 1 mGy_a per hour, measured at the source
 - 10 mGy_a per hour
 - 1 mGy_a per hour, measured at 1 m from the housing
 - 100 mGy_a per hour, measured at 1 m from the housing
41. Organelles are located in the:
- DNA
 - Cytoplasm
 - RNA
 - Cellular nucleus
42. Relative biological effectiveness (RBE) describes the:
- Ability of radiation to produce biological damage
 - Efficacy of radiation therapy
 - Sensitivity of DNA to radiation exposure
 - Radiosensitivity of water in the cytoplasm
43. The law of Bergonié and Tribondeau states:
- Radiation intensity is inversely proportional to the square of the distance
 - Cells are most sensitive to radiation when they are immature, undifferentiated, and rapidly dividing
 - Voltage is equal to current times resistance
 - All radiation exposure causes damage to the cell
44. Which of the following describes the radiosensitivity of lymphocytes?
- Low radiosensitivity
 - Least radiosensitive cells in the body
 - Most radiosensitive cells in the body
 - There is no connection between lymphocytes and radiation exposure
45. When are embryologic effects least likely to occur?
- During the final trimester of gestation
 - During the middle trimester of gestation

- c. During the first trimester of gestation
d. At conception
46. Lead aprons must be worn to protect against which photon–tissue interaction?
a. Compton
b. Coherent
c. Photoelectric interaction
d. Pair production
47. What is plotted on the x-axis of a dose-response curve?
a. Dose
b. Response
c. Receptor exposure
d. Radioactivity
48. What is the preferred source-to-skin distance for C-arms?
a. 12 inches
b. 10 inches
c. 20 inches
d. 15 inches
49. Photoelectric interaction occurs at what level in the atom?
a. L-shell
b. K-shell
c. M-shell
d. Outer shell
50. Radiation exiting the patient in very divergent paths would be indicative of
a. Photoelectric rays
b. Scatter
c. Coherent interaction
d. Patient motion during the exposure
51. Cellular components contained in the cytoplasm are called
a. Free radicals
b. Ions
c. Organelles
d. DNA strands
52. Long-wavelength x-rays are removed from the primary beam by the use of a
a. Collimator
b. Filter
c. Cylinder cone
d. Gonadal shield
53. The primary purpose of radiation safety practices is to
a. Limit occupational exposure
b. Limit the introduction of mutations into the population
c. Limit long-term somatic effects
d. Limit short-term somatic effects
- Image Production (Questions 54-103)**
54. Devices in the x-ray circuit that increase or decrease voltage are called:
a. Rectifiers
b. Generators
c. Timers
d. Transformers
55. The filament circuit makes use of what type of transformer?
a. Step-up
b. Autotransformer
c. Step-down
d. Falling load
56. Because the x-ray tube requires DC to operate properly, what device is required in the x-ray circuit?
a. Autotransformer
b. Step-up transformer
c. Rectifier
d. Falling load generator
57. Where is the rectifier located in the x-ray circuit?
a. Between the timer and the step-up transformer
b. Between the step-up transformer and the step-down transformer
c. Between the primary and secondary coils of the step-up transformer
d. Between the step-up transformer and the x-ray tube
58. Thermionic emission occurs at the:
a. Anode
b. Control panel
c. Rectifier
d. Cathode
59. At the time of exposure, the charge on the focusing cup is:
a. Irrelevant
b. Positive
c. Negative
d. Alternating
60. An interaction that produces heat at the anode and also produces x-rays is called:
a. Characteristic
b. Photoelectric
c. Compton
d. Bremsstrahlung
61. When a quality control test for exposure linearity is performed, adjacent mA stations must be within _____ of one another.
a. 2% of SID
b. 4%
c. 10%
d. 5%
62. When a quality control test for exposure reproducibility is performed, successive exposures must be within _____ of one another.
a. 2% of SID
b. 4%
c. 10%
d. 5%
63. When a quality control test for collimator accuracy is performed, the result must be within _____.
a. 2% of SID
b. 4%
c. 10%
d. 5%

64. When a quality control test for accuracy of kVp is performed, the result must be within _____ of the control panel setting.
- 2% of SID
 - 4%
 - 10%
 - 4
65. The accuracy of collimation at a 72-inch SID must be:
- ± 1.44 inches
 - ± 7.2 inches
 - ± 3.6 inches
 - ± 0.02 inch
66. The feature of the image intensifier that ensures the radiation dose striking the input phosphor is constant is the:
- Photocathode
 - Electron focusing lens
 - Automatic brightness control
 - Vidicon tube
67. Instead of Vidicon or Plumbicon tubes, what device may be used in the television system?
- Charge-coupled device (CCD)
 - C-arm
 - Automatic brightness control
 - Output phosphor
68. The electronic device that may be used for many quality control tests on x-ray equipment is the:
- Automatic exposure control
 - Digital dosimeter
 - Penetrometer
 - Densitometer
69. The smallest particle of a compound that retains the characteristics of the compound is a(n):
- Element
 - Atom
 - Molecule
 - Neutron
70. Given an original technique of 20 mAs and 80 kVp, which of the following would produce a radiograph with double the IR exposure?
- 40 mAs, 90 kVp
 - 30 mAs, 92 kVp
 - 40 mAs, 80 kVp
 - 15 mAs, 92 kVp
71. Distance and density are governed by what law or rule?
- Reciprocity law
 - 15% rule
 - Inverse square law
 - Density maintenance rule
72. Unwanted markings on a radiographic image are called:
- Processing irregularities
 - Processing artifacts
 - Artifacts
 - Plus-density markings
73. Manual manipulation of the digital image after acquisition is referred to as:
- Digital coding
 - Postprocessing
 - Leveling
 - Archiving
74. As speed class decreases, patient dose:
- Increases
 - Decreases
 - Remains the same
75. Because the digital system software ultimately controls contrast, kVp may be:
- Increased
 - Decreased
 - Kept the same
76. Image acquisition, image display, and image storage are the primary components of what system?
- DICOM
 - CR/DR
 - PACS
 - HIS
77. What "language" is used by PACS?
- DICOM
 - Base 10
 - HIS
 - RIS
78. Which exposure factor causes excessive image noise if set too high?
- kVp
 - mAs
 - AEC
 - Time
79. Which of the following can be documented as an indication of patient dose?
- AEC
 - Exposure indicator
 - System speed class
 - Histogram
80. Choosing the anatomic region on a touch screen display to set technique is called:
- Phototiming
 - Anatomically programmed radiography
 - AEC imaging
 - Automatic radiography
81. What is used to reduce both patient dose and the production of scatter radiation?
- Grids
 - High speed class
 - Collimation
 - Filtration
82. Image artifacts are usually classified as:
- Scatter
 - Plus or minus density
 - Compton and photoelectric
 - Patient motion and equipment motion

83. Grid ratio is expressed as:
- Length of the lead strips to the space between them
 - Height of the aluminum strips to the space between them
 - Height of the interspacers to the lead strips
 - Height of the lead strips to the space between them
84. The primary type of grid used in diagnostic imaging is:
- Crosshatch
 - Parallel
 - Rhombic
 - Focused
85. Which of the following does *not* belong in the definition of matter?
- Travels at the speed of light
 - Has shape
 - Has form
 - Occupies space
86. The accuracy of collimation at a 60-inch SID must be:
- ± 6 inches
 - ± 3 inches
 - ± 2 inches
 - ± 1.2 inches
87. Which of the following is true regarding frequency and wavelength of electromagnetic radiation?
- Frequency and wavelength are directly proportional
 - Frequency and wavelength are unrelated
 - Wavelength and frequency are inversely proportional to the square of the distance between wave crests
 - Wavelength and frequency are inversely proportional
88. Beam restrictors reduce the amount of scatter produced by reducing which of the following?
- Characteristic rays
 - Photoelectric effect
 - Compton interactions
 - Pair production
89. What effect does increasing filtration have on contrast?
- Increases contrast
 - Decreases contrast
 - No effect
 - Varying effect
90. Decreased SID causes image:
- Minification
 - Foreshortening
 - Elongation
 - Magnification
91. Inaccurate use of grids may result in repeat exposures due to what condition?
- Overexposure
 - Grid analysis error
 - Underexposure
 - Cut-off
92. The measure of a grid's ability to enhance contrast is called:
- Grid ratio
 - Grid selectivity
 - Speed
 - Contrast improvement factor
93. Which of the following grid errors would result in an image that shows normal exposure in the middle but decreased exposure on the sides, assuming the correct side of the grid faces the x-ray tube?
- Upside down
 - Off-level
 - Lateral decentering
 - Grid-focus decentering
94. Which of the following grid errors would result in an image that shows decreased density more to one side than the other?
- Upside down
 - Off-level
 - Lateral decentering
 - Grid-focus decentering
95. Grid ratio is described by which of the following?
- H & D
 - H/D
 - mAs = mAs
 - 15% rule
96. Grid radius is described as:
- The height of the lead strips divided by the distance between the lead strips
 - The distance between the lead strips divided by the height of the lead strips
 - The number of lead strips per inch or centimeter
 - The SID at which the grid may be used
97. Structures seen outside of the collimated area on a radiograph, produced by "off-focus" (extrafocal) radiation, are the result of:
- Electron interaction within the x-ray tube at a point other than the focal spot
 - Scatter radiation emanating from the patient or tabletop
 - The use of an SID that is not recommended with the grid in use
 - The x-ray tube positioned off-center to the grid
98. Geometric unsharpness within the radiographic image can be minimized by using the:
- Smallest focal spot
 - Shortest object-image receptor distance
 - Longest target-image receptor distance
- 1 and 2 only
 - 1 and 3 only
 - 2 and 3 only
 - 1, 2, and 3
99. An *undistorted* radiographic image results when the object plane and the image plane are:
- Angled in relation to each other
 - At right angles
 - Parallel
 - Perpendicular

- 100.** A radiographic grid should be used when:
1. The body area to be radiographed measures more than 10 cm
 2. A field size larger than 10 to 12 inches is used
 3. More than 60 kVp is required to penetrate a body part
- a. 1 and 2 only
 - b. 1 and 3 only
 - c. 2 and 3 only
 - d. 1, 2, and 3
- 101.** Twice as many electrons strike the target in the x-ray tube when:
- a. kVp is doubled
 - b. mAs is doubled
 - c. SID is reduced by one-half
 - d. OFD is reduced by one-half
- 102.** How does beam restriction affect contrast?
- a. Decreases contrast
 - b. Longer scale of contrast
 - c. Shorter scale of contrast
 - d. No effect on contrast
- 103.** Grid conversion factor (Bucky factor) is described as the:
- a. Height of the lead strips divided by the distance between the lead strips
 - b. Distance between the lead strips divided by the height of the lead strips
 - c. Number of lead strips per inch or centimeter
 - d. Amount of exposure increase necessary to compensate for the absorption of image-forming rays and scatter in the cleanup process
- Procedures (Questions 104-167)**
- For the following questions, choose the single best answer.
- 104.** An enlargement at the end of a bone is called a:
- a. Prominence
 - b. Sharp prominence
 - c. Tubercle
 - d. Head
- 105.** A rounded projection of moderate size is called a:
- a. Prominence
 - b. Sharp prominence
 - c. Tubercle
 - d. Tuberosity
- 106.** A spine describes a:
- a. Prominence
 - b. Sharp prominence
 - c. Tubercle
 - d. Tuberosity
- 107.** A pit is described as a:
- a. Fossa
 - b. Groove
 - c. Sulcus
 - d. Sinus
- 108.** A furrow is described as a:
- a. Fossa
 - b. Groove
 - c. Sulcus
 - d. Sinus
- 109.** A “typical” skull would be described as:
- a. Synarthroses
 - b. Amphiarthroses
 - c. Diarthroses
 - d. Mesocephalic
- 110.** Synovial joints are called:
- a. Synarthroses
 - b. Amphiarthroses
 - c. Diarthroses
 - d. Mesocephalic
- 111.** Fibrous joints are called:
- a. Synarthroses
 - b. Amphiarthroses
 - c. Diarthroses
 - d. Mesocephalic
- 112.** The radiocarpal joint has what type of movement?
- a. Hinge
 - b. Pivot
 - c. Saddle
 - d. Condyloid
- 113.** The proximal radioulnar articulation has what type of movement?
- a. Hinge
 - b. Pivot
 - c. Saddle
 - d. Gliding
- 114.** Which of the following bones has a temporal process?
- a. Sphenoid bone
 - b. Ethmoid bone
 - c. Mandible
 - d. Zygomatic bone
- 115.** Which of the following bones has an alveolar process?
- a. Sphenoid bone
 - b. Ethmoid bone
 - c. Mandible
 - d. Maxilla
- 116.** Which of the following bones has wings?
- a. Sphenoid bone
 - b. Ethmoid bone
 - c. Mandible
 - d. Maxilla
- 117.** Which of the following bones has a coronal suture?
- a. Frontal bone
 - b. Temporal bone
 - c. Occipital bone
 - d. Parietal bone
- 118.** Which of the following bones has an external protuberance?
- a. Frontal bone
 - b. Temporal bone
 - c. Occipital bone
 - d. Mandible

119. Which of the following bones consists of five fused segments?
a. Sacrum
b. Axis
c. Thoracic vertebra
d. Lumbar vertebra
120. Which of the following bones has a dens?
a. Atlas
b. Axis
c. Thoracic vertebra
d. Lumbar vertebra
121. Which of the following individual vertebra is larger and heavier than other individual vertebrae?
a. Atlas
b. Axis
c. Thoracic vertebra
d. Lumbar vertebra
122. The eleventh and twelfth pairs of ribs are called:
a. Manubrium
b. Floating
c. Xiphoid
d. Jugular notch
123. The blunt cartilaginous tip of the sternum is the:
a. Manubrium
b. Floating
c. Xiphoid
d. Jugular notch
124. Located between the greater and lesser tubercles of the humerus is (are) the:
a. Greater and lesser tubercles
b. Bicipital groove
c. Capitulum
d. Trochlea
125. Located below the tubercles of the humerus is (are) the:
a. Greater and lesser tubercles
b. Bicipital groove
c. Capitulum
d. Surgical neck
126. Which of the following part(s) of the humerus articulate(s) with the ulna?
a. Greater and lesser tubercles
b. Bicipital groove
c. Capitulum
d. Trochlea
127. Which bone is located in the wrist, between the trapezoid and the hamate?
a. Scaphoid
b. Hamate
c. Pisiform
d. Capitate
128. Which bone is located in the wrist, between the lunate and the pisiform?
a. Scaphoid
b. Hamate
c. Pisiform
d. Triquetrum
129. Which bone distributes body weight from the tibia to the other tarsal bones?
a. Navicular
b. Calcaneus
c. Talus
d. Cuboid
130. Which bone lies along the lateral border of the navicular bone?
a. Navicular
b. Calcaneus
c. Talus
d. Cuboid
131. Which of the following articulate(s) with the first, second, and third metatarsal bones?
a. Navicular
b. Calcaneus
c. Talus
d. Cuneiforms
132. This structure has superior, middle, and inferior lobes:
a. Trachea
b. Left lung
c. Right lung
d. Hilus
133. This structure is approximately 12 cm long and is located in front of the esophagus:
a. Trachea
b. Left lung
c. Right lung
d. Hilus
134. The narrow distal end of the stomach that connects with the small intestine is called the:
a. Rugae
b. Pylorus
c. Fundus
d. Greater curvature
135. The section of the stomach where the esophagus enters is called the:
a. Rugae
b. Pylorus
c. Fundus
d. Cardiac portion
136. The lateral surface of the stomach is called the:
a. Rugae
b. Pylorus
c. Fundus
d. Greater curvature
137. The portion of the colon located between the splenic flexure and the sigmoid portion is called the:
a. Duodenum
b. Descending
c. Ileum
d. Ascending

- 138.** The portion of the small bowel that connects with the cecum is called the:
- Duodenum
 - Jejunum
 - Ileum
 - Ascending
- 139.** The portion of the small bowel that connects with the stomach is called the:
- Duodenum
 - Jejunum
 - Ileum
 - Ascending
- 140.** The outer part of the kidney is called the:
- Cortex
 - Medulla
 - Nephron
 - Glomeruli
- 141.** The part of the kidney through which blood is first filtered is called the:
- Cortex
 - Medulla
 - Nephron
 - Glomeruli
- 142.** For radiography of the fingers, the central ray enters:
- Perpendicular to the distal interphalangeal joint
 - Parallel to the distal interphalangeal joint
 - Parallel to the proximal interphalangeal joint
 - Perpendicular to the proximal interphalangeal joint
- 143.** For a PA projection of the hand, the central ray is centered:
- Perpendicular to the first metacarpophalangeal joint
 - Perpendicular to the third metatarsophalangeal joint
 - Parallel to the third metacarpophalangeal joint
 - Perpendicular to the third metacarpophalangeal joint
- 144.** For a lateral projection of the wrist, the elbow must be flexed:
- 45 degrees
 - 90 degrees
 - Only slightly
 - Approximately 25 degrees
- 145.** For PA axial projection of the clavicle, the central ray is angled:
- 25 to 30 degrees caudad
 - 25 to 30 degrees cephalad
 - 20 degrees caudad
 - 20 degrees cephalad
- 146.** For AP projection of the toes, the central ray enters at the:
- Third metatarsophalangeal joint
 - Second metacarpophalangeal joint
 - First metatarsophalangeal joint
 - Second metatarsophalangeal joint
- 147.** For AP projection of the foot, the central ray enters at the:
- Head of the third metatarsal
 - Head of the second metatarsal
 - Base of the first metatarsal
 - Base of the third metatarsal
- 148.** For axial projection of the calcaneus, the central ray is angled how many degrees to the long axis of the foot?
- 25
 - 15
 - 10
 - 40
- 149.** For AP projection of the ankle, the central ray is directed perpendicular to the:
- Lateral malleolus
 - Ankle joint midway between malleoli
 - Medial malleolus
 - Tibia
- 150.** For AP projection of the knee, the central ray is angled:
- 5 to 7 degrees cephalad
 - 5 to 7 degrees caudad
 - 10 degrees cephalad
 - 10 degrees caudad
- 151.** For AP projection of the cervical spine, the central ray is directed:
- 10 degrees cephalad
 - Parallel to C4
 - 15 to 20 degrees caudad
 - 15 to 20 degrees cephalad
- 152.** For lateral projection of the cervical spine, the central ray is directed:
- Perpendicular to C4
 - Parallel to C4
 - 15 to 20 degrees caudad
 - 20 to 25 degrees cephalad
- 153.** For AP projection of the thoracic spine, the central ray is directed:
- 5 degrees cephalad
 - Parallel to T7
 - 3 to 4 degrees caudad
 - Perpendicular to T7
- 154.** For AP projection of the lumbar spine, the central ray is directed:
- Parallel to midline, entering at the level of the iliac crests
 - Perpendicular to L2
 - Perpendicular to midline, entering at the level of the iliac crests
 - Perpendicular to L4
- 155.** For AP oblique projections of the sacroiliac joints, the central ray is directed:
- 1 inch lateral to elevated ASIS
 - 1 inch medial to elevated ASIS
 - 1 inch lateral to dependent ASIS
 - 1 inch medial to dependent ASIS

156. For PA projection of the chest, the central ray is directed:
- Perpendicular to T10
 - Parallel to the thoracic spine
 - Perpendicular to T7
 - Perpendicular to the posterior ribs
157. For AP projection of the lower ribs, the central ray is directed:
- Perpendicular to T10
 - Perpendicular to T5
 - Perpendicular to T7
 - Perpendicular to T12
158. For AP axial (Towne) projection for the skull, the central ray is directed:
- 30 degrees to IOML
 - 37 degrees to OML
 - 25 degrees to IOML
 - 30 degrees to OML
159. For lateral projection of the facial bones, the central ray enters at the:
- Glabella
 - Medial surface of the zygomatic bone
 - Medial surface of the nasal bone
 - Lateral surface of the zygomatic bone
160. An imaging exam using a contrast agent to visualize the uterus and fallopian tubes is called a(n):
- Uterogram
 - Hysterosalpingogram
 - Intravenous urogram
 - Pregnancy study
161. An imaging exam using a contrast agent to evaluate possible herniated intervertebral discs is called a(n):
- Arthrogram
 - Spinal study
 - Myelogram
 - Discography
162. An exam that may be diagnostic and therapeutic is:
- Hysterosalpingogram
 - Myelogram
 - Arthrogram
 - Barium enema
163. The injection site for a lumbar myelogram is:
- C6-C7
 - L5-S1
 - L3-L4
 - L1-L2
164. An imaging exam using a contrast agent to visualize possible meniscal tears is called a(n):
- Myelogram
 - Arthrogram
 - Joint manipulation study
 - Sports injury exam
165. Arthrography is increasingly being replaced by what imaging modality?
- CT
 - Diagnostic ultrasound
 - PET scanning
 - MRI
166. The ilium is part of the:
- Hip
 - Shoulder
 - Skull
 - Small intestine
167. An AP lordotic chest radiograph best demonstrates the:
- Apices of the lungs
 - Bases of the lungs
 - Mediastinal structures
 - Position of the diaphragm

Patient Care (Questions 168-200)

168. The major advantage of nonionic contrast media over ionic contrast media is that nonionic contrast agents:
- Are considerably less expensive
 - Are less likely to cause an adverse reaction in the patient
 - Provide better radiographic contrast
 - Require the use of considerably less kV and mAs
169. Which of the following should be used when a person is choking on a piece of food?
- Heimlich maneuver
 - Modified Valsalva maneuver
 - Valsalva maneuver
 - Toe touch maneuver
170. During an injection of contrast media, extravasation occurs. The proper procedure is to:
- Continue the injection and tell the patient the burning sensation will subside momentarily
 - Remove the needle and hold pressure on the vein until all bleeding has stopped
 - Remove the needle, repuncture the same vein, and continue the injection
 - Place a warm compress above the site of injection and continue administering the contrast
171. What must precede any examinations involving iodinated contrast media?
- Chest x-ray study
 - Nephrotoxicity assessment
 - Patient held NPO
 - Pregnancy test
172. Diabetic patients should be scheduled:
- Later because of their need for insulin
 - Early because of their need for insulin
 - Just before mealtime
 - Just after mealtime
173. The pelvocalyceal system reaches greatest visualization approximately how many minutes after injection?
- 1 to 2
 - 2 to 5
 - 2 to 8
 - 15 to 20

174. The ARRT Rules of Ethics and Code of Ethics are contained in what document?
- Standards of Ethics
 - Practice Standards
 - Mission Statement
 - Scope of Practice
175. Violations of civil law are known as:
- Assault
 - Battery
 - False imprisonment
 - Torts
176. Unjustified restraint of a patient defines:
- Assault
 - Battery
 - False imprisonment
 - Invasion of privacy
177. The suffix that means “like” is:
- oma
 - oid
 - osis
 - pathy
178. The suffix that means “tumor” is:
- oid
 - pathy
 - oma
 - algia
179. A legal doctrine that states that the cause of the negligence is obvious is known as:
- Respondeat superior
 - Res ipsa loquitur
 - Gross negligence
 - Slander
180. Tachycardia indicates a pulse of:
- Greater than 100 beats per minute
 - Less than 60 beats per minute
 - Greater than 90 beats per minute
 - Less than 50 beats per minute
181. Some level of hypertension is indicated when diastolic pressure is:
- Greater than 100 mm Hg
 - Less than 60 mm Hg
 - Greater than 90 mm Hg
 - Less than 50 mm Hg
182. When oxygen is administered to the patient, the usual flow rate is:
- 3 to 5 L/second
 - 5 L/hour
 - 1 to 3 L/minute
 - 3 to 5 L/minute
183. This item is used to clear an obstructed airway:
- Crash cart
 - Suction unit
 - Defibrillator
 - Sphygmomanometer
184. This item is used to restore the heart to normal rhythm:
- Crash cart
 - Suction unit
 - Defibrillator
 - Sphygmomanometer
185. A type of shock that is caused by a severe allergic reaction is called:
- Hypovolemic shock
 - Septic shock
 - Neurogenic shock
 - Anaphylactic shock
186. An item that is used to feed the patient or to suction gastric contents is a:
- Ventilator
 - Nasogastric tube
 - Chest tube
 - Venous catheter
187. An item that must never be placed above the level of the bladder is a:
- Ventilator
 - Nasogastric tube
 - Chest tube
 - Urinary catheter
188. A mechanical respirator is called a:
- Ventilator
 - Nasogastric tube
 - Chest tube
 - Venous catheter
189. Barium sulfate should be mixed with water at what temperature for a barium enema?
- 100° C
 - 75° F
 - 85° C
 - 100° F
190. A positive contrast agent administered to a patient in the form of an inert salt is:
- Barium sulfate
 - Iodine
 - Perforated ulcers or ruptured appendix
 - Air
191. The most effective method to prevent the spread of infection is:
- Use of gloves
 - Use of gowns
 - Time, distance, and shielding
 - Handwashing
192. If you suspect an object is contaminated, assume:
- That it is contaminated
 - That it should be used immediately
 - That it is not contaminated, so as not to waste supplies
 - That your hands must be sterilized

193. Factors that may cause the patient to react to a contrast agent simply as a result of anxiety are termed:
- Local irritation
 - Cardiovascular
 - Anaphylactic
 - Psychogenic
194. A reaction that may occur in the vein in which an injection occurred is:
- Local irritation
 - Cardiovascular
 - Anaphylactic
 - Phlebitis
195. This type of infection transmission occurs when an animal contains and transmits an infectious organism to humans:
- Contact transmission
 - Airborne transmission
 - Droplet transmission
 - Vectorborne transmission
196. This type of infection transmission occurs as a result of coughing or sneezing:
- Contact transmission
 - Airborne transmission
 - Droplet transmission
 - Common vehicle transmission
197. This type of infection transmission occurs when an infected person or contaminated object touches a host:
- Contact transmission
 - Airborne transmission
 - Droplet transmission
 - Common vehicle transmission
198. The complete removal of all organisms from equipment and the environment in which patient care is conducted is called:
- Medical asepsis
 - Surgical asepsis
 - Standard precautions
 - Gas sterilization
199. The word part that means “organ” is:
- Viscer
 - Megal
 - Trans
 - Emia
200. The word part that means “kidney” is:
- Viscer
 - Megal
 - Trans
 - Nephr

Scoring

Traditionally you have probably focused on how many questions you miss on a test. As you prepare for the certification exam, I encourage you to focus on how many you answer correctly. Use [Table 6-3](#) to calculate the percentage of questions you answered correctly in each category and on the test as a whole. Remember, a score of less than 75% on any topic or the entire test is an indication that more review is needed on that topic. Now go back and concentrate on which items were missed and the reason why. When you are done reviewing, go on to the tutorials and tests found on the Evolve web site.

TABLE 6-3 Calculating Your Score for Challenge Test Number 3

Topic	Percentage Calculation	Your Score
Safety	Number correct _____ $\times 100, \div 53 =$	
Image Production	Number correct _____ $\times 100, \div 50 =$	
Procedures	Number correct _____ $\times 100, \div 64 =$	
Patient Care	Number correct _____ $\times 100, \div 33 =$	
<i>Total</i>	Number correct _____ $\times 100, \div 200 =$	

PART II

Career Planning

7

Career Paths

Career Planning Inventory

Individuals pursue chosen careers for a variety of reasons. Their sources of motivation for enrolling in an educational program and satisfying all of the graduation requirements may include the need for a stable income, the desire to become established in a career, or an interest in expanding their horizons. Incentives for undertaking such a process are unique to each individual and may clearly distinguish a 45-year-old from an 18-year-old. Also, incentives can change as you move toward a goal, so the circumstances that led you to select this educational program may differ considerably from circumstances that influence you to establish a career in this field.

Whether you are reading this chapter as a new radiography student, during your final year, or in your final semester, it is a good idea to examine your motivation for seeking employment and establishing a career in radiologic technology. You should reexamine your motivation and adjust your goals regularly—perhaps annually. The following questions can help with that process and assist you in establishing career goals.

1. Based on my studies and clinical education so far, what aspects of this profession am I really excited about?
2. Which aspects of patient care have I found the most satisfying?

Rationale: Questions 1 and 2 attempt to help you focus on what has brought you true satisfaction so far in the educational program. Being excited about what you do is critical to your longevity in the field. It is a daily reinforcement to your motivation. It helps you bring a positive attitude to class and to the clinical environment. Many individuals find certain aspects of patient care particularly satisfying. Identifying yours can help you set goals for job placement or for continuing your education. For example, if you find great satisfaction working with children, pediatric radiography may be an excellent choice for a career. You could consider job possibilities at children's hospitals. Perhaps trauma radiography is particularly challenging and satisfying for you. Pursuing employment at an institution with a trauma center and a shift with a high level of trauma cases would be a wise choice. Maybe teaching and working with students appeals

to you. If so, your goals may include completing advanced academic degrees and finding a clinical job in a teaching institution.

Take time now to answer questions 1 and 2 in the space provided. Remember, you are examining situations you find motivating and exciting. You will have an opportunity to set your goals later in this chapter.

I am really excited about:

The aspects of patient care that have been most satisfying are:

3. Of the people with whom I have worked in clinical education, who has been most helpful?
4. Which characteristics do I want to emulate most?

Rationale: As a radiography student, you may be profoundly influenced by the personnel in the clinical department. It is important to identify people who have been particularly helpful to you as you have acquired your clinical skills. It is often tempting to think about, talk about, and remember only the people who have been hindrances to your education or who simply did not enjoy working with students. Concentrate instead on the positive people, and prepare a list of their names. Describe the personal and professional characteristics they possess. Explain why you enjoy working with them. Everyone benefits from role models. Describe why you wish to emulate, or pattern your professional attitudes and demeanor after, certain people with whom you have worked.

The most helpful individuals in clinical education have been:

They have been great to work with because:

I will emulate the following positive behaviors (also explain why):

5. When during the educational process have I been most satisfied?
6. When during the educational process have I been least satisfied?

Rationale: An awareness of events, people, or situations that have caused you to feel happy or unhappy can be helpful in setting goals for employment. It is impossible to be satisfied or happy on the job all of the time or to avoid all unpleasant situations; however, being aware of such times can help you decide where you may or may not wish to work. In addition, addressing these issues now can help you understand how you respond to positive and negative situations and how to alter your responses if necessary. You may also wish to consider ways to maintain a positive outlook when dealing with unpleasant situations or individuals by recalling successful, self-motivating strategies from the past. The mark of a true professional is the ability to summon the highest level of performance from yourself and the people around you even during difficult times.

I have been most satisfied during my education when:

I have been most dissatisfied during my education when:

7. What employment needs will I have after graduation?
8. What financial needs will I have after graduation?
9. What housing needs and living conditions will I seek after graduation?
10. Do I want or need to stay in this geographic area, or do I want or need to relocate?

Rationale: Individuals often do little or no planning for their employment, financial needs, or living conditions.

Consider what your needs will be for employment when you graduate. Decide whether you will need to begin work immediately and have to accept the first job offer you receive or whether you can wait a short time to scout the job market more thoroughly. It is crucial to have some idea of what your financial needs will be. Be aware of the cost of setting up your own living arrangements, paying back school loans, or providing for your family. If you are not currently responsible for your own housing, decide how it will be arranged.

With a fluctuating job market, you must consider whether you will remain rooted where you are or relocate to find the type of position you desire. Perhaps relocating is something you have wanted to do all along or maybe relocating is simply not possible at this point in your life.

Answer each question in the space that follows. Describe what your needs and wants will be after graduation.

Employment:

Financial:

Housing:

Location:

Use the financial planning worksheet shown in [Figure 7-1](#) to determine your actual salary needs. Be sure to base your compensation needs on your individual obligations, regardless of any domestic relationship that may include a combination of incomes.

11. Am I more excited about working with the high-touch (people-oriented) aspects of this profession or the high-tech (equipment) aspects of the field?

Rationale: Some individuals work in this field because they truly love working with people and assisting with the diagnosis of their conditions. Others prefer working with complex electronic and computerized equipment and would rather not be involved in direct patient care. There is room for both types of people in this profession and for people who truly enjoy blending high touch with high tech. Identifying the aspects of the field that excite you can help with your career planning.

Perhaps you wish to continue providing direct patient care. Maybe you would rather work in areas involving significant use of equipment, such as in quality control, medical physics, or the sale and service of equipment. You may also serve patients indirectly in a position such as PACS administrator. Nothing will cause you to become more dissatisfied with your career choice than working in an area of radiologic technology to which you are not suited. Develop awareness now of what you most enjoy doing. There is no right or wrong answer, and your choice does not make you “good” or “bad.” Most important, be honest with yourself. You will have much to contribute to this field if you work where you are happiest and most productive.

Take some time and write in the space that follows your honest preferences based on your experiences so far.

Annual Living Expenses

These are for the entire year; be sure to calculate annual figures.

Federal income tax (annual salary × %)	\$ _____
Social Security tax (annual salary × 7.65%)	_____
State income tax (annual salary × %)	_____
Medicare tax (annual salary × %)	_____
Savings	_____
Health insurance	_____
Rent or house payment	_____
Renter or homeowner insurance	_____
Child care	_____
College loan repayment	_____
Electricity	_____
Water	_____
Gas	_____
Cable/satellite services	_____
Cellular phone service	_____
Internet service provider	_____
Food (excluding eating out)	_____
Car payment	_____
Car insurance	_____
Car operation (gasoline, oil changes, etc.)	_____
Clothing	_____
Entertainment (night out, movie rentals, music, etc.)	_____
Gifts (for birthdays, holidays, weddings, anniversaries, etc.)	_____
Donations (place of worship, charities, etc.)	_____
Debt, credit card payments	_____
Other:	_____
Other:	_____
Total annual estimated living expenses =	\$ _____
I will need the following annual salary to meet these expenses:	\$ _____
I will need the following hourly salary to meet these expenses: (divide annual salary needed by 2080 hours to determine hourly salary needed)	\$ _____

This form is not meant to be a substitute for guidance provided by a financial counselor or tax advisor. Scholarships are not included in salary because they are one-time payments, not hourly salary. Taxes could be reduced with personal exemptions, deductions, credits, etc. Consider these factors when calculating actual tax liability.

• **Figure 7-1** Annual living expenses.

Remember, you are not setting a goal at this point, and your answer may change over time.

High tech versus high touch—my preference and why:

12. Do I enjoy learning all I can about this field, or do I want to learn only what I need to graduate?

Rationale: Your answer to this question is very important. The field you have chosen changes rapidly. You must be honest with yourself about your desire to study and learn. The equipment currently used in clinical education did not even exist a few years ago. You will use equipment a few years after you graduate that does not exist today. If you are content to learn only what you need to graduate, you will soon possess outdated skills. You should also consider whether you truly enjoy learning or tend to regard it as a burden. Your education in this field will have barely begun by the

time you graduate. Be aware you will need to set a course for lifelong learning. Understanding this reality now can assist you in developing your professional attitude and planning for continuing education. Realizing the importance of a commitment to learning may also serve to motivate you through the remainder of your educational program.

Take time to assess your motivation for learning. In the space that follows, describe your honest feelings and attitudes about the enjoyment of learning for its own sake as opposed to learning just enough to perform your job.

I want to learn all I can or just enough to get by. Here are my reasons and motivations:

13. Which aspect(s) of the specialty of radiography do I enjoy the most (e.g., general, fluoroscopy, mobile, surgical, trauma, pediatric)?

14. Have I particularly enjoyed any other radiologic specialties (e.g., angiography, mammography, CT, MRI, sonography, nuclear medicine, fusion imaging, radiation therapy, quality control)?

Rationale: You may not yet realize radiography is a specialty within which are areas of further specialization (e.g., general, fluoroscopy, mobile, informatics). You are probably already familiar with the other specialties listed in question 14. By being aware of what you enjoy, you will have little difficulty later setting goals for employment or education. If you have not yet had the opportunity to spend clinical time in some of the areas mentioned, you may need to postpone answering this question. However, when such an opportunity arises, prepare yourself for the clinical experience by reading about the specialty area in your textbook and taking careful notes about your experiences. This field has countless opportunities for you in the practice of radiography or any of the other special imaging or therapy modalities.

Use the space provided to list the areas in which you are particularly interested, and describe why you have enjoyed them. Also list the areas you look forward to exploring, and explain why they are important to you.

I particularly enjoy working in the following area(s):

I want to explore the following areas further:

15. Are there any special projects I have done that brought me satisfaction (e.g., research papers, exhibits, in-class presentations, participation in radiography scholar bowls)?
16. Am I interested in pursuing positions of leadership or membership in local, state, or national radiologic technology organizations?

Rationale: This profession needs you. It needs what you have to offer. It needs your fresh ideas and observations. It needs your leadership, motivation, talents, and abilities. By considering the issues mentioned in questions 15 and 16, you can set goals for your postgraduation involvement.

Perhaps you have already written a research paper, constructed an exhibit, or participated in a scholar bowl competition. Do not stop now. You have momentum working in your favor. Consider how these projects may have brought you satisfaction and served to motivate you further. Think about how you may set goals for doing additional projects or presentations as a radiographer for state or national presentations.

Local, state, and national professional organizations in radiologic technology need the involvement of motivated, committed professionals. Gauge your interest in becoming involved. Do not let fear of the unknown deter you. Remember, individuals who are currently active were at one time

attending their first meeting, serving on a committee for the first time, or holding their first office. Think about how such involvement may add to your career and personal satisfaction.

In the space provided, write your thoughts and feelings about pursuing these activities. Describe how you would feel if you became involved at this level of the profession.

The special projects that brought me the most satisfaction were:

I wish to become involved in the following organization(s) in this capacity:

17. Do I believe I will have an interest in working with students when I am employed?

Rationale: You will need to assess your interest in working with students. Many of us truly enjoy helping students acquire skills, whereas some would prefer to avoid educating others. If you believe you would enjoy teaching, seeking employment in an academic environment is a reasonable goal. If you would prefer not to work with students, it would be better for you and for the students if you seek employment in another setting. Many otherwise excellent radiographers find frustration on the job because they are not suited to the clinical teaching role. Do not take this issue lightly. Having a student assigned to you every day of work can be exhilarating or burdensome, depending on your professional preferences.

In the space provided, state whether you prefer to work with students or to find employment in a nonteaching institution.

I would or would not like to work with students after graduation. Here are my reasons:

18. In what type of clinical setting am I most comfortable (e.g., hospital, small clinic, physician's office, urgent care)?

Rationale: Health care assumes many forms, depending in part on the environment in which it is delivered. If you have had the opportunity to spend clinical time in more than one of the settings mentioned, decide which you enjoyed most. If you have not had this opportunity, check with your program director about the availability of clinical rotations. If none are available in the program, consider spending time outside of school in one or more of these clinical settings to get some idea of how they operate and to observe the radiographer at work.

Each clinical setting has qualities that may appeal to you as a radiographer and others that may make it a less attractive

choice. You may also be guided by a strong personal preference about where you would like to work. Consider these factors carefully when setting goals for employment.

I have had experience in the following clinical settings. Here is what I liked and disliked:

19. What particular talents do I possess about which I feel proud?

Rationale: Identify your talents and all you have to offer a potential employer. Consider how you may use these talents to pursue your personal and professional goals. Think of how your strengths may benefit the patients you serve. Understand the impact you may have on coworkers. It is important to be proud of your talents and use them. It is not conceited to list them. You must concentrate on being the best you can be by developing your abilities and acquiring others. Use them to enhance your practice of radiography and your personal life.

My particular talents and positive attributes follow. Here is how I have used them and why I am excited about them:

KEY POINTS

Career Planning Inventory

- Examine your motivation for seeking employment and establishing a career in radiologic technology.
- Adjust your goals regularly.
- Being passionate about what you do is key to your longevity in the field.
- Identify people who have been particularly helpful to you in clinical education.
- Concentrate on positive people who enjoy working with patients and students.
- A true professional has the ability to summon the highest level of performance even during difficult times.
- Consider what your needs will be for employment when you graduate.
- It is important to ascertain your financial needs.
- Determine whether you will remain where you are or if you wish to, or will need to, relocate.
- Balancing high tech with high touch is key to quality patient care. Knowing your preference leads to your success.
- A thorough understanding of options in radiologic technology can assist with career goals.
- This profession needs your fresh ideas, observations, leadership, motivation, talents, and abilities.
- Consider professional involvement such as presenting at conferences, writing a research paper, constructing a scientific exhibit, or holding office in a professional organization.

- Assess your interest in working with students and seek employment accordingly.
- Consider the numerous venues in which you may practice radiography, such as hospitals, clinics, physician offices, and prompt care sites.
- Identify the talents you have to offer a potential employer and how you may use these talents to pursue your personal and professional goals.
- Examine how your strengths may benefit the patients you serve and how they may have a positive impact on your coworkers.

Goal Setting

By carefully answering the previous questions, you should develop a good idea of the things that motivate you in this field. The choice of a career is important, and you should be intent on doing the things you particularly enjoy.

Individuals who have been successful in the field of radiologic technology have set goals for themselves and worked hard to achieve them. Goal setting is not an easy task, particularly because it is seldom taught in school. However, all of the great motivational speakers and career planners indicate that goal setting should be a priority, not only when beginning a career, but throughout your working lifetime.

Goals are not meant to be etched in granite and never changed or updated. Goal statements should be flexible and fluid. They should be realistic, measurable, and achievable. If you are the type of person who needs to see immediate or short-term progress, break down your goals into smaller events. Approach these goals incrementally and celebrate each achievement. As mentioned previously, goals should be updated as needed and at least annually.

The wording of goal statements can be as important as setting the goals themselves. Statements such as “I want to be a nuclear medicine technologist within 3 years” are not powerful enough. “I will be a registered nuclear medicine technologist by the end of (specify year)” is more specific. It is action oriented. It says you will do something, and you will direct your energies toward achieving that goal within a specific time frame. It is more than a wish; it is a statement of a goal that you expect to realize.

Post your goals where you can see them daily, and share them with the people who are significant in your life. Encouragement and moral support of loved ones can help you achieve your goals. Shared goals are more likely to be met because of the increased sense of accountability to others who are aware of them.

The following is a series of questions to consider as you write your goal statements. Sample goal statements are provided. Note that they are specific, have time frames, and use the words “I will.” You may be thinking that you lack some of the information needed to write your goal statements. However, recognize that by writing goals and planning your future, you are in the process of making that future a reality. This helps you direct your energies toward pursuing and accomplishing your goals.

Setting goals should not be taken lightly, but it should not be so arduous a task that it becomes a burden. Be excited about setting your goals and beginning to map out your future. Do not get discouraged if your goals seem simple at first. They are there to provide you with direction. It will be up to you to adjust them and to direct the course you plan to follow.

1. What deadline have I set for completion of my goal statements?

GOAL: I will list my goals along with a timetable by the following date:

2. What kind of review schedule have I established to prepare for the radiography certification exam?

GOAL: I will review the subjects included on the exam according to the following schedule:

Patient Care:

Safety:

Image Production:

Procedures:

3. Do I want to pursue additional education in radiologic technology or seek an advanced degree?

GOAL: I will visit college or university websites to examine baccalaureate degree options by the following date:

GOAL: I will take _____ number of credit hours per semester beginning on _____ so that I will complete my degree on _____.

GOAL: I will visit websites regarding educational programs in _____ (e.g., sonography, nuclear medicine, radiation therapy, CT, MRI) by _____.

GOAL: I will attend an educational program in _____ (e.g., sonography, nuclear medicine, radiation therapy, CT, MRI) beginning _____ and will graduate from the program in _____.

4. Do my regular study habits need to be examined and fine-tuned?

GOAL: I will examine my current study habits on _____.

GOAL: I am modifying my current study habits as follows:

GOAL: I will begin my new study habits on _____.

5. Do I need to examine my lifestyle choices regarding diet, exercise, and sleep requirements?

GOAL: I will evaluate my lifestyle choices in diet, exercise, sleep, and recreation on _____.

GOAL: I am modifying my diet as follows (be specific):

GOAL: I am modifying my exercise routine as follows (be specific):

GOAL: I am modifying my sleep routine as follows:

GOAL: I am taking time for recreation as follows:

6. Have I taken into account the needs of my family or significant others?

GOAL: I will consult with my significant others regarding these goals on _____.

GOAL: I will list here the needs of my significant other(s) in view of the goals I have set:

7. What do I want to accomplish in the next 30, 60, and 90 days related to my career?

GOAL: By 30 days from now, on _____, I will have accomplished the following to advance my career goals:

GOAL: By 60 days from now, on _____, I will have accomplished the following to advance my career goals (built on my 30-day objectives):

GOAL: By 90 days from now, on _____, I will have accomplished the following to advance my career goals (built on my 30-day and 60-day objectives):

8. To reinforce my positive attitude, I will need to obtain access to motivational materials.

GOAL: By _____, I will read the following motivational books:

9. I must consider postgraduation needs.

GOAL: I will begin work by _____.

GOAL: I will make the following hourly salary to maintain the lifestyle I have chosen:

GOAL: I will live in the following type of housing:

GOAL: I will live in the following city or geographic area:

10. What are my preferences regarding high-tech versus high-touch aspects of radiography?

GOAL: I will work in the following direct patient care area of medical radiography:

GOAL: I will work in the following patient care support area:

11. I need to consider continuing education in radiography.

GOAL: I will follow this schedule for remaining current in my chosen field:

Type of meetings or conferences I will attend regularly:

Local:

State:

National:

12. What other radiologic specialties should I explore?

GOAL: I will do extra reading and clinical observation in the following radiologic technology specialties (e.g., angiography, mammography, CT, MRI, sonography, nuclear medicine, radiation therapy, quality control) by the dates I have listed:

13. I will pursue special projects after graduation.

GOAL: I will write a research paper and submit it for competition at the state or national level on _____. The possible subjects for this paper are:

GOAL: I will prepare a scientific exhibit for presentation at a state or national meeting on _____. The possible subjects for this exhibit are:

GOAL: I will assist with planning the following local or state meeting: _____ on _____.

GOAL: I will run for the office of my local, state, or national professional organization on _____.

14. What is my attitude toward working with students?

GOAL: I will work in a department that (is/is not) in a teaching institution.

15. I will explore different work settings.

GOAL: I will work in the following type of institution: hospital, clinic, imaging center, physician's office, urgent care.

16. What professional attributes do I consider important?

GOAL: I will work to maintain the attributes that I admire most in the professionals who have helped me in my clinical education. Those attributes are:

17. What other goals will I set for myself?

GOAL:

GOAL:

GOAL:

GOAL:

By now you have had considerable experience in describing the aspects of this field that you find motivating. You have also listed specific career goals that you have the ability to

KEY POINTS

Goal Setting

- A career choice is significant; focus on doing the things you particularly enjoy.
- Success in radiologic technology is based on setting goals and working hard to achieve them.
- Goal setting must be a priority throughout your working lifetime.
- Goals are not meant to be rigid and inflexible but alive and fluid.
- Goals should be realistic, measurable, and achievable.
- Approach goals incrementally; celebrate each achievement.
- Goals should be updated as needed and examined at least annually.
- Make goal statements specific and action oriented.
- Direct your energy toward achieving your goal within a specific time frame.
- Goals must be more than wishes; they must be a visualization of what you expect to achieve.
- Post your goals where you can see them daily, and share them with the people who are significant in your life.
- Shared goals are more likely to be met.
- Goal statements use the words “I will.”
- Setting goals should not be taken lightly, but it should not be a difficult task.

achieve. Performing this type of personal inventory has gotten you off to a great start. In addition to reading your goal statements daily, reexamine these goals at regular intervals over the coming months. There will be no stopping you now!

Continuing Education Requirements

The quality of a person's life is in direct proportion to their commitment to excellence regardless of their chosen field of endeavor.

VINCE LOMBARDI

Meeting Professional and Governmental Requirements

The purpose of certification is to assure the public that you are competent to practice in your chosen field. However, passing a certification exam to enter the profession is no assurance that you will remain competent. It is of critical importance that you have the most current knowledge and skills needed to practice radiologic technology.

Mandatory continuing education has been established in an attempt to ensure the continued competence of clinicians. Although research indicates that mandatory continuing education in any field of study is not a guarantee of competence, it is the route that has been chosen for many health professions, including radiologic technology, to maintain credibility with the public.

After you successfully pass the certification exam and receive your initial registration, the American Registry of Radiologic Technologists (ARRT) requires documentation of continuing education for you to renew your registration. Participating in continuing education and documenting your participation are your responsibility as a registered technologist. Although acquiring continuing education credits is not difficult for most technologists, knowledge of the applicable rules and regulations is of paramount importance.

In addition to certification, many states require individuals practicing medical radiography to hold licensure or accreditation issued by the state. Because legislation regulating state licensure may be subject to the addition or revision of statutes at any time, the requirements specific to each state are not listed here. Many states accept ARRT certification as proof of the applicant's competency. In those states, you need to apply to the appropriate agency, supply a copy of your ARRT credentials, and pay the proper fee. Be sure to obtain the rules and regulations pertaining to licensure in the state or states in which you will be employed. Such rules advise you of the application process, any testing or fees involved, continuing education requirements, and the status of any reciprocity with the ARRT. Visit the ARRT website at <http://www.arrt.org> to obtain a complete list of state agencies responsible for credentialing and requirements.

Because state and national continuing education requirements may differ, it is the responsibility of the individual technologist to keep abreast of the current requirements for continuing education. Neither state nor national agencies accept a lack of knowledge of the rules and regulations as an

excuse for failure to meet the requirements. An insufficient number of continuing education credits may result in the issuance of probationary status, the levy of fines by the state, or loss of the ability to work.

You need to renew your certification with the ARRT each year, and you will need to submit proof of continuing education activities every 2 years (known as a biennium). This may be accomplished by documenting 24 hours of continuing education for that biennium. These hours must be continuing education activities that have met the criteria established by the ARRT and may include educational activities you completed in order to qualify to take another ARRT-approved exam in an area of radiologic technology in which you were not previously credentialed. Consult with ARRT to verify such activities will be accepted. Beginning January 1, 2018, merely passing the additional exam does not count toward CE requirements.

You must comply with the ARRT rules governing continuing education beginning with the first day of your birth month after you pass the radiography exam. Your subsequent bienniums then occur in your birth month. State continuing education requirements may differ on their due dates. Be sure to keep the two sets of requirements clear. You should choose continuing education activities based on the area of practice that would meet your needs and the needs of your patients. Remember, this is *your* practice of radiography. What activities would help you be a better caregiver and imaging technologist?

States may differ on the type of activities that satisfy their continuing education requirements. Know the law in your state, and keep files on both state and ARRT requirements, as applicable.

As a registered technologist, it is your responsibility to know whether the continuing education program you are attending has been approved and to obtain the necessary documentation proving your participation in the activity. As an attendee, you are not responsible for submitting a program for approval to obtain credit. The sponsor of the event seeks approval before the date of the presentation. The coordinator of a continuing education program can answer questions concerning the approval of the event.

At the end of each biennium, you must provide proof that you have satisfied the continuing education requirement. Keep the original attendance documents for at least 1 year beyond the 2-year period. The ARRT may conduct random audits to verify such documentation. The documentation must show the date of the program; title and content; number of contact hours; and signature of an individual associated with the program, such as the speaker, instructor, or coordinator. The documentation should also include a continuing education reference number provided by the Recognized Continuing Education Evaluation Mechanism (RCEEM). It is a good idea to set up your own file for continuing education for both the ARRT and the state requirements before you graduate so that it will be in place and ready for immediate use as soon as you are

registered. Be certain to keep copies of all documents for audit purposes.

Technologists who fail to meet the ARRT continuing education requirements are placed on probationary status by the ARRT. This means the technologist must make up continuing education credits by a specific date and keep up with credits in the current biennium. Failure to satisfy probationary requirements can lead to further sanctions up to and including a requirement for re-examination. Inquiries submitted to ARRT by employers receive a response that includes a notation of probationary status or revocation; this could result in your rejection as a job applicant or loss of employment.

Penalties regarding noncompliance with state continuing education requirements vary by state. Be sure to visit <http://www.arrt.org> often and read all of the information sent to you from the ARRT, particularly the “Stories of Quality Patient Care—Annual Conversation with Registered Technologists.”

It is your responsibility to learn about modifications to the continuing education requirements. Be sure to read all of the information sent to you from the ARRT. You should also remain alert for changes to such requirements in your state.

Take time to review the ARRT’s “Continuing Education Requirements” at <http://www.arrt.org>. This is your best source for complete up-to-date information on continuing education requirements along with frequently asked questions (FAQs). Your instructors can assist you with questions, or you may contact the ARRT office by telephone at 651-687-0048.

Continuing Education Opportunities

There are many opportunities to obtain continuing education credits. The primary mission of your professional societies is continuing education. Become an active member of the American Society of Radiologic Technologists (ASRT). Through its sponsorship of conference events, numerous online programs, and its Directed Readings in the journal *Radiologic Technology*, you can obtain a considerable portion of your continuing education credits. The ASRT may be visited at <http://www.asrt.org>.

The various state affiliate societies of the ASRT provide many continuing education opportunities every year. Ask your instructors or radiologic technologists in clinical settings for membership information. As part of the state society, your local professional society may have monthly or quarterly meetings that stress continuing education. Take advantage of these meetings.

If you choose a career in any of the radiologic specialties, education, or management, there are many other professional organizations you may join. Each organization offers approved continuing education as part of its mission. Being an active member of a professional society helps ensure that you are informed about the continuing education programs that will contribute most to your skill development.

Continuing education is a vital part of your medical radiography practice. View it as an opportunity to learn and

enhance your skills rather than as an imposed obligation. Attend programs that you know will help you become a better technologist. Take an active part in these events, both as an attendee and as a coordinator. Conduct your own presentation for a more complete learning experience. You will find that such activities enhance your professional image and gain you the respect and admiration of your colleagues. Stay in regular contact via <http://www.arrt.org> and <http://www.asrt.org>.

Continuing Qualification Requirements (CQR)

Continuing Qualification Requirements (CQR) are required every 10 years for registered technologists in addition to the continuing education requirement. Documenting continued qualifications through the use of time-limited certificates is the next logical step beyond testing and certification (entry-level knowledge), registration (annual renewal and compliance with ethical requirements), and continuing education (biennially). Beginning approximately 7 years into the 10-year period from the original date of certification, technologists will have to demonstrate, choosing from a choice of ARRT-approved activities, that they have kept up with changes in their specific field and the core knowledge required to practice.

Requirements may include compiling a professional profile, conducting a self-assessment and completing targeted learning activities. These requirements are congruent with the mission of the ARRT regarding high patient care standards. Note that retaking the entry-level certification exam will NOT be a requirement.

Regulatory agencies are placing more emphasis on accountability for individuals practicing in the health care professions. CQR is an integral part of your practice. Be certain to remain current on the requirements by visiting <http://www.arrt.org> often.

KEY POINTS

Continuing Education

- Quality patient care dictates that you have the most current knowledge and skills needed to practice radiologic technology.
- Mandatory continuing education was established to ensure the continued competence of clinicians.
- States may have their own continuing education requirements.
- ARRT requires proof of 24 hours of continuing education activities every 2 years (known as a biennium).
- The continuing education requirement may be accomplished by documenting 24 hours of continuing education activities that have met the criteria established by the ARRT.
- Keep continuing education documents for at least 1 year beyond the biennium for possible ARRT audit.

- Consult “Continuing Education (CE) Requirements” at <http://www.arrt.org>.
- Continuing education opportunities include ASRT (sponsored programs and Directed Readings), state and local radiologic technology conferences, and employer-sponsored approved activities.
- CQR provides the opportunity to document up-to-date skills and knowledge.

Radiologic Specialties

No one can predict to what height you can soar. Even you will not know until you spread your wings.

As demand increases for radiologic technologists with multispecialty capabilities, many radiography students, graduates, and practicing technologists are considering furthering their education in imaging, therapy, education, or management. Other radiologic clinical specialties include: diagnostic medical sonography, nuclear medicine technology, radiation therapy, CT, angiography, MRI, quality management, interventional technology, mammography, and bone densitometry. Credentialing in these fields is evolving rapidly, with additional educational requirements and clinical requirements being established. Numerous education programs are offered in those areas, and an online search of such opportunities is recommended.

Information concerning advanced level, or post primary, exams in these areas is available from the ARRT. The requirements for all specialty areas could change at any time; the appropriate credentialing agencies listed in this chapter should be contacted when the technologist is pursuing a specialty.

Information about the specialties presented in this chapter provides you with access to the website of the professional organization associated with each specialty. The websites give you access to the most current and accurate listings of all educational programs in the United States accredited by that organization and the certification requirements. Because certification requirements and educational programs are subject to change for various reasons, the interested professional should use the websites for such information.

For each exam and specialty listed in this chapter, it is important to contact the certifying organization(s) for details regarding specific clinical requirements that may have to be documented as part of the application process. This chapter is meant to be informational only and does not attempt to take the place of the formal and comprehensive handbooks published by the respective organizations.

Diagnostic Medical Sonography

Educational programs in sonography may be 1½, 2, or 4 years in length, depending on the curriculum offered and

the inclusion of earned credit hours for an academic degree. The course of study involves biology, sectional anatomy, patient care, physics and equipment of sonography, diagnostic procedures, imaging, and image evaluation. Clinical education also constitutes a major portion of the program. Use of the following websites will ensure that you obtain the most accurate, current information available.

For information on a career as a diagnostic medical sonographer, contact the following organization:

Society of Diagnostic Medical Sonography
Plano, TX

<http://www.sdms.org>

For a listing of accredited educational programs in sonography, contact:

The Committee on Accreditation of Allied Health Education Programs

<http://www.caahep.org>

For information on certification exams in sonography, contact either:

American Registry of Diagnostic Medical Sonographers
Rockville, MD

<http://www.ardms.org>

Exams offered for sonographers:

- Abdomen
- Adult echocardiography
- Breast
- Fetal echocardiography
- Musculoskeletal sonography
- Obstetrics and gynecology
- Pediatric echocardiography
- Pediatric sonography
- Sonography principles and instrumentation
- Vascular technology

or

American Registry of Radiologic Technologists
St. Paul, MN

<http://www.arrrt.org>

Exams offered for sonographers:

- Sonography (primary and post primary exam)
- Vascular sonography (post primary exam)
- Breast sonography (post primary exam)

Nuclear Medicine

Educational programs in nuclear medicine technology may be 1, 2, or 4 years in length, depending on the curriculum offered and the inclusion of earned credit hours for an academic degree. The course of study involves biology, anatomy, patient care, nuclear physics and instrumentation, computer technology, biochemistry, radiopharmacology, radiation biology and health physics, radiation protection, immunology, radionuclide therapy, and statistics. Diagnostic procedures, imaging, and image evaluation, including extensive clinical education, also constitute a major portion of the program. Use of the following websites will ensure that you obtain the most accurate, current information available.

For information on a career as a nuclear medicine technologist, contact the following organizations:

American Society of Radiologic Technologists
Albuquerque, NM

<http://www.asrt.org>

Society of Nuclear Medicine and Molecular Imaging
Reston, VA

<http://www.snmmi.org>

For a listing of accredited educational programs in nuclear medicine technology, contact:

Joint Review Committee on Education in Radiologic Technology

Chicago, IL

<http://www.jrcert.org>

For information on certification exams in nuclear medicine technology, contact either:

American Registry of Radiologic Technologists
St. Paul, MN

<http://www.arrrt.org>

Nuclear medicine exam offered:

Nuclear medicine

or

Nuclear Medicine Technology Certification Board
Tucker, GA

<http://www.nmtcb.org>

Nuclear medicine exams offered:

- Nuclear medicine
- Nuclear cardiology
- Positron emission tomography (PET)
- Nuclear medicine advanced associate

Radiation Therapy Technology

Educational programs in radiation therapy technology may be 1, 2, or 4 years in length depending on the curriculum offered and the inclusion of earned credit hours for an academic degree. The course of study involves biology, radiation oncology, pathology, radiation biology, physics and equipment of radiation therapy, intensity modulated radiation therapy, dosimetry, computer technology, and quality assurance. Use of the following websites will ensure that you obtain the most accurate, current information available.

For information on a career as a radiation therapist, contact the following organization:

American Society of Radiologic Technologists
Albuquerque, NM

www.asrt.org

For a listing of accredited educational programs in radiation therapy technology, contact:

Joint Review Committee on Education in Radiologic Technology

Chicago, IL

www.jrcert.org

For information on the certification exam in radiation therapy technology, contact:

American Registry of Radiologic Technologists

St. Paul, MN
<http://www.arrt.org>
 Radiation therapy exam offered:
 Radiation therapy

Other Imaging Specialties

Education in other imaging specialties may be provided on the job or in courses that are one semester or one academic year in length depending on the curriculum offered, the current credentials of the radiologic technologist, and the inclusion of earned credit hours for an academic degree. The course of study should provide educational opportunities specific to the imaging modality, including pathology, radiation biology, anatomy, patient care, physics and instrumentation, computer technology, radiation protection, diagnostic procedures, imaging, image evaluation, quality assurance, and clinical education. The imaging specialties that might be included are:

- Angiography (all types)
- Bone densitometry
- CT
- MRI
- Mammography
- Quality management

Use of the following websites will ensure that you obtain the most accurate, current information available.

For information on a career in these specialty areas, contact:

American Society of Radiologic Technologists
 Albuquerque, NM
<http://www.asrt.org> (search by topic)

Alternatively, use any comprehensive Internet search engine, such as Google (search by topic).

For a listing of educational programs for these imaging specialties, use any comprehensive Internet search engine, such as Google (search by topic).

For information on certification exams in these specialties, contact:

American Registry of Radiologic Technologists
 St. Paul, MN
<http://www.arrt.org>

Post primary exams offered other than sonography:

- CT
- MRI (also a primary exam)
- Cardiac interventional radiography
- Vascular interventional radiography
- Mammography
- Quality management
- Bone densitometry

Radiologist Assistant

As structured by the ASRT, a radiologist assistant is “an advanced-level radiologic technologist who works under the supervision of a radiologist to enhance patient care by assisting the radiologist in the diagnostic imaging

environment.”* Radiologist assistants are ARRT-certified radiographers who have “successfully completed an advanced academic program encompassing a nationally recognized radiologist assistant curriculum and a radiologist directed clinical preceptorship.”* Working under the supervision of a radiologist, “the Radiologist Assistant performs patient assessment, patient management and selected exams.”*

Education of radiologist assistants is based at the baccalaureate and postbaccalaureate levels. The ASRT has written a core curriculum for a bachelor of science in radiologic sciences (B.S.R.S.) degree. The ASRT states that the radiologist assistant has the following areas of responsibility:

1. Participate in patient assessment, patient management, and patient education
2. Perform selected radiology procedures including, but not limited to, fluoroscopy
3. Evaluate image quality and perform initial image observations*

For information on a career as a radiologist assistant, contact either:

American Society of Radiologic Technologists
 Albuquerque, NM
<http://www.asrt.org>

American College of Radiology
<http://www.acr.org>

For a listing of educational programs for radiologist assistants, contact:

American Society of Radiologic Technologists
 Albuquerque, NM
<http://www.asrt.org>

For information on the certification exam for radiologist assistant, contact:

American Registry of Radiologic Technologists
 St. Paul, MN
<http://www.arrt.org>

Radiography Educator

One of the fastest growing specialties in radiologic technology over the next 10 to 15 years will be in the area of radiography education. There are currently nearly 800 radiography programs in the United States. They are staffed, depending on size and enrollment, with directors, clinical coordinators, instructors, and laboratory assistants. Similar to a large percentage of the population as a whole, radiography educators are nearing retirement in unprecedented numbers. For registered technologists who enjoy working with students and teaching, countless opportunities for career advancement and great satisfaction will be available. The profession will need a steady supply of educators to keep its programs functioning and to graduate the numbers of radiographers who will be needed in the coming decades. The need for educators in

* American Society of Radiologic Technologists, <http://www.asrt.org>

all of the medical imaging and therapy professions will be great. Radiography education is highlighted here because the need will be greatest in that field.

If you are interested in a career specialty in radiography education, prepare by earning degrees as follows, in addition to R.T.(R) credentials:

- Program director: Master's degree (consider radiologic technology, education, adult education, curriculum design)
- Clinical coordinator: Baccalaureate degree or master's degree (consider radiologic technology, education, adult education, curriculum design)
- Instructor or laboratory assistant: Baccalaureate degree (for full-time instructors), with strong clinical experience, a great interest in teaching, and proven expertise in radiography

For information on requirements for becoming a radiography program official or instructor, contact the following organization:

Joint Review Committee on Education in Radiologic Technology
Chicago, IL

<http://www.jrcert.org>

For information specific to radiography educators, contact the following organizations:

Association of Collegiate Educators in Radiologic Technology (ACERT)

<http://www.acert.org>

Association of Educators in Imaging and Radiologic Sciences (AEIRS)

<http://www.aeirs.org>

Imaging Manager

In many clinical environments, individuals advance into management, shift supervisor, or radiology administrative positions by promotion. In such situations, promotion occurs because an individual has proved to be exemplary in some field of clinical work. If you are planning a career in radiology management, seriously consider college degrees that provide you with the managerial and legal foundation to be effective in management. Managing the human and physical resources in an imaging or therapy department requires mastery of an entirely different set of skills. Consider a master's degree in radiologic technology, management, communication, human resources, or business administration.

For information on degrees in these areas, use any comprehensive Internet search engine, such as Google (search by degree).

For information on a career as an imaging manager and for the exam for a certified radiology administrator, contact:

AHRA: The Association for Medical Imaging Management.
Sudbury, MA

<http://www.ahraonline.org>

Academic Degrees

You cannot discover new oceans unless you have the courage to lose sight of the shore.

An increasing number of radiography students and technologists are interested in pursuing higher level academic degrees. This is particularly true for individuals seeking a career in radiology management or education. Master's degrees are required of radiography program directors. Baccalaureate degrees are required of clinical coordinators and full-time instructors. Others would like to pursue degrees because they enjoy learning or would find the achievement fulfilling. Some hope to expand their earning potential or raise the level of their professional status. The baccalaureate degree is considered the professional level for radiologic technologists.

The U.S. Departments of Education and Labor possess ample data to support the contention that earnings and employment opportunities are greater for individuals who have higher levels of education. Regardless of the motivation, career planning and goal setting must be based on accurate information.

Individuals interested in pursuing advanced degrees should visit the institution's website and request the latest edition of the college or university catalog to determine what curriculum is offered. Information available on the Internet also provides listings of degree programs as they become available.

As with many other health professions, an advanced degree in radiologic technology is not required for career advancement. However, baccalaureate and master's degrees in business, management, and education have become increasingly important. You should carefully define your career goals and pursue advanced education opportunities that are specific enough to provide skills in certain areas but broad enough to allow for flexibility. Advancing to higher levels of responsibility in radiologic technology no longer depends entirely on moving up through the ranks; a solid college education is required.

If an advanced degree is among your career goals, begin planning now. Requests for information take time. The use of websites greatly expedites the process. The sooner you acquire the needed information, the sooner you will be able to establish your plans for further education and achieve your desired goals.

Consider interviewing radiologic technologists at your clinical sites who are currently enrolled in degree completion programs. They can provide helpful information about the college or university in which they are enrolled.

For specific college and university information, visit the institution's website or use major search engines, such as Google, typing in keywords such as "radiologic technology," "radiography," and "radiologic technology degree."

As you begin planning for an advanced degree, keep in mind you will already have at least an associate's degree by the time you graduate from your radiography program. This places you nearly halfway to a 4-year degree. Your program director may have advice about writing a portfolio of education, clinical, and work experiences to help you receive additional college credit for what you already know and have accomplished.

The work environment of the twenty-first century requires that you have as much knowledge and as many credentials as possible to advance in your career. Now is a good time to begin planning and setting goals for a lifetime of learning and achievement!

KEY POINTS

Radiologic Specialties and Academic Degrees

- Demand is increasing for radiologic technologists who have multispecialty capabilities.
- Specialties include: diagnostic medical sonography, nuclear medicine technology, radiation therapy technology, CT, angiography, MRI, quality management, interventional technology, mammography, and bone densitometry.
- Formal classes in person or online should be attended whenever possible.
- Information concerning advanced level, or post primary, exams is available from the ARRT.
- Visit the website of the professional organization associated with each specialty for specific educational, clinical, and credentialing requirements.
- Other specialties to be considered include radiography educator and imaging department administrator or manager.
- Academic degrees enhance career opportunities in every aspect of radiologic technology.

8

Writing a Professional Resume

Purpose of a Resume

Your resume serves as your professional calling card. Its purpose is to obtain an interview. It is a summary of your academic and work history and relevant accomplishments and credentials. It should be brief (i.e., one to two pages). It is essentially a snapshot of your career to date. In addition to offering samples of resumes, this chapter describes ways to use the resume and provides the rationale for including or excluding certain information.

There are probably as many different styles and formats for resumes as there are instructors attempting to describe them. Take advantage of your radiography instructor's expertise in this area. In addition, local colleges may have a learning resource center, a writing center, or a career counseling center from which you can obtain additional guidance. There are many books available on the subject of writing resumes. In addition, numerous software packages provide guidance on writing resumes. With all of these resources to choose from, writing a resume can become a dizzying experience. The material presented in this chapter was developed for my courses and has been used by students and graduates.

The resume may be used in three ways. Most commonly, it will be (1) electronically attached to the online job application form submitted to the human resources department. It may also be (2) sent as part of a mailing or an emailing to prospective employers and followed with a telephone call or (3) left with an interviewer after an appointment.

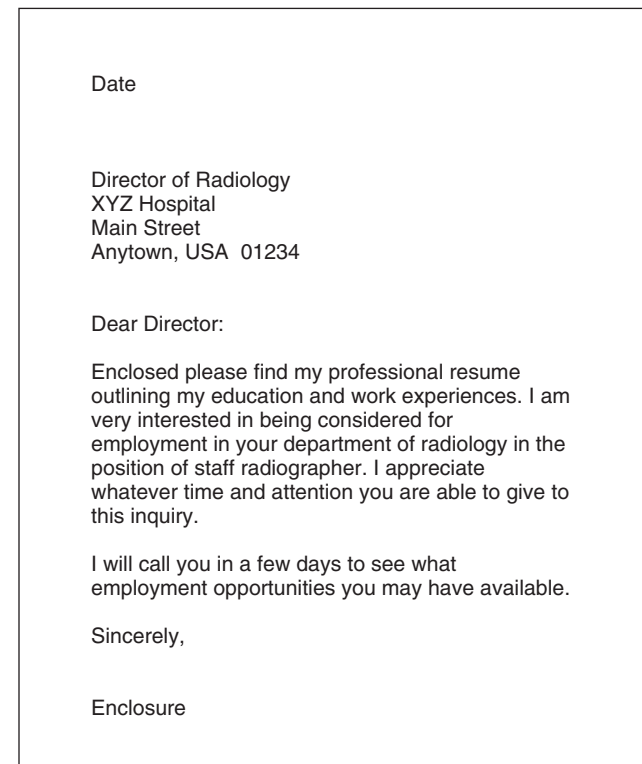
Often the student or graduate radiographer wishes to indicate availability to numerous prospective employers in a certain geographic area. The resume, accompanied by a cover letter, may be mailed or emailed to the directors of radiology at all facilities in the area where the student is interested in working. Although this is the least effective method to use in a job search, a well-constructed resume with an appropriate cover letter can produce results. [Figure 8-1](#) shows a sample cover letter to accompany the resume in these situations. Such a mailing should always be followed by a personal telephone call to the radiology manager, as promised in the cover letter. Following up in

this way can be time-consuming, but it is one method for reaching a large number of prospective employers.

In certain situations, the student or graduate radiographer may have an interview with a radiology manager who has not yet seen his or her resume. For this reason, it is always a good idea to take a printed copy of the resume and give it to the radiology manager at the interview. Similar to appropriate attire and grooming, a professional resume can make a powerful first impression during an interview.

Contents of a Resume

In addition to ensuring that you have the appropriate writing tools available, you should spend time thinking



• **Figure 8-1** Sample cover letter, general mailing.

about what to include in the resume and what to exclude. Include all postsecondary (i.e., after high school) education. You should account for all of your time since high school. Include all professional society memberships, ARRT credential or state licensure numbers, awards, and accomplishments on the resume.

The resume should contain only information that is relevant to your accomplishments and goals as a professional. Information of a personal nature (beyond that presented in the next section) or data that could be used to discriminate should be excluded from the resume. Your resume is an opportunity to advertise yourself in your absence. Construct it wisely.

Writing the Resume

Figures 8-2, 8-3, and 8-4 show three resumes. Figure 8-2 could have been written by a student in the final year or semester of the radiography program. Figure 8-3 is a sample of a resume of a recent graduate. Figure 8-4 is similar, but goes into greater detail concerning the clinical experiences gained while being a student. With the increasing competitive nature of the radiography job market, this style of resume can be used to highlight specific clinical experiences that may set you apart from other applicants. Seriously consider its use. These resumes present applicants with slightly different backgrounds and so include different information. Your resume is likely to be a variant of these. Remember, brevity is the rule when constructing your resume. However, do not use abbreviations. Keep your resume polished and proper.

Personal Data

The first section should include your name, followed by the address and telephone number (and email address; this is optional) at which you may be reached during your current job search. If your address and telephone number change during the course of your job search, a prospective employer would be unable to contact you, possibly eliminating you as a candidate for the position. If you must change your address and telephone number after submitting the resume, inform prospective employers in writing.

No additional personal information should be included on the resume. Specific items to be excluded are date of birth, gender, race, marital status, religious affiliation, number of children, disabilities, hobbies, and any other data that are irrelevant to your status as a job seeker. Although a prospective employer may not use such information, including it on your resume brings it to the forefront.

Goal Statement

As shown in the examples, the next section of the resume should include your goal statement. The goal statement can be as simple as “To obtain a position as an entry-level radiographer,” or it may include your desire to cross-train

in another specialty, such as “To obtain a position as an entry-level radiographer; desire to cross-train in computed tomography.” Careful consideration should be given to the goal statement. If the wording suggests that you absolutely must have the opportunity to cross-train in other modalities, you would be eliminated from consideration if the prospective employer is looking for a staff radiographer only. Wording such as “To obtain a position as an entry-level radiographer; willing to be cross-trained in other modalities” indicates your desire to expand your horizons but without the sense of urgency conveyed by the previous statement.

The goal statement may also be altered depending on where you are seeking employment. If you know the prospective employer is seeking radiographers who definitely want to cross-train, that interest should be included in your goal statement. In addition, if one of your goals is to cross-train and you are unwilling to accept a position that does not offer that opportunity, you should include it in your goal statement, realizing that you may be excluded from consideration if such a position is unavailable. Words in the goal statement that identify the strength of your interest are “desire to cross-train” or “willing to cross-train.”

As you prepare to write your resume and begin setting your professional goals, give them serious consideration. The goal statement may include you in the final group of candidates for a position, or it may exclude you immediately, depending on how it is worded. As a final example, consider the goal statement of an applicant to a clinic or urgent care setting. The responsibilities in these positions often are multifaceted. A goal statement such as “To obtain a position as a radiographer; willing to perform venipuncture, simple laboratory procedures, and electrocardiograms, and take patient histories and vital signs” indicates not only a willingness to learn new procedures but also an ability to be flexible and work as a team member in a small clinic setting. Conversely, if you have no desire to perform these other functions, you should not include such places in your job search.

Employment Experiences

Beginning with your most recent employment and working backward, you should list all employment experiences related either to health care or to working with the public. Indicate the month and year that each position began and ended, the name of the employer, the location of the employer, and a simple phrase describing your responsibilities. It is unnecessary to list the names of supervisors or the salary you received. It is also unnecessary to account for every job held since high school. The resume is your statement of professional experience. Include the positions that demonstrate your ability to work with people and willingness to take on responsibility. Try to avoid lapses in dates whenever possible. Your work experience and education should blend into a seamless timeline.

Personal Data

Name
 Address
 City, State, Zip Code
 Telephone Number
 Email Address

Goal

To obtain a position as an entry-level radiographer; willing to cross-train in computed tomography.

Employment Experience

September 20__-Present

Front Office Clerk
 Medical Imaging Department
 City Medical Center
 This Town, State
 Duties: Greet patients arriving for radiographic exams; update electronic medical record

November 20__-August 20__

Certified Nursing Assistant
 Extended Care Unit
 County Rehabilitation Center
 Our Town, State
 Duties: Provided care to patients such as bathing, grooming, basic exercise, and assistance with meals

Education

June 20__-Present

Radiography Program Name
 Our Community College (or) Our Hospital
 This City, State
 Graduation scheduled for May 20__

Fall 20__-Spring 20__

Radiography program prerequisites
 Our Community College
 This Town, State
 Earned 48 semester hours in liberal arts and sciences

Professional Accomplishments, Associations, and Credentials

- Taking American Registry of Radiologic Technologists radiography exam, May 20__
- Student member, American Society of Radiologic Technologists
- Student member, This State Society of Radiologic Technologists
- Awarded First Place for scientific exhibit entitled "Osteogenesis Imperfecta" at State Society Radiologic Technologists Annual Conference
- Participant, Scholar Bowl, State Society of Radiologic Technologists Annual Conference
- Certified Nursing Assistant, credentialed by Our State

References available upon request.

• **Figure 8-2** Sample resume, second-year student.

Personal Data

Name
Address
City, State, Zip Code
Telephone Number
Email Address

Goal

To obtain a position as an entry-level radiographer; desire to cross-train in mammography.

Employment Experience

December 20__-Present
Patient Transporter
Department of Imaging
XYZ Area Hospital
This Town, State
Duties: Transport inpatients to and from imaging department

May 20__-November 20__
Great Food Restaurant
This Town, State
Duties: Greeted customers at their table; took order, served food

Education

August 20__-July 20__
Radiography Program Name
Our Medical Center (or) Our College
That City, State
Graduated July 20__
Awarded Diploma in Medical Radiography (or) Associate in Applied Sciences Degree

Spring 20__-Spring 20__
Liberal Arts Coursework
Community College
This Town, State
Earned 36 semester hours

Professional Accomplishments, Associations, and Credentials

- Took Registry exam in August; passed; awaiting credentials
(or) Registered by the American Registry of Radiologic Technologists, #123456 through January 20__
- Credentialed by the State of __, #987654, through July 20__
- Active member, American Society of Radiologic Technologists
- Active member, This State Society of Radiologic Technologists
- Member of student team winning first place in radiography scholar bowl at This State Society of Radiologic Technologists Annual Conference, 20__
- Awarded first place for scientific paper presentation entitled "Cervical Spine Injuries" at This State Society of Radiologic Technologists Annual Conference, 20__

References available upon request.

• **Figure 8-3** Sample resume, recent graduate.

Personal Data

Name
 Address
 City, State, Zip Code
 Telephone Number
 Email Address

Goal (optional) To obtain a position as an entry-level radiographer; desire to cross-train in...

Employment Experience

December 20__-Present
 Patient Transporter
 Department of Imaging
 XYZ Area Hospital
 City, State
 Duties: Transport inpatients to and from imaging department

May 20__-November 20__
 Great Food Restaurant
 City, State
 Duties: Greeted customers at their table; took order, served food; followed up for positive guest experience

Radiography Education

August 20__-July 20__
 Radiography Program Name
 Our College (or) Our University (or) Our Hospital
 City, State
 Graduated July 20__
 Awarded Associate (or) Baccalaureate degree

Radiography Clinical Education Experiences

Rotated to three clinical sites during my radiography program:

Small rural hospital - became proficient at routine radiographic and fluoroscopic procedures; followed patients from admission to the imaging department until completion of their exam and discharge from the department; operated (brand name of equipment) and (brand name of PACS); observed CT and sonography when possible

Large medical center - in addition to radiographic and fluoroscopic procedures, passed all competencies in portables and surgery; became proficient in the use of (brand name of equipment) and (brand name of PACS); became comfortable with evaluating acquired images, identifying required anatomy, and determining the acceptability of the images; did multiple rotations through trauma imaging in the ED to increase competency level there; took advantage of rotations to CT, MRI, angiography, nuclear medicine, sonography, and radiation therapy; did additional rotation thorough sonography

Prompt care clinic - expanded skills to include (brand name of equipment) and (brand name of PACS); understanding of the operation of the clinic; developed enhanced history taking skills; participated in team effort among nursing, radiography, lab, and admissions to deliver exceptional patient care experiences

Radiography Program Prerequisites

Spring 20__-Spring 20__
 College (or) University
 City, State
 Earned 36 semester hours

Professional Accomplishments, Associations, and Credentials

- Credentialed by the American Registry of Radiologic Technologists, through January 20__
- Credentialed by the State of __, through July 20__
- Active member, American Society of Radiologic Technologists
- Active member, This State Society of Radiologic Technologists
- Member of student team winning first place in radiography scholar bowl at This State Society of Radiologic Technologists Annual Conference, 20__
- Awarded second place for scientific paper and presentation entitled "Cervical Spine Injuries" at This State Society of Radiologic Technologists Annual Conference, 20__

References available upon request.

• **Figure 8-4** Sample resume with clinical experiences

Education

Your resume should include all of the formal education you have acquired since high school, listed in reverse chronologic order (i.e., beginning with the most recent). It is unnecessary to provide a detailed list of the courses studied. Rather, you may wish to indicate a broad area of study (e.g., liberal arts and sciences, radiography program prerequisites, etc.). Some entries in this section are self-explanatory. A radiology manager would not require explanation of an entry such as “Radiography Program.” In each of your educational experience entries, indicate whether you graduated or received some form of certificate, diploma, or degree. The dates in this section, along with the dates accompanying your employment history, should account for most of your time since high school.

Professional Accomplishments, Associations, and Credentials

In this section, you should list all professional organizations to which you belong. Include any offices or other positions of responsibility you have held, such as being a member or chair of a committee. Examples of information for this section include membership in local, state, or national professional societies; membership in student radiographer associations; and any professional licenses already held. Awards for academic excellence, such as honors listings, and participation in competitions, such as research paper writing, scientific exhibits, and scholar bowls, should be included. You may also wish to include a list of your attendance at state or national professional society meetings.

If you have not yet taken the ARRT exam, you should describe your status, such as “Taking ARRT exam in [list month].” If you have taken the exam but have not yet received your credentials, describe your status such as “Took Registry exam on August 20; passed; waiting for credentials.” Note there is no such status as “Registry eligible”; do not use the term. Radiology managers encounter this situation routinely and are not dissuaded from considering your application because of your transitional status. If you have received your credentials, you should indicate your ARRT number and expiration date. Do not include your test score.

References

References are not listed on the professional resume. A prospective employer provides space on the job application form for listing both work and personal references. For the resume itself, the statement “References available upon request” suffices. Be sure you have obtained the permission of the individuals you wish to use as references so that they will be expecting inquiries from prospective employers.

Cover Letter

If emailed in response to an actual job posting or advertisement, the resume should always be accompanied by a

Date

Director of Radiology
XYZ Hospital
Main Street
Anytown, USA 01234

Dear Director:

It was with great interest that I read your hospital's advertisement for the position of staff radiographer. Enclosed please find my professional resume outlining the experiences and education that I believe qualify me for this position.

I wish to notify you of my interest in being employed in your department. I am also completing an application for employment in your Department of Human Resources and am including a copy of my resume with it. I look forward to hearing from you regarding a personal interview so that we may discuss our mutual needs and interests.

Sincerely,

Enclosure

• **Figure 8-5** Sample cover letter, response to job posting.

concise cover letter, which can comprise the body of the email. [Figure 8-5](#) shows a sample of a cover letter you can adapt for your use.

Appearance of the Resume and Cover Letter

As you compose your resume, you should create a rough draft and then refine the resume after proofreading it. It is recommended that you have someone else read it as well. Be sure to use the “spell check” feature in your software. There should be no mistakes in your resume.

In most situations, you will attach your resume to an online application form. Be sure to convert your electronic resume to PDF format before attaching it.

If printing your resume, be sure to use a high-quality laser or ink-jet printer. After printing, make certain there is no smeared ink or partially printed lines caused by a faulty printer. There are nearly as many different types of paper available as there are resume formats. The resume and cover letter should be printed on 60- to 75-lb text paper that is preferably white or ivory, which provides a positive image for your resume. Because this paper has a heavier weight, it should not be folded. Avoid using copier-type paper; it is an inexpensive grade of paper and does not make a positive impression on the reader. In addition, many papers of this type produce a poorer printed image when used with a laser printer. If you are unfamiliar

with paper types and weights, your writing center or retail copy shop can provide you with information. If handling a paper copy, you should use a large manila envelope so the resume lies flat and unfolded.

Job Application

Students are often dismayed that after investing much time and effort in writing a resume, they must still complete a job application form. This is a standard practice for employers and is required by institutional accrediting agencies.

Assuming you are applying to an institution that uses online applications, have all of your information nearby when filling in the form. Again, be sure to attach a PDF copy of your resume as directed by the online application instructions. If you are using job search websites, most will permit you to post your resume for employers to examine. In either case, a professional resume, clearly indicating your professional experience and goals, will go a long way toward securing the position you desire.

You may request former or current employers not be contacted. In addition, a detailed employment and reference check cannot be conducted without your signed authorization. Carefully read the statement on the application form before you sign it with the appropriate electronic signature.

Proper preparation of a professional resume is not a task to be taken lightly. Spend the time needed to construct your resume carefully, and be aware of its impact on potential employers. Your resume is a statement of your professionalism that speaks for you in your absence.

- List all jobs held since high school, oldest first; include all jobs that dealt with the public; emphasize jobs in health care.
- List all postsecondary education; high school should be left off.
- Indicate whether you graduated and whether you received a certificate, diploma, or degree.
- List offices or other positions of responsibility you have held, such as membership in local, state, or national professional societies and membership in student radiographer associations; any professional licenses already held; awards for academic excellence such as honors listings; participation in competitions such as research paper writing, scientific exhibits, and scholar bowls; and attendance at state or national professional society meetings.
- References are not listed on the professional resume.
- Use spell check, proofread your resume, and have someone else proof it as well.
- When applying online, attach the resume electronically.
- If printing, use high-quality 60- to 75-lb paper, white or ivory, using a good printer.
- Your resume is a statement of your professionalism that speaks for you in your absence.

KEY POINTS

Writing a Professional Resume

- Your resume is a summary of your academic and work history and relevant accomplishments and credentials.
- Keep resume length to one or two pages, as a snapshot of your career to date.
- Include your name, address, phone number, and email address.
- Exclude date of birth, gender, race, marital status, church affiliation, number of children, disabilities, hobbies, and any other data that are irrelevant to your status as a job seeker.
- Include only information that is relevant to your accomplishments and goals as a professional.
- Brevity is the rule.
- Do not use abbreviations of any kind.
- Resumes may be used as part of a mailing or emailing to prospective employers, left with an interviewer after an appointment, included with the job application form, or attached as a PDF document.
- Prepare a cover letter to accompany your resume if doing a mailing, or use the cover letter as the body of the email.
- Include a simple goal statement.

9

Interviewing Techniques

Purpose of an Interview

If your resume is your detailed calling card, your personal interview is your house call. It is your only opportunity to make a strong, lasting first impression with your possible future employer. Because of the legalities surrounding the issue of discrimination, the personal interview may not be as detailed as it has been in the past. However, this does not diminish its significance or the importance of proper preparation.

The employer can use the personal interview to verify information submitted on the resume or job application. It can serve as an opportunity for the employer to show you the facilities in which you may be working, familiarize you with the equipment, and determine your experience with such equipment. The interviewer may also be interested in your career goals and plans for establishing a career.

Another purpose of an interview is for you to become acquainted with your prospective employer. It is also a time for you to decide whether you want to work for that department or organization if offered a job. As you prepare for the interview, always remember it is a two-way street.

Personal Appearance

There is no substitute for making a strong first impression with the person or persons who will be conducting your interview. Like it or not, we are visual creatures, and your physical appearance during your initial contact with the receptionist and interviewers has a profound effect on their perception of you as a potential employee.

How you choose to present yourself for your interview says a lot about your professional self-image. Regardless of where you work, you represent that department or organization to the patient or customer. Appropriate professional attire begins with the interview and continues every day once the job begins.

Dressing for social occasions varies by age group and geographic region. However, dressing for a professional job interview is fairly standard regardless of age or location. What you choose *not* to wear is as important as what you do wear. For the interview, do not wear your professional uniform. Casual attire and trendy clothing, such as blue jeans, casual slacks, shorts, T-shirts, and

athletic shoes, are also inappropriate. Be careful not to over apply cologne or arrive at the interview smelling of smoke. Pay attention to details. It does little good to wear a clean, pressed business suit only to have the interviewer see dirty fingernails. Similarly, proper grooming loses its impact when your cologne precedes you to the interview by 5 minutes.

Conservative clothing is a must. Men should always wear a business suit or blazer, tie (optional), and dress slacks. Women should wear a business suit. Clothing must be clean and free of wrinkles. Shoes (polished), socks, and belt should complement the clothing. Hose must be free of runs. Hair should be neatly styled and pulled back if shoulder length or longer. Jewelry should be conservative and kept to a minimum, including visible piercings.

As your attire varies from these suggestions, the likelihood of a favorable impression on the interviewer decreases. Applying for a professional position requires that you dress and present yourself professionally.

By taking the time to prepare your personal appearance and dress professionally, you are telling the interviewers that you respect their time and appreciate their serious consideration of you as a job candidate. You are also making a statement about how you believe a professional should appear, not only to potential employers but also to peers. The interviewers will assume that, although you would be wearing a professional uniform or even scrubs at work, you would appear as neat and clean when caring for patients as your appearance during the interview suggests.

Because you will undoubtedly be nervous, your mouth will likely be dry. Until the interview begins, use a breath mint to keep your mouth moist and your breath fresh. Gum chewing is never acceptable in a professional setting. Be certain your cell phone is turned off (not just on vibrate).

Another aspect of your appearance may also be reflected in your postings on various social media. While useful as a communication link with friends and relatives, social media are increasingly used by employers to evaluate a candidate for hire. Carefully consider what types of photos you post, what language you use, and what activities you promote in your social media postings.

If you were hiring someone for a position such as this, what decision would you make based on what you see and read in your social media postings? What impression would

you have of your professionalism, habits, or activities? Your interviewer wants to hire the best candidate for the position who will reflect the values, image, and reputation of their institution. Invest some time evaluating what you post or have someone look at it for you. You want to make the best overall impression you can in a challenging job market.

Preparing for the Interview

To prepare for the interview, you should attempt to find out as much about your potential employer as possible. If you cannot ascertain this information ahead of time, be prepared with questions about the employer you can ask during the interview.

KEY POINTS

Questions You May Wish to Ask the Interviewer

- Why is the current position available?
- What is the annual rate of turnover in the imaging department?
- What is the overall harmony among employees in the department?
- How is the feedback from employee or patient satisfaction surveys?
- What advancement opportunities are available, including cross-training in other imaging modalities?
- Does the organization provide continuing education, in-service programs, or tuition reimbursement?
- What is the financial security of the organization?

Before the interview, you may wish to examine the organization's most recent annual report (which is normally found on the organization's website). The overall reputation in the community and the financial stability of your prospective employer are factors you should consider before accepting a job offer.

It should not be necessary to bring anything to the interview unless you have not previously submitted your resume to the interviewer; if you have not, bring a clean copy inside a manila folder or large envelope. All the facts pertaining to your professional preparation are on the resume. If documentation is required for any item, it may be submitted at a later time to the department of human resources. Similarly, your list of references is probably already entered on the job application form. If not, these may also be furnished later to the human resources department. In most cases, individual department directors do not perform reference checks because of the legalities involved.

If you are unsure where the interview will be held, you should find the building and the office several days ahead of time. You do not want to spend time searching for the site on the day the interview is scheduled. You should allow plenty of time to get to your destination. If you arrive early, there is always a waiting area. Arriving late for an interview is inexcusable.

When you arrive at the interview site, you may want to visit the restroom. Anxiety about the interview may make this necessary, but it also gives you the opportunity to make sure your hair and attire are presentable. When arriving at the appropriate office, greet everyone as if they were going to conduct the interview. Many radiology managers ask receptionists their impressions of the interviewee.

Feeling nervous and apprehensive about an interview is normal, especially if you greatly desire the position. Try to convert your nervous energy into enthusiasm when speaking with others throughout the course of the interview.

Interview Process

When the interviewer approaches, stand and shake hands firmly. Make eye contact. A smile and an enthusiastic (although not excessively demonstrative) attitude create a positive first impression. As the interview begins, try to appear as calm, comfortable, and professional as possible. Maintain appropriate eye contact and smile. Maintain good posture and remain alert. Be pleasant, avoid joking, and be attentive. Speak distinctly, and use appropriate terminology. Be a good listener. You may wish to bring up your career goals as summarized in the goal statement on your resume. Carefully indicate how you may be an asset to the department without sounding as though you are bossy, arrogant, or demanding. Answer the interviewer's questions clearly, avoiding very short or very long answers. Be prepared to discuss any items you have included on your resume.

There have been numerous legal challenges in recent years to what are alleged to be discriminatory interview questions and techniques. Although the emphasis of such legal rulings has been to require the interviewer to ask only questions that reveal your job qualifications, it is wise for you to know what can and cannot be asked in a job interview. This knowledge assists you in preparing for the interview. It also makes you aware of your rights so you may recognize potentially discriminatory situations.

Many interviewers begin an interview with the question "Tell us about yourself." This type of wide-open question can be an opportunity for you to expand on what you put on your resume, or it can also lead you to discussing personal information that should not be discussed in an interview. Although the question is seemingly harmless, you may find yourself answering it by discussing your children, child care issues, your family plans, your hobbies, etc. These items cannot be asked by the interviewer but can be ascertained by having you talk about yourself. Remember to keep your answer to this question focused on the position for which you are interviewing and why you would make the best candidate to be hired. Do not delve into anything not related to the job.

Be prepared for behavioral interviews. Such interviews probe your responses to various interpersonal and professional situations. Do not attempt to outwit the interviewer. It is best to answer the questions honestly and professionally. Likewise, be prepared to be interviewed by radiology

supervisors or staff radiographers. This has become more commonplace in recent years. Bear in mind they must keep their questions focused on the specific position for which you are interviewing. Because they are your peers does not mean they may ask inappropriate or personal questions.

The following box lists topics that may be addressed during an interview. They are relevant to the job and are legitimate areas of inquiry. You may wish to write out your answers ahead of time in anticipation of the interview. Other interview questions not included in this list may also be appropriate and within current legal guidelines.

KEY POINTS

Questions You May Be Asked That Are Appropriate and That You Should Be Prepared to Answer

- Any information you entered on the application form
- Why you left your last job
- How your former employers view you
- What your duties were in your last job or a summary of your clinical rotations if you are a new graduate
- What you liked or disliked about your previous jobs or your favorite or least favorite experiences as a student
- What job duties interest you
- The days or hours you are (or are not) available to work
- The size of the facility in which you previously worked
- What you thought of your previous supervisors or instructors (e.g., whether you got along, what kind of people they were, whether they were strict or easygoing)
- The kind of supervisor you prefer
- How employee or student problems and complaints were resolved at your previous job or clinical site and whether you thought it was a good procedure
- How you would prefer to have employee problems and complaints handled if hired for this job
- What wages you received at your previous job
- Whether you were promoted and on what criteria the promotion was based (e.g., merit, length of service)
- How much you expect an employer to communicate with you and to keep you involved in workplace activities
- Which mode of communication you prefer

The interviewer will probably provide you with information about the salary structure, benefits package, sick leave, and vacation time allowed. Although this information is important to you, try to wait until the interviewer brings it up. In this way, you will not appear to be interested only in money and benefits.

In any interviewing situation, you should be aware of the types of questions that may not be asked. Although it is not likely to occur in a truly professional organization, it is always possible that you may be asked an inappropriate question. If you are asked an inappropriate question relating to the subjects listed in the following box, you may wish to ask the interviewer, “Can you explain to me how this question relates to the requirements of this position?” Most likely, the interviewer will retract the question. However, if a series of improper questions is asked, and you realize it

is intentional, you may not wish to continue pursuing the position. If blatant harassment or violation of ethical interviewing guidelines occurs, you must ask yourself whether you wish to work in such an environment, regardless of how much you might desire the position. If either of these situations develops, you may decide to conclude the interview with a statement such as, “Thank you for your time, but I feel you are asking irrelevant questions in violation of my rights. Please remove my name from consideration for this position,” or you may opt to finish the interview and remove your name from consideration in a follow-up email.

Be careful not to answer questions on the topics in the accompanying box. You are not required to answer them and should not volunteer such information. If you believe you have been discriminated against based on questionable interview practices, you may wish to seek private legal counsel or remedy through the Equal Employment Opportunity Commission (EEOC) as a last resort. Recommendations concerning legal issues that may arise during the interview are beyond the scope of this text. A personal attorney is best equipped to answer such questions.

KEY POINTS

Questions You May Be Asked That Are Not Appropriate and That You Should Not Answer

- Your age
- Your birth date
- How long you have resided at your present address
- Your previous address
- The house of worship you choose to attend (if any) or the name of your clergy person
- Your family's surname
- Your birth name, if married
- Whether you are married, divorced, separated, widowed, or single
- Who lives with you
- How many children you have or intend to have
- The ages of your children
- Who will care for your children while you are working
- How you will get to work (unless owning a car is a job requirement)
- Where a spouse or parent works or lives
- Whether you own or rent your place of residence
- The name of your bank or any information concerning outstanding loan amounts
- Whether you have ever had your wages garnished or filed bankruptcy
- Whether you have ever been arrested
- If you have ever been convicted of a felony (this question is illegal in many cities and states until a firm job offer is presented to you)
- Whether you have ever served in the armed forces of another country
- How you spend your spare time or to which clubs or organizations you belong
- Your position on labor unions or whether you have ever been a member of a union
- The nationality of your name

Radiology Manager's Name
 Imaging Center or Hospital Name
 Armstrong Avenue
 My Town, OH 45895-1969

Dear Radiology Manager's Name:

Thank you for the opportunity to interview for the position of staff radiographer. I appreciate the time you spent with me yesterday. It was a pleasure meeting you and seeing your imaging department.

I look forward to hearing from you regarding this position.

Sincerely,

Applicant, R.T.(R)

• **Figure 9-1** Sample interview follow-up letter.

Do not allow the interviewer to take advantage of your friendly nature to ask questions that should not be asked or to pry into personal aspects of your life. This is not a conversation between friends; it is a professional job interview. If you conduct yourself professionally, a competent interviewer will respect you and your position.

The last impression can be as important as the first. You may wish to ask, "Is there anything else you'd like to ask me?" At the conclusion of the interview, shake hands firmly, make eye contact, and thank the interviewer for the time spent with you. The interviewer will probably give some indication of when the hiring decision will be made based on the number of applicants and the date by which the position must be filled. As you leave, say good-bye to the administrative assistants you pass and thank them for their assistance.

Immediately send or email a follow-up letter to the interviewer. A sample is shown in [Figure 9-1](#). If printed, be

sure it is on good-quality paper and reinforces the positive impression you have sought to make. Keep in mind this is basically a thank you letter and is not meant to provide additional information about yourself. Most important, be sure to send it. Many individuals fail to follow up with a letter, and consequently, you will stand out from the rest!

Interview Outcomes and Follow-Up

Even after a good interview, you may not be hired or take the job offer. The following box lists some of the possible reasons.

KEY POINTS

Why You May Not Be Hired

- Your references were unsatisfactory.
- Your interview created a poor impression; you did not seem interested; you used poor grammar or other unacceptable communication skills.
- You have had inappropriate social media postings.
- You are unable to work the required hours.
- You choose to reject the job offer because you are not interested in the position.
- You are not qualified for the position, or other candidates were better qualified.
- You did not pass the preemployment drug screening or background check.
- Inconsistent or inaccurate statements were made on your application form.
- You are physically unable to perform the job duties; however, the Americans with Disabilities Act guidelines must be considered.
- There was not a good match between what you had to offer and this employer's needs.

Following the guidelines and suggestions in this chapter will not guarantee employment. However, it will guarantee that you will present yourself as the true professional you have worked so hard to become.

10

Employment Expectations

Entering the Health Care Workforce

As you enter the workforce in medical radiography, the individuals in charge of the facility in which you will work will have expectations of you as a professional. From their standpoint, it is reasonable to expect you will be able to fulfill the requirements of your job description. You are being hired because you have the abilities to function as an entry-level radiographer. Ultimately, the most important expectations you must exceed are those of the patient.

The task inventory conducted by the American Registry of Radiologic Technologists (ARRT) reflects the skills performed by entry-level radiographers responding to the ARRT survey. Not only does this form the basis of the radiography exam content specifications listed in [Chapter One](#), it also coincides with the terminal competencies of your educational program. You should also be aware your new employer will have expectations you are competent in these skills regardless of where you attended school. The task inventory is provided here so you can understand the technical skills expected of you as you enter the workforce.

Task Inventory*

Completion of your educational program should enable you to carry out the following tasks:

1. Confirm patient's identity.
2. Evaluate patient's ability to understand and comply with requirements for the requested examination.
3. Obtain pertinent medical history.
4. Manage complex interpersonal interactions within the workplace in an effective manner.
5. Explain and confirm patient's preparation (e.g., diet restrictions, preparatory medications) prior to beginning imaging examinations.
6. Review imaging exam request to verify accuracy and completeness of information (e.g., patient history, clinical diagnosis, physician's orders).

7. Respond as appropriate to imaging study inquiries from patients.
8. Sequence imaging procedures to avoid residual contrast material affecting future exams.
9. Assume responsibility for medical equipment attached to patients (e.g., IVs, oxygen) during the imaging procedures.
10. Follow environmental protection standards for handling and disposing of biohazardous materials (e.g., sharps, blood and body fluids).
11. Provide for patient safety, comfort, and modesty.
12. Notify appropriate personnel of adverse events or incidents (e.g., patient fall, wrong patient imaged).
13. Communicate scheduling delays to waiting patients.
14. Demonstrate and promote professional and ethical behavior.
15. Verify informed consent as necessary.
16. Recognize abnormal lab values relative to the imaging study ordered.
17. Communicate relevant information to others (e.g., MDs, RNs, other radiology personnel).
18. Explain procedure instructions to patient or patient's family.
19. Practice Standard Precautions.
20. Follow appropriate procedures when caring for patients with communicable diseases.
21. Use immobilization devices, as needed, to prevent patient movement and/or ensure patient safety.
22. Use proper body mechanics when assisting a patient.
23. Use patient transfer devices when needed.
24. Prior to administration of a medication other than a contrast agent, review information to prepare appropriate type and dosage.
25. Prior to administration of a contrast agent, review information to prepare appropriate type and dosage.
26. Prior to administration of a contrast agent, determine if patient is at risk for an adverse reaction.
27. Use sterile or aseptic technique when indicated.
28. Perform venipuncture.
29. Administer IV contrast agents.
30. Observe patient after administration of a contrast agent to detect adverse reactions.

*From American Registry of Radiologic Technologists: *Radiography exam task inventory*, St Paul, MN, 2015, ARRT. Implementation date January 2017.

31. Follow environmental protection standards for handling hazardous materials (e.g., chemotherapy IV, radioactive implant).
32. Obtain vital signs.
33. Recognize and communicate the need for prompt medical attention.
34. Administer emergency care.
35. Explain post-procedural instructions to patient or patient's family.
36. Maintain confidentiality of patient information.
37. Clean, disinfect, or sterilize facilities and equipment, and dispose of contaminated items in preparation for next examination.
38. Document required information on patient's medical record (e.g., imaging procedure documentation, images).
 - a. On paper
 - b. Electronically
39. Evaluate the need for and use of protective shielding.
40. Take appropriate precautions to minimize radiation exposure to the patient.
41. Question female patient of childbearing age about date of last menstrual period or possible pregnancy and take appropriate action (e.g., document response, contact physician).
42. Restrict beam to the anatomical area of interest.
43. Set technical factors to produce diagnostic images and adhere to ALARA.
44. Document radiographic procedure dose.
45. Select continuous or pulsed fluoroscopy.
46. Document fluoroscopy time.
47. Document fluoroscopy dose.
48. Prevent all unnecessary persons from remaining in area during x-ray exposure.
49. Take appropriate precautions to minimize occupational radiation exposure.
50. Advocate radiation safety and protection.
51. Describe the potential risk of radiation exposure when asked.
52. Wear a personnel monitoring device while on duty.
53. Evaluate individual occupational exposure reports to determine if values for the reporting period are within established limits.
54. Determine appropriate exposure factors using the following:
 - a. Fixed kVp technique chart
 - b. Variable kVp technique chart
 - c. Calipers (to determine patient thickness for exposure)
 - d. Anatomically programmed technique
55. Select radiographic exposure factors:
 - a. Automatic Exposure Control (AEC)
 - b. kVp and mAs (manual)
56. Operate radiographic unit and accessories including:
 - a. Fixed unit
 - b. Mobile unit (portable)
57. Operate fluoroscopic unit and accessories including:
 - a. Fixed fluoroscopic unit
 - b. Mobile fluoroscopic unit (C-arm)
58. Operate electronic imaging and record keeping devices including:
 - a. Computed radiography (CR) with photostimulable storage phosphor (PSP) plates
 - b. Direct radiography (DR)
 - c. Picture archival and communication system (PACS)
 - d. Hospital information system (HIS)
 - e. Radiology information system (RIS)
 - f. Electronic medical record (EMR)
59. Modify technical factors to correct for noise in a digital image.
60. Remove all radiopaque materials from patient or table that could interfere with the image (e.g., clothing removal, jewelry removal).
61. Perform post-processing on digital images in preparation for interpretation.
62. Use radiopaque anatomical side markers at the time of image acquisition.
63. Add electronic annotations on digital images to indicate position or other relevant information (e.g., time, upright, decubitus, post-void).
64. Select equipment and accessories (e.g., grid, compensating filter, shielding) for the examination requested.
65. Explain breathing instructions prior to making the exposure.
66. Position patient to demonstrate the desired anatomy using anatomical landmarks.
67. Modify exposure factors for circumstances such as involuntary motion, casts and splints, pathological conditions, contrast agent, or patient's inability to cooperate.
68. Verify accuracy of patient identification on image.
69. Evaluate images for diagnostic quality.
70. Respond appropriately to digital exposure indicator values.
71. Determine corrective measures if image is not of diagnostic quality and take appropriate action.
72. Identify image artifacts and make appropriate corrections as needed.
73. Store and handle image receptor in a manner that will reduce the possibility of artifact production.
74. Visually inspect, recognize, and report malfunctions in the imaging unit and accessories.
75. Recognize the need for periodic maintenance and evaluation of radiographic equipment affecting image quality and radiation safety (e.g., shielding, image display monitor, light field, central ray detector calibration).
76. Perform routine maintenance on digital equipment including:
 - a. Detector calibration
 - b. CR plate erasure
 - c. Equipment cleanliness
 - d. Test images
77. Adapt radiographic and fluoroscopic procedures for patient condition (e.g., age, size, trauma, pathology) and location (e.g., mobile, surgical, isolation).
78. Select appropriate geometric factors (e.g., SID, OID, focal spot size, tube angle).

Position patient, x-ray tube, and image receptor to perform the following diagnostic examinations:

79. Chest
80. Ribs
81. Sternum
82. Abdomen
83. Esophagus
84. Swallowing dysfunction study
85. Upper GI series, single or double contrast
86. Small bowel series
87. Contrast enema (e.g., barium, iodinated), single or double contrast
88. Surgical cholangiography
89. ERCP
90. Cystography
91. Cystourethrography
92. Intravenous urography
93. Retrograde urography
94. Hysterosalpingography
95. Cervical spine/soft tissue neck
96. Thoracic spine
97. Scoliosis series
98. Lumbar spine
99. Sacrum/coccyx
100. Sacroiliac joints
101. Pelvis/hip
102. Skull
103. Facial bones
104. Mandible
105. Zygomatic arch
106. Temporomandibular joints
107. Nasal bones
108. Orbits
109. Paranasal sinuses
110. Toes
111. Foot
112. Calcaneus
113. Ankle
114. Tibia/fibula
115. Knee/patella
116. Femur
117. Fingers
118. Hand
119. Wrist
120. Forearm
121. Elbow
122. Humerus
123. Shoulder
124. Scapula
125. Clavicle
126. Acromioclavicular joints
127. Bone survey
128. Long bone measurement
129. Bone age

Assist radiologist with the following invasive procedures:

130. Joint injection (arthrography)-fluoroscopic guided contrast injection
131. Myelography/fluoroscopic guided contrast injection

Organizational Structure and Your Professional Responsibility

The employer has a right to expect you to use your knowledge and abilities in radiography efficiently and provide high-quality service to the patient. In return, you have a right to expect the salary and benefits to which you and your employer agreed. You should also expect to perform your job in an environment that is in compliance with safety and public health requirements and free of all forms of harassment and discrimination.

You are entering a dynamic and fluid sector of the national economy. Health care advances in diagnosis, treatment, and delivery are in a constant state of flux. Funding of health care services is a matter of national debate. This is the nature of the industry in which you have chosen to work and build a career. You should expect to stay abreast of changes in the delivery of health care and remain alert to how such changes affect your employer. Remember, issues affecting your employer also affect you and your coworkers.

Your employer will expect you to function as part of a team, all of the members of which will be dedicated to the cost-effective provision of efficient, accurate, and compassionate care to the patient. At the same time, the employer is the coach of the team and has an obligation to maintain the provision of high-quality service to patients and proper accountability to payers. An examination of the expectations of your employer will reveal your professional responsibilities are accountable to the five distinct groups described in this chapter.

Two primary expectations are common to each of the five groups. The first expectation is you will provide the highest quality patient care of which you are capable in congruence with what your employer and your profession require. Such patient care is all-encompassing, from providing quality service to the patient, to supporting the patient's physical needs, to creating the most diagnostic images possible. The second expectation is you will respect and accommodate diversity in all of its forms. Such diversity may be linked to culture, language, gender, age, ethnicity, socioeconomic, and the multitude of other unique characteristics that are an integral part of each person. In health care, we serve patients as they are, not as we may wish them to be. Our practice of radiography must be blind to differences while being caring and compassionate to all.

Expectations of Administrators

The administrators of the facility in which you will be employed expect you are going to fulfill the job description associated with an entry-level radiographer. They expect you to be honest and straightforward with them while providing excellent care and service to the patient or customer. High-quality customer service is paramount to your success. It is vital that the patient knows true professionals are providing care.

Administrators trust you will speak highly of the facility and be supportive of its efforts to provide high-quality patient care. You are expected to use professional judgment when using social media, avoiding posting anything that may reflect negatively on the institution. You are expected to arrive for work on time and keep absenteeism to an absolute minimum. There may be times when you are expected to work extra hours, such as when another employee is on vacation or is sick. Administrators are looking for employees who are willing to be strong, supportive team players.

Administrators also expect you will be willing to contribute new ideas for more efficient operation. They assume you will work in harmony with other departments in the facility. They may request you serve on committees or perform other tasks not directly related to radiography. Be the type of employee who exceeds the expectations of administrators, and you will be well on your way toward establishing the type of reputation that will ensure your success.

Expectations of Physicians

Physicians are customers too. The physicians with whom you will be working, including radiologists and referring physicians, have their own particular set of expectations. Referring physicians expect their orders for radiologic exams will be carried out as indicated. They expect high-quality images will be acquired by the radiographers and interpreted properly by the radiologists. Although your interactions with these physicians may be minimal, they are nevertheless important.

Referring physicians often come to the radiology department to view images themselves or consult with the radiologist. They expect to be treated as professionals. They may be unfamiliar with the department and where supplies are kept. They may be there to perform a procedure. They expect to be shown where supplies are kept and be assisted as needed. As a professional radiographer, it will be your responsibility to meet or exceed expectations and provide high-quality service to the physician as well as the patient.

The physicians with whom you will interact most frequently are the radiologists, and most of this exchange will occur during fluoroscopy. The radiologists expect to receive the highest quality images you are capable of producing. They will be providing the diagnosis from your images. Radiologists do not expect to have to ask you to reacquire an image you already know is unacceptable. They do not want to hear excuses for poor images. Radiologists insist you keep them informed about variations from protocol. They expect you to take an adequate but concise patient history for their use during the interpretation of the images.

As a student, you may have had radiographers facilitate your interactions with the radiologists. As a new, entry-level radiographer, you now have the responsibility to be straightforward and professional during interactions with

the radiologists. This includes not only providing the highest quality images of which you are capable but also demonstrating a willingness to resolve personality and work-related conflicts.

It is important to determine ahead of time how you wish to be regarded by the physicians. You have a right to be treated respectfully and should take immediate steps to rectify a situation in which you are being mistreated. At the same time, the physicians have a right to expect you will reciprocate in your professional conduct.

Expectations of the Radiology Manager

The person who is hiring you, the radiology manager, also has a particular set of expectations. This individual is directly responsible for your on-the-job performance and overall value to the patient or customer and the administration. In research I conducted, radiology managers responded to a survey regarding their expectations of new radiography graduates. Of particular interest are the traits the radiology managers considered most important in an applicant and the areas in which radiology managers have had the most difficulty with employees after they were hired.

When hiring a new graduate radiographer, 43% of radiology managers said knowledge of the technical aspects of radiography was the most important factor they considered; this is a given because the new employee must be able to perform the job. However, 33% responded customer service skills and interpersonal communication skills were the factors they most considered when hiring a recent graduate. These individuals are assuming you know how to perform the job and expect you will provide excellent service to the patient while performing it. This research shows radiology managers have high expectations of you. They expect you to know the practice of radiography, deliver quality service to patients, and be capable of establishing positive relationships with your coworkers.

A second question inquired about problems radiology managers encountered with radiographers on the job. Poor communication skills were identified by 37% as the most significant problem and usual cause for a reprimand or termination. Lack of knowledge of the technical aspects of the job was cited as the primary reason for a reprimand or termination by 36%. In comments entered on the survey, many radiology managers mentioned attendance problems, tardiness, lack of dependability, and substance abuse as problems in the workplace that led to reprimands and terminations.

Other areas of concern raised by the radiology managers included bringing personal problems to work and overall lack of initiative. These are problems you should keep out of your radiography practice. Should any of these issues become matters of personal concern for you, seek counseling immediately so that you can bring such problems under control. Your employer and your patients deserve no less.

Another survey question asked the managers which areas should be most strongly emphasized with student

radiographers as they prepare to enter the workforce. They stressed the following:

1. Ongoing technical training
2. Knowledge of basic nursing skills, such as using IV pumps, taking vital signs, and performing venipuncture
3. Ability to work alone without constant supervision
4. Awareness of the customer's or patient's viewpoint
5. Strong communication skills
6. Provision of high-quality service with a smile
7. Professionalism in dealing with the public
8. Loyalty to the employer
9. Maintenance of clinical skills

The radiology managers were asked to rank the factors they considered to have the most positive effect on customer service in their department. The most important factor (according to 60% of the respondents) was a pleasant and courteous staff. To add to this point, a percentage of Medicare reimbursement is now based on patient satisfaction scores.

Similar to the administrators to whom they report, radiology managers expect you to be ready to begin work on time and to keep absenteeism to a minimum. They are counting on you to show up—on time—and provide the highest quality patient care each day you are assigned to work. Such patient care is expected to be delivered within the scope of practice determined by the profession and in full compliance with the standards of ethics and confidentiality of radiologic technology.

The radiology manager also expects you to conduct yourself as a professional in your dealings with the patient or customer, the physicians, and your coworkers. You are expected to be a reliable member of the radiology team. You must be flexible and have a positive attitude about handling all the different assignments you may be given in a typical workday.

The need for balance between the high-touch and high-tech aspects of radiography is evident. Radiology managers have high expectations of new employees. Be prepared to exceed those expectations. Because you are ready to enter the workforce, you must determine how many of these traits are present in your practice already and which ones need additional attention. The managers have carefully described what they need and expect. Are you prepared to enter their workplace?

Your radiology manager will expect you to remain busy throughout the day. In addition to performing your primary job duties, you may be asked to complete assignments that do not involve patient care. Quality control testing or the routine cleaning of imaging equipment or lead aprons may be a part of your job responsibility. If you think of your work area as an integral part of your practice, that sense of ownership will motivate you to care for it. Slow periods at work may be few and far between; you should take advantage of them whenever they occur. Your attitude toward the aspects of your work that do not involve patient care may determine whether the radiology manager gives you other assignments you may be seeking. If you consider lounge areas off limits and keep

busy throughout the day, you will find great fulfillment in your work and will likely exceed the radiology manager's expectations.

In a field that changes as rapidly as medical imaging, your radiology manager will expect you to be knowledgeable about the newest types of equipment and advances in imaging techniques. You are also expected to keep your skills at a level that allows you to perform all of the different types of radiographic procedures required in your radiology department. On a regular basis, you should review your favorite text on radiographic positioning and procedures to refresh your memory and maintain your skills.

You have become accustomed to studying, and throughout the course of your radiography program, you have had to learn how to learn. This process does not end with graduation or passing the certification exam. It is important to keep abreast of events in the field by reading the latest radiologic technology journals and textbooks. Textbooks are not written solely for students. As a practicing radiographer, you will want to keep your personal library updated with the best resources available.

Another way to be aware of current developments in the field and exceed your manager's expectations is to become an active member of your national and state professional organizations. Both have publications that will bring you the latest news in the profession. In addition, these organizations need your talents to be successful. As a student, you have acquired a store of information and have developed skill in communicating this knowledge. Take advantage of that momentum, and continue to do research in the field.

Most radiology managers will expect you to give something back to your profession, which will increase your level of knowledge. Present research papers at state or national meetings, hold an office in one of the organizations, or offer to help out in planning and conducting a continuing education meeting. Organizing and conducting an in-service education program for your department is a great place to begin. If you have never taken part in such activities, this is a perfect time to begin. It does not matter whether you are sure about what you are doing; just offer to help or do that first research paper as a graduate.

Meeting and exceeding the radiology manager's expectations are sure ways to set a course for success in your chosen field. Individuals who follow this path derive the most satisfaction from their job and are held in the highest esteem by their employers. Most important, a commitment to excellence in your profession results in healthy self-esteem, which is reflected in the care and service provided to the patients.

Expectations of Students Under Your Supervision

Your new employer may have students present as part of an educational program in radiologic technology. The

employer may be the sponsor of the program or may serve as a clinical site for a program sponsored by another institution.

It may seem ironic that although you are probably reading this as a student still in school, it is already time to consider the aspect of future expectations for students. Should you choose to work in an imaging department that serves as a clinical site, you will be working with students shortly after graduation. This is an awesome responsibility, especially because you will still be in learning mode yourself, mastering the requirements of a staff radiographer in your new position.

Working with students is a task to be taken seriously. As you already know from your experiences, the students will expect you to share with them your knowledge of the art and science of imaging and patient care. They will want fair and honest evaluations of their performance. They will want to be treated with the respect due an adult in college, not as another worker, an inexpensive laborer, or someone to perform menial tasks. The students under your supervision will rely on you to help them through the learning process.

Whether or not it is part of the orientation to your new job, seek out the clinical instructor for students in your department. Find out what is expected of you from the educational program. Become thoroughly familiar with the evaluation forms and competency testing forms and system you may be expected to use. As a new graduate yourself, determine whether there is a limit to what role you can play. Learn the specific requirements of direct and indirect supervision of students performing exams and repeat exposures. Consider carefully the legal ramifications of following such supervisory requirements.

As you work with students, remember you are shaping the next generation of radiographers. These individuals will be your coworkers after their graduation. This is a key role to play as you become acclimated to the role of radiographer as well. You have the ability to be a strong influence on future professionals in your field. Take the responsibility seriously, and take pride in the impact you will have on these radiographers who will follow you into the field.

Expectations of Your New Coworkers

At the same time you are taking and passing the credentialing exam, becoming oriented to a new job, possibly working with students, and learning your new employer's expectations, there will be another very important set of expectations to consider. This area includes your employer's expectations of your relationship with your new coworkers.

As a new graduate, you will, in some respects, be like a new student all over again. Learning the technical aspects of a new job, even in your chosen field, will take much time and energy. At the same time, becoming part of a work group such as a department of radiology, urgent care center, cardiac

catheterization laboratory, or physician's office will probably take more energy than you might expect. Establishing your professional relationships will make a world of difference in the satisfaction you receive from your work and your ability to provide the level of care you expect of yourself.

Approach your new position as a learner, eager to find out all you can regarding routines, protocols, professional relationships within the work setting, and how the group functions together. Determine everyone's level of responsibility and where you fit in. Your new employer expects you will establish professional working relationships and conduct yourself with everyone as a member of a tight work unit. You will be expected to avoid gossip, cliques, and any other behavior that inhibits the delivery of high-quality patient care and service. Your employer will expect you are ready to learn all you can from your coworkers regarding the technical aspects of imaging and operation of the imaging department or clinic. You and your coworkers will need to work out personal problems as professionals and not allow them to enter the flow of the workplace.

Your coworkers will expect you to come up to speed quickly and to ask questions when necessary. They will expect you to conduct yourself as a new graduate, still in learning mode but ready to assume a high level of responsibility and take on your share of patient care. They will expect you to establish a positive, uplifting relationship with them. They can assist you as you enter the field as a

KEY REVIEW POINTS

Employment Expectations

- Skills expected of an entry-level radiographer are outlined in the ARRT Task Inventory.
- Advances in diagnosis and treatment are in a constant state of change.
- Be honest and straightforward while providing excellent care and service to the patient.
- Speak highly of the facility and be supportive of its efforts to provide high-quality patient care.
- Use social media postings carefully and wisely.
- Arrive for work on time; keep absenteeism to a minimum.
- Be a strong, supportive team player.
- Work in harmony with other departments in the facility.
- Carry out referring physicians' orders for radiologic exams as written.
- Interact professionally with physicians visiting the imaging department.
- Work with radiologists as fellow team members, providing them the finest diagnostic images possible.
- Make knowledge of technical aspects of radiography, customer service, and communication skills the foundation of your practice.
- Maintain knowledge and skills as imaging procedures change.
- Share knowledge and provide direction to students assigned to you.
- Come up to speed quickly and ask questions of coworkers to assimilate into the department.

professional. Use their experience and knowledge to your benefit as you deliver patient care. Respond to their help by working with them cooperatively, as a new colleague and as a professional who is eager to assume a key role in their work unit. Exceed your new employer's expectations by working cooperatively and learning all you can from your new coworkers.

There will be expectations from everyone associated with your new position as a graduate radiographer. Meeting and exceeding those expectations while learning your new position will create the need to balance all aspects of your radiography practice. In doing so, you will then exceed the expectations of your program's instructors, who first guided you on your road to success.

Answers to Review Questions

Students: Welcome to my classroom!

Below are the answers to the review questions in the book. I have provided rationales where appropriate. The explanations are written for you in the same way I go over exams in my own classes. In most cases, I provide key points regarding the answer, study suggestions, or both. For other questions, such as labeled drawings or radiographs, the answers may be obvious and do not require a detailed explanation.

You will also encounter facts asked in multiple ways, challenging you to think about information from several different directions. This will help prepare you for whatever way the questions may be asked on the certification exam and will also reinforce the material by causing you to interact with it more than once. In any case, be sure to return to the chapter and use the study outline for detailed review and to reinforce concepts, facts, and illustrations that need your attention.

Now let's see if you really know the material.

Chapter 2 – Patient Care

1. D. Be sure to know all of these.
2. C. MSDS: Material Safety Data Sheets.
3. C. Elderly patients tend to be stronger earlier in the day.
4. B. Patients who have been held without food should be imaged first.
5. C. The need for insulin means patients who are diabetic should be imaged early.
6. B. It is important that either the stomach or the colon be empty, with nothing interfering from a previous procedure.
7. D. Be sure to know these basic legal concepts. D is the most complete answer.
8. B. Choice A is a violation of privacy, choice C is a form of assault, and choice D is unprofessional behavior
9. A. Keep in mind that assault does not have to involve touching the patient.
10. C. Choices A and D constitute battery. Choice B could be considered false imprisonment.
11. A. Although unintentional, it still carries with it penalties. Something that should have been done was not done.
12. B. The defendant is compared with individuals having similar experience.
13. D. The employer is always responsible for the actions of the employees. This does not mean the radiographer is not also responsible.
14. C. Choice B actually involves loss of life or limb; gross negligence does not have to involve an actual loss.
15. D. Be familiar with these facts concerning malpractice.
16. D. This means “the thing speaks for itself.” It is something that could not have occurred by natural means.
17. A. Choice 2 is incorrect because a brochure does not have to be given to the patient. Choice 5 is incorrect because patients are unlikely to completely understand all aspects of a procedure.
18. B. Choice A is incorrect because a patient who is ambulatory would not be on a cart. Choice C is incorrect because patient care must never be compromised because of short staffing. Choice D is incorrect because safety is of paramount importance.
19. A. It is very important to obtain an accurate patient history on all patients.
20. B. Be sure to review the principles of infection control.
21. D.
22. B.
23. A. Vectors involve animals.
24. B. This differs from vector-borne transmission and does not involve motor vehicles.
25. B. Choice C would be vector-borne, and choice D would be direct contact.
26. B. Choice A would be droplet transmission, choice C would be vector-borne transmission, and choice D would be direct contact.
27. B. Standard precautions were formerly called *Universal precautions*.
28. A. Standard precautions are used because we can never know for sure what each patient may carry.
29. D. Handwashing is always the first defense. However, it does not replace any other methods.
30. A. This is the ideal apparel for these procedures. Head and shoe coverings do little, and a regular uniform may carry organisms after the exam is over.
31. C. This precaution is very important to observe.
32. A. This greatly increases the chance for a needlestick injury and the transmission of pathogens.
33. A. Health care workers must always assume that pathogens are present. Washing per protocol is mandatory.
34. B. Handwashing is the best protection against transmission of pathogens.
35. C. Surgical asepsis is the complete removal of organisms.
36. A. This is much more complete than medical asepsis.
37. B. Always wash hands before beginning any procedure.
38. D. Underarms (because of perspiration), sides, and back are considered nonsterile.
39. D.

40. B. Droplet transmission involves coughs and sneezes, direct contact involves a person, and airborne transmission involves droplets and dust. Radiographers must be constantly aware of the methods of transmission.
41. D. Standard precautions must be practiced at all times.
42. D. Note the constant emphasis on handwashing. None of the other choices must be followed in every circumstance.
43. B. Gloves need not be worn with respiratory isolation. All of the other choices involve body fluids.
44. D. This prevents the patient from contracting something from the health care worker or the equipment.
45. A. Standard precautions is always the most all-inclusive.
46. B.
47. C.
48. B. Working as a team.
49. C. Great care must be taken when the patient has a urinary catheter.
50. A.
51. D. The radiographer should be constantly observing the patient for any such signs.
52. D. Choice A is incorrect because it indicates degrees centigrade. Choice B is incorrect because it indicates a range of normal temperature in degrees centigrade.
53. D. All are clear liquids.
54. B.
55. C. This is the real name for a “blood pressure cuff.”
56. D. The numerator indicates the blood pressure when the heart is pumping, the systolic pressure. The denominator indicates the blood pressure when the heart is at rest, the diastolic pressure. The symbol “Hg” stands for mercury.
57. C. Be certain to flow the oxygen at the proper rate, which is per minute.
58. C. The Heimlich maneuver is performed by a person, CPR is for cardiac/respiratory arrest, and a nasogastric (NG) tube is for introducing substances directly into the stomach.
59. A. The radiographer must always be familiar with the contents of the crash cart and what each item does.
60. C. Anaphylaxis is an allergic reaction to foreign proteins, cardiogenic shock results from cardiac failure, and septic shock occurs when toxins produced during infection cause a dramatic drop in blood pressure.
61. D. Anaphylaxis is an allergic reaction to foreign proteins, cardiogenic shock results from cardiac failure, and hypovolemic shock occurs following loss of a large amount of blood or plasma.
62. A. Cardiogenic shock results from cardiac failure, hypovolemic shock occurs following loss of a large amount of blood or plasma, and septic shock occurs when toxins produced during infection cause a dramatic drop in blood pressure.
63. D. Anaphylaxis is an allergic reaction to foreign proteins, cardiogenic shock results from cardiac failure, and hypovolemic shock occurs following loss of a large amount of blood or plasma.
64. B. Anaphylaxis is an allergic reaction to foreign proteins, cardiogenic shock results from cardiac failure, and hypovolemic shock occurs following loss of a large amount of blood or plasma.
65. A. Anaphylaxis is an allergic reaction to foreign proteins. Cardiogenic shock results from cardiac failure, hypovolemic shock occurs following loss of a large amount of blood or plasma, and septic shock occurs when toxins produced during infection cause a dramatic drop in blood pressure.
66. D. The radiographer must be able to recognize all of these. These types of questions may be on the certification exam because patient care in imaging is the responsibility of the radiographer.
67. B. Keep blood flowing to the brain by placing the patient in the Trendelenburg position, head lower than the hips.
68. C. Choice 2 is incorrect because the patient should never be left alone under any circumstances. Choice 3 is incorrect because of potentially devastating consequences; a spinal injury should always be assumed.
69. D. Be sure to be familiar with these various devices that may be present in a patient.
70. D. Be sure to be familiar with these various devices that may be present in a patient.
71. A. Nosocomial infections are those acquired in the health care setting. Most of these infections are the result of urinary catheter use. This is similar to a previous question but uses the term “nosocomial.” It’s important to know both terms.
72. C. The radiographer must be careful working around the ventilator so as to not affect its operation.
73. D. Air is a negative contrast agent. Hence, chest x-ray exams are contrast studies. For the best contrast the exposure is made on the second (and deeper) inspiration. Exposure after only one inspiration is an incomplete study.
74. The correct choices are: b, e, f, g. Choice a is incorrect because air is a negative contrast agent. Choice c is incorrect because barium should be mixed with warm water. Choice d is incorrect because nonionic contrast media do contain iodine.
75. D. This is the first and most important issue that must be taken into consideration. Be sure to read the package inserts that come with contrast agents and review the contraindications and side effects.
76. A. Extravasation involves escape of the contrast agent into the tissues surrounding the injection site.
77. D. The radiographer must be aware of all possible symptoms and know what to do immediately.
78. B. It is important to remain with the patient and observe for symptoms of a possible reaction.
79. B. Maintain composure, yet react quickly.

80. D. This is sometimes confusing, so be sure to review and be familiar with it.
81. A. Special care must be taken when venipuncture is performed. Review all of the steps in venipuncture.
82. B.
83. B. Be familiar with all the items used for venipuncture.
84. C. You already know that any list of steps for a procedure will begin with washing hands. That immediately rules out choices A and D. As soon as hands are washed, the next step must be gloving. That points directly to choice C, which is the only possible answer to this question. Always evaluate the question and read all of the possible answers. Many times you will recognize a shortcut such as this.
85. A. Venipuncture is part of a radiographer's scope of practice. It is tested on the ARRT exam. It may, however, be regulated by state law in some circumstances. Be sure to know what you can and cannot do on the job.
86. D. All relevant history and blood values must be present on the chart and consulted before the exam is begun.
87. A.
88. C.
89. C. This may indicate that a reaction is starting.
90. A. The radiographer must respond quickly and be aware that a more severe reaction may be imminent that a more severe reaction may be imminent.
91. B. Understanding of diversity is a prime part of every radiographer's practice.
92. B. The radiographer should be calling for assistance.
93. A. Although the other choices may be part of a radiographer's practice in various venues, patient education is always part of practice.
94. B. A cardiac arrest code should be called; CPR should be initiated.
95. B.
96. C.
97. D. The Rules of Ethics are enforceable by the ARRT. Be certain to understand these for the ARRT exam.
98. B. The Code of Ethics is a set of aspirational goals for radiographers' practice.
99. A. Contrast agent reactions can begin with very benign symptoms. Never leave the patient alone.
100. B.
5. C. Artificial, or human-made, radiation represents close to 50% of the total human exposure.
6. B.
7. D. Air kerma is radiation depositing energy at a specific point.
8. A. W_R , radiation weighting factor.
9. A.
10. C. This form of scatter has no effect on the image below 70 kVp and does not cause ionization. It is negligible above 70 kVp.
11. D. Pair production occurs above 1.02 million electron volts.
12. A. Photoelectric interaction results in absorption of the incident, or incoming, x-ray photon. The difference between this interaction and the rays that pass through the body unaltered to strike the image receptor is what provides contrast. Compton scatter, with its resultant fog, certainly affects contrast, but it does not produce contrast itself.
13. B. Compton scatter that is not absorbed by a grid may strike the image receptor and reduce contrast.
14. C. This is also known as classical or Thompson's scattering. It has no effect on the image below 70 kVp. It is negligible above 70 kVp.
15. A. This complete deposition of energy results in contrast being produced on the image.
16. C. No electrons are removed from the atoms being struck.
17. D. Pair production occurs at megavoltage levels.
18. A. Photoelectric effect occurs as incident photons deposit their energy in the K-shell.
19. B. Compton interaction primarily involves outer shell electrons, wherein both the electron and the photon scatter, causing the atom to become ionized.
20. A. The inner shell electron is ejected, becoming a photoelectron. The atom becomes ionized.
21. B. Because Compton interaction causes the production of scatter, a grid is needed to attempt to absorb the scatter before it reaches the image receptor.
22. B. Compton produces scatter, which during fluoroscopy or mobile procedures may expose the radiographer. Hence a lead apron is required when either one is performed.
23. D. Gy_t indicates gray in tissue.
24. C.
25. C. Gray indicating absorbed dose, a indicating in air.
26. A. Actually, choice B is a good choice as well, but A is more complete. Remember, *LET* stands for *linear energy transfer*. Choice C is incorrect because particulate radiations deposit more energy than wave radiations. Choice D is incorrect because a radiation weighting factor is used in the calculation of equivalent dose, not absorbed dose. Keep in mind that the certification exam will require you to choose the one best answer.
27. C. NCRP reports are the standards on which radiation protection practices are based.

Chapter 3 - Safety

1. B. Natural and artificial background are each approximately 50% of human's exposure.
2. D. Radon gas is part of humans' natural background exposure, which totals 50% of humans' total exposure.
3. D. Earth's atmosphere and magnetic fields help shield us from cosmic radiation.
4. A. Radon gas may be present in homes, particularly basements. Special kits should be used to determine its presence.

28. A. The NRC has the authority to enforce radiation protection standards relating to radioactive material.
29. D. Choice A is not as complete. Choices B and C are incorrect because they imply that there is no risk of damage to the individual.
30. D. ALARA stands for *as low as reasonably achievable*.
31. D. The effects mentioned in choices A and B are graphically demonstrated on dose-response curves.
32. B. It is assumed that for every dose of radiation there is some response in the organism. This does not mean there is damage, just a response.
33. A. Be sure to refer to the illustrations in [Chapter 3](#).
34. B. This forms the basis for all radiation protection standards. Be sure to review the dose-response curves in [Chapter 3](#) and be able to recognize them both from a diagram and from a written description.
35. C. The presence of a threshold means that exposures below that level will not cause a response resulting in certain conditions. For example, certain doses will not cause cataracts. Those doses are below the threshold dose.
36. D. Be sure to review the dose-response curves in [Chapter 3](#) and be able to recognize them both from a diagram and from a written description.
37. A. Increased dose equals increased probability of effects, although it does not increase severity of effects.
38. B. Deterministic effects have threshold doses below which the effects do not occur.
39. A. Note the answer is in millisievert.
40. D. For example, a 29-year-old radiographer could have a cumulative exposure of 29 mSv.
41. A. This is the dose to remember when you are asked about radiographers' annual exposure limit.
42. A. The same as radiographers' annual exposure limit.
43. A.
44. A. This is the same as the annual general public dose for infrequent exposure.
45. B.
46. D. Be sure to master all of the effective dose limits for occupational exposure and exposure of the general public.
47. C. The radiation weighting factor takes into account the source of exposure, which may be wave or particulate, and the actual amount of energy deposited per unit length of tissue—the LET (linear energy transfer).
48. A. The amount of energy deposited in tissues is directly responsible for any biologic damage that may occur.
49. C. Relative biologic effectiveness.
50. D. Remember that the cellular life cycle always begins with interphase. The reason D is the correct answer is because the three steps in interphase are listed in their proper order. This makes choice D a better answer than choice B.
51. D. Choice A defines cell division for somatic cells only.
52. C. The DNA in the cell's nucleus has been directly struck by the photons.
53. B. The master molecule is the DNA in the cell's nucleus.
54. C.
55. A. The energy is deposited in the cytoplasm, causing radiolysis to occur, which poisons the cell. This indirectly causes the damage to the cell's nucleus.
56. A. Radiolysis causes the production of hydrogen peroxide in the cytoplasm, a poison to the cell.
57. D. Most radiation-induced mutations are recessive.
58. A. Free radicals are produced as a result of radiolysis.
59. C. The master molecule is DNA, located in the cellular nucleus.
60. A. This is a result of radiolysis.
61. D. Because the cellular cytoplasm is so much larger than a cell's nucleus, it is more likely to be struck by an incoming x-ray photon. Therefore, statistically speaking, more damage will occur to cells because of indirect effect than from the less probable occurrence of direct effect.
62. B. The Law of Bergonié and Tribondeau states that cells are most radiosensitive when they are immature, undifferentiated, and rapidly dividing.
63. B. This law describes cell radiosensitivity.
64. A. This is known as oxygen enhancement ratio (OER).
65. A.
66. A. The least radiosensitive cells are nerve and muscle cells.
67. C. Epithelial cells are very radiosensitive.
68. B. Ova are more radiosensitive in young girls and after middle age.
69. B. It is important to remember that most somatic effects of exposure to ionizing radiation do not occur at doses used during diagnostic procedures, unless repeated procedures are performed at high dose levels. It is always important to practice ALARA.
70. A. Genetic effects may occur in the next generation as mutations.
71. A. Alzheimer disease and Parkinson disease have not been linked to radiation exposure.
72. C.
73. A. Gonadal shields may reduce exposure to males by up to 95%.
74. B. Use of low-mAs, high-kVp techniques always results in a lower patient dose. Focal-spot size is not related to patient dose.
75. C. The other choices all result in increased dose to the patient.
76. C. These are the three basic methods for providing optimal radiation protection.
77. C. TLDs and film badges are used for personnel measurement, whereas a Geiger-Mueller detector is used to detect the location of a specific source of radiation such as a radionuclide.
78. B.

79. B. Metal and plastic filters are incorporated into the film badge case.
80. C. This is the monitor of choice to be used when surveying radiation dose in a fluoroscopic installation. The TLD and film badge are used for personal monitoring, and the Geiger-Mueller detector surveys for radioactive particles.
81. D.
82. A.
83. D. The TLD and film badge are not digital and are used to measure personal dose.
84. A. The optically stimulated luminescent dosimeter may also be used up to 3 months.
85. B. The film badge is sensitive to extremes in temperature and humidity. It is being phased out of use.
86. C. *MMD* stands for *mean marrow dose*.
87. A. *GSD* stands for *genetically significant dose*.
88. D. Choice A is incorrect because the timer must sound an alarm after 300 seconds (5 minutes). Choice B is incorrect because the purpose of the alarm is to sound an alert. Choice C is incorrect because the alarm sounds after 5 minutes.
89. D. This is one of the three cardinal principles of radiation protection; the others are time and shielding.
90. B. This problem is different from many you have been asked: you are being given the new dose and asked to figure out what the new distance should be. You should not need to use an equation on paper or a calculator to solve this problem. The question wants you to reduce your dose to $\frac{1}{4}$ the amount you receive at a distance of 2 feet. Keeping in mind the inverse square law, you may recall that doubling distance causes the dose to drop to $\frac{1}{4}$. Therefore the correct answer would be to step back to a distance of 4 feet from the table. Choice A implies that you need to quadruple your distance from the table to reduce the dose to $\frac{1}{4}$. Choice D would result in a decrease in dose because of shielding but not the specific reduction in dose mentioned in the problem.
91. D. This thickness is the minimum that *must* be worn; 0.5-mm lead equivalent *should* be worn. This is tricky and is used here to make the point that careful reading of the question is very important.
92. C. Choice A is incorrect because holding patients should never be routine. Choice B is incorrect because a radiographer should be the last choice to hold the patient. Choice D is incorrect because routinely using student radiographers is unacceptable in practice.
93. A.
94. B. Hence this is the best place to stand whenever possible, when necessary.
95. A.
96. B. Dose area product meter
97. C. The OSL dosimeter is most sensitive, followed by the TLD and film badge.
98. B.
99. D. It is also known by its abbreviation of PBL.
100. D. Choices A, B, and C are all reasons filtration is used; however, filtration should never be adjusted by the radiographer. A qualified radiation physicist should be the only person adjusting x-ray beam filtration.

Chapter 4 - Image Production - X-ray Equipment Operation

1. B. Most views required by the radiologist are acquired digitally during fluoroscopy.
2. B. The atom may be broken down into subatomic particles but they would not have the characteristics of the element.
3. C. The information acquired must be converted from its analog form to digital for further manipulation.
4. D. Photons may also be called *quanta*.
5. A. Atomic number is the number of protons. Protons and neutrons are contained in the atomic nucleus.
6. C. The AEC is calibrated to provide the images most preferred by the radiologists.
7. D. Hence, the exposure time when using an AEC is very dependent on the kVp.
8. D. The falling load generator makes use of the maximum heat storage capacity at every mA and time combination. This allows for the shortest exposure time possible.
9. A. This necessitates the use of a rectifier to change AC to DC.
10. B. The octet rule states that no more than eight electrons can be in the outer shell. It does not stipulate that there must be eight electrons in the outer shell.
11. B. Particulate radiations are highly ionizing.
12. A. Because it has mass, particulate radiation may travel along different paths.
13. D.
14. C. Do not be fooled by choices that use different units of measurement. Light speed is expressed in miles per second, not miles per hour.
15. A.
16. D. Wavelength can be measured from crest to crest or trough to trough.
17. B. Higher-frequency waves have shorter wavelengths; lower-frequency waves have longer wavelengths.
18. D. The speed of x-ray travel is constant, regardless of the factors used to produce them.
19. B.
20. B. Attenuation means that the x-rays may be absorbed or scattered.
21. C. Be certain to review the inverse square law; always remember the inverse square relationship. The resulting answer cannot be double or half; it will be $\frac{1}{4}$ or 4 times.
22. C. Energy cannot be created or destroyed, only changed in form. The energy is merely transferred.

23. A, D. You may encounter some questions in this format.
24. A, B, C, E, G, H.
25. D. Electromagnetic induction does not require that two conductors touch each other.
26. B. Self-induction occurs in the autotransformer; mutual induction occurs in the step-up and step-down transformers.
27. B. Mutual induction occurs in the step-up and step-down transformers.
28. B. This intensifies the magnetic fields, making the transformers more efficient.
29. C. A generator at the power company converts mechanical energy to electrical energy. A motor converts electrical energy to mechanical energy.
30. C. 60 Hertz means 60 cycles per second. The voltage may be 110 or 220.
31. A. 60 cycles per second results in 120 pulses per second because it cycles back and forth 120 times per second.
32. B. Such a low ripple means higher average photon energy. High frequency is very efficient.
33. C. Three-phase power produces higher average photon energy than single-phase power.
34. B. The autotransformer is a variable transformer that operates on the principle of self-induction.
35. A. Voltage is stepped up while current is stepped down in the same proportion. A transformer is named for what it does to voltage.
36. C. The voltage is varied at the autotransformer, then boosted to kilovoltage levels by the step-up transformer.
37. D. Older x-ray machines require that the line voltage compensator be adjusted manually, whereas newer equipment lets the machine do the adjustment itself.
38. A. A transformer is named for what it does to voltage.
39. C. Thermionic emission is the boiling off of electrons from the filament wire.
40. D. The kVp meter indicates what the voltage will be after being stepped up. Hence it is prereading.
41. A. The step-down transformer is located in the filament circuit.
42. D. The timer is accurate as low as $\frac{1}{1000}$ of a second (which is 1 ms or 0.001 second).
43. B. The rectifier changes incoming alternating current from the power company into direct current for use by the x-ray tube.
44. C. The filament and focusing cup are part of the cathode assembly. The focusing cup has a negative charge at the moment of exposure so as to repel the electrons from the cathode.
45. B. The rectifier changes AC to DC.
46. D. Most equipment uses an electronic timer.
47. B. At this point, AC is changed to DC so that current is flowing in only one direction through the x-ray tube.
48. B. Current is the flow of electrons, as measured in milliamperes (mA). Hence the mA meter provides the reading.
49. A. High-speed anodes spin from 10,000 to 12,000 rotations per minute (rpm).
50. D. This type of generator allows extremely short exposure times.
51. A. These are the x-rays produced by two types of interactions that occur between incident electrons from the cathode and the tungsten atoms of the anode.
52. D. This is where voltage is boosted to kilovoltage levels.
53. C. The ionization chamber is located between the patient and the image receptor. Phototimers are seldom used.
54. D. Coupled with an electronic timer, this results in times as short as $\frac{1}{1000}$ second.
55. A. Pressing the rotor button activates a motor that turns the anode. It also begins thermionic emission at the cathode.
56. C. The ionization chamber is a wafer-thin chamber containing gas that is ionized by the x-rays passing through it. At a predetermined level of ionization, the exposure is terminated.
57. A. The machine keeps the filament warm between exposures.
58. B. Each time the rotor is activated, thermionic emission begins to occur at the filament. This heating of the filament causes tungsten to evaporate, thus slowly deteriorating the filament.
59. B. Choice C is incorrect, although many first-year students experience this activity when technologists try to hurry them from the room! Choices A and D are incorrect because unnecessarily heating the filament actually reduces x-ray tube life.
60. D. This causes a space charge or electron cloud to form around the filament.
61. B. Voltage is the force behind the movement of electrons in a circuit.
62. B. This is primarily a result of bremsstrahlung interactions at the anode.
63. C. X-rays and heat are produced at the anode. This is the result of a massive energy conversion in which more than 99% of the incident electrons' kinetic energy is converted to heat energy, while less than 1% is converted to x-ray energy. This is a clear example of the law of conservation of energy. No light is produced in the x-ray tube.
64. C. As incident electrons fly past the atomic nuclei, they are slowed, causing the production of heat and x-rays by bremsstrahlung. X-rays are also produced by the characteristic interaction.
65. A. As incident electrons dislodge K-shell electrons in the target material, outer shell electrons fall inward to fill the holes. This causes the release of energy in the form of x-rays, with energy characteristic of the difference in energy levels between the K-shell and L-shell.
66. C. More than 99% of the energy is converted to heat.
67. B, C, D, G, H, J.

68. D. Choice A is correct in stating that the x-ray beam is heterogeneous, but the second half of choice A is incorrect.
69. C. We do not often discuss the x-ray beam in this detail, but be sure to review *discrete* and *continuous* in Chapter 3.
70. A. Choice B is incorrect because soft rays have long wavelengths. Choice C is true, but it is not the primary purpose of filtration. Choice D is incorrect because long-wavelength rays are called *soft rays*.
71. B. We more commonly discuss beam quality using the term *half-value layer*. Regardless of the fraction, it is always the amount of material needed to reduce beam intensity to that level.
72. D. These are detailed statements attempting to define the amount of filtration required. D is the most complete and accurate of all the choices. A is incorrect as to amount, B is incorrect because we cannot remove all soft rays from the beam, and C is incorrect because compensating filtration is added only for certain exams.
73. D. Fill-in questions may be used on the certification exam, although they probably will not have three blanks like this one. Although we do not often deal with heat units, be sure to review the constants used in heat unit production.
74. D. kVp must be within plus or minus 10% of what is set. Be aware that some sources set the range from 4-6 kVp.
75. D.
76. A. This is where the electronic image again becomes visible.
77. B. The electrons are then accelerated toward the output phosphor.
78. C. This is the point where the rays exiting the patient strike the input phosphor and it glows with visible light, releasing electrons from the photocathode.
79. A. This is the equation used to calculate total brightness gain.
80. D. Although A, B, and C are all good answers, remember that we need to choose the one best answer, which is D. You are not likely to encounter this type of wording, but this question is a good exercise to remind you to look for the one best answer.
81. A. 13% ripple direct current, not alternating current. Three-phase, 12-pulse produces ripple as low as 4%. Single-phase ripple is 100%.
82. B. Three-phase, six-pulse produces ripple as low as 13%. Single-phase ripple is 100%.
83. D. This is why the formula for heat units for three-phase, six-pulse equipment is multiplied by 1.35.
84. B. This is why the formula for calculating heat units for three-phase, 12-pulse equipment is multiplied by 1.41.
85. C. This question asks for two answers; be sure you know what is meant by each term.
86. B.
87. C. Be sure to review these quality control standards before you take the certification exam.
88. D. Some sources state accuracy within 4-6 kVp. Be sure to review these quality control standards before you take the certification exam.
89. D. Be sure to review these quality control standards before you take the certification exam.
90. B. Be sure to review these quality control standards before you take the certification exam.
91. B. It is measured in-air at the tabletop.
92. B. Automatic brightness control
93. D. Be sure to review these quality control standards before you take the certification exam.
94. A. Be sure to review these quality control standards before you take the certification exam.
95. B. Be sure to review these quality control standards before you take the certification exam.
96. C. Be sure to review these quality control standards before you take the certification exam.
97. A. This provides for actually radiographing an object.
98. B. Note that this question is asking the amount of mA actually used and not the setting of the mA on the control panel.
99. C. Choices A, B, and D are also marks on the focal track, but they are caused by malfunctions.
100. A. Representatives of The Joint Commission (TJC) regularly visit health care facilities to examine documentation of compliance with quality control and quality assurance standards.

Chapter 4 - Image Production - Digital Image Acquisition

1. B. Dose area product
2. A.
3. B. mAs controls the electrons flowing through the x-ray tube and striking the anode. Therefore it directly controls the number of x-rays produced. In digital imaging, brightness may be manipulated using window level.
4. A. Whatever is changed in mAs directly impacts receptor exposure.
5. C. mAs controls the electrons flowing through the x-ray tube and striking the anode. Therefore it directly controls the number of x-rays produced.
6. C.
7. B. Photostimulable phosphor.
8. D. mAs is a quantitative factor.
9. D.
10. D. kVp controls the wavelength and penetrating ability of the beam. In digital imaging window width can be used to manipulate contrast.
11. B. It is governed by the 15% rule.
12. A.
13. A, B, D. Think about each answer individually before answering this question.

14. B. The use of the 15% rule to increase kVp results in double the density. In equal receptor exposure as doubling mAs.
15. C.
16. D. This is another way of asking about the inverse square law.
17. A.
18. B, C, E, F. These factors all impact the geometry of the image.
19. B. The monitor must be high resolution.
20. A.
21. B.
22. D. Overall, the beam is harder so contrast may be lower.
23. C.
24. B. Due to a change in SID resulting from the tube angle
25. C. The intensity of the x-ray beam is actually a little higher toward the cathode side of the tube.
26. B. Anode heel effect
27. D. Without contrast, produced by differential absorption of the x-ray beam, detail cannot be visible.
28. A.
29. D. This is the space from center to center of adjacent pixels.
30. C, E, F.
31. A, B, D. This is the opposite of question 30.
32. B.
33. D. Photoelectric interaction results in absorption of incoming photons. It is also very influenced by the atomic number, not atomic mass, of anatomic structures.
34. D. Compton interactions produce scatter, which causes contrast to decrease.
35. D. Rays that have been removed from the beam must be restored by increasing mAs. The area being irradiated still remains smaller.
36. D. Many of the scatter photons are being absorbed by the grid, resulting in higher contrast.
37. C. The overall wavelength of the beam is shorter, resulting in lower contrast.
38. D.
39. D. Controlled by SID, OID, focal-spot size, pixel pitch
40. A, D, F.
41. B. Pixel pitch is very important to detail in digital imaging.
42. B.
43. A. Choices B, C, and D are all examples of distortion.
44. B.
45. B. The optimum conditions are longer SID and shorter OID.
46. D. This results in the part appearing shorter than it really is.
47. A. This results in the part appearing longer than it really is.
48. B. Digital imaging takes into account the total dose to the patient.
49. C.
50. B. But erasing daily is better and preferred.
51. A.
52. A. However, smoothing may negatively impact resolution.
53. A. Detection of collimated edges is crucial to obtaining an accurate histogram.
54. D. This is in congruence with ALARA.
55. A.
56. D.
57. C. Technologists' monitors are not usually high definition (HD).
58. D. Total exposure reaching the IR
59. D.
60. B. This enhances visibility of detail.
61. A. This may allow for higher kVp and lower mAs, which causes an increase in quantum mottle or noise.
62. C. More total exposure is required to produce a useable image.
63. C.
64. A. The more the image is processed the greater the opportunity for image degradation.
65. B. There is a greater difference between the signal and any noise that may be present.
66. A.
67. C.
68. C. Expressed as H/D. Did you notice how choice B tried to get your attention? Be sure to read the entire answer.
69. D.
70. A, B, F. Keep in mind that grids are used over part thickness of 10 cm; the grid conversion factors are used to change mAs, not kVp; and grids do not prevent the production of scatter, they just try to absorb it after it has been produced.
71. B. These grids can be used only within a certain range of SIDs, as stated on the label on the grid.
72. D. Using a focused grid outside of its grid radius will result in grid cutoff.
73. C. But crosshatch grids prevent angling of the tube and are extremely susceptible to grid cutoff.
74. B. Choice A is incorrect because decreased density in the middle would not be caused by use of an inverted parallel grid. Choice C is incorrect because density would decrease in the middle of this radiograph. Choice D is incorrect because density could decrease across the entire radiograph, depending on how the grid has been positioned.
75. A. The grid conversion factor or Bucky factor for a 12:1 grid is 5 times the original mAs.
76. D. Even though not used much anymore, it is particularly effective on lateral cervical spine radiographs.
77. D. Technique charts are generally not needed for exams when AECs are used.
78. D. Automatic exposure controls are set to terminate the exposure after a certain amount of radiation has passed through the ionization chamber. Consequently, changes in kVp will have no effect on receptor exposure.

Some effect on contrast may occur if the change in kVp is substantial.

The following answers relate to terminology used in digital imaging. Be certain to review these basic concepts. Keep in mind the ARRT exam will not ask questions related to specific brands of equipment made by various manufacturers. Therefore, the concepts tested should be broad in nature, similar to these questions.

79. B.
80. C.
81. B.
82. D.
83. B.
84. B.
85. B.
86. C.
87. B.
88. D.
89. B.
90. B.
91. A. Modulation transfer function
92. D.
93. D.
94. B. Picture element
95. A.
96. C.
97. B.
98. A.
99. B.
100. A.

Chapter 5 - Procedures

1. D. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
2. A. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
3. D. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
4. C. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
5. B. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
6. A. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
7. D. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
8. A. Be sure you can identify each body habitus by word description and by diagram. Review them in [Chapter 5](#).
9. B. Reread each of the other choices carefully, and you will see that this is the one best answer. Other choices have certain valid points, but only this one covers the most important aspects of pediatric radiography.
10. C. Although choices A and B are certainly valid, choice C takes precedence over all the others. Choice D is incorrect because the radiographer may take additional projections as needed.
11. D. Choice A is incorrect because it does not mention that a physician has approved such removal. Choice B is incorrect because it is not necessary for a radiologist to provide the order. Choice C is incorrect because the patient's attending physician may direct that the collar be removed.
12. A. This plane divides the body into superior and inferior portions.
13. C. This plane divides the body into equal right and left portions.
14. A. A transverse plane passes crosswise through the body at right angles to its longitudinal axis.
15. B. This plane divides the body into anterior and posterior portions.
16. D. This plane would still divide the body into right and left portions, but they would be unequal.
17. A. A ball-and-socket joint has a rounded head of one base moving in a cuplike cavity; it is capable of movement in an infinite number of axes.
18. A. The primary example is the hip. Do you see how questions can be worded differently to ask for basically the same information? Reread questions 17 and 18. Be sure to really know what you are studying, so you can choose the correct answer no matter how the question is worded.
19. C. An example of a hinge joint is the elbow. Do you see why patients with elbow injuries are in so much pain? Any movement whatsoever causes great discomfort.
20. D. Motions can be flexion, extension, adduction, and abduction; an example is the carpometacarpal joint of the thumb.
21. B. An example of this type of joint is the proximal radioulnar articulation.
22. B. These two may not necessarily be AP and lateral. The important point is the part may be viewed from two angles 90 degrees to one another.
23. D. This allows for maximum visualization of the lower ribs.
24. A. All of the answers are valid. Be sure to know at least the basic points regarding arthrography, even though it is gradually being replaced by MRI.
25. D. Choice 1 is incorrect when cervical myelography is performed. Choice 2 is incorrect because contrast agents used in myelography are water soluble. Choice 4 is incorrect because gravity is used to distribute the contrast medium. Choice 5 is incorrect when lumbar myelography is performed. Be sure to know at least the basic points regarding myelography, even though it is gradually being replaced by MRI.

26. A. Intravenous urography is gradually being replaced by CT.
27. B. Notice how similar choices A and B are. Read carefully, and then choose only the correct answer.
28. A. Choice B is incorrect because the ulnar surface is in contact with the film. Choice C is incomplete; parallel with what? Choice D is incorrect, because using the fastest imaging system is not imperative.
29. C. Choice 2 is incorrect because the thumb should be up. Choice 4 is incorrect because the elbow should be flexed 90 degrees. Choice 5 is incorrect because the central ray should be directed to the midpoint of the forearm.
30. B. Choice 1 is incorrect because the forearm and humerus should be in the same plane. Choice 4 is incorrect because the hand must be supinated.
31. A. Choice 1 is incorrect because the hand is not pronated. Choice 4 is incorrect because the arm may be slightly abducted. Notice the difference one letter can make in a medical term (adducted vs. abducted). Read carefully.
32. C. Choice 2 is incorrect because no angle is put on the central ray. Choice 4 is incorrect because respiration should be suspended.
33. B. Choice A is incorrect because it would not be appropriate to double-expose the IR. You may put both joints on one IR, but not both joints with and without weights. Choice C is incorrect because both joints may not necessarily be placed on the same IR. Choice D is incorrect because the patient should be standing, if possible, and respiration must be suspended.
34. D. Choice 1 is incorrect because an AP projection is commonly used to radiograph the clavicle. PA may be used, but it is not mandatory. Choice 2 is incorrect because the direction of tube angle in the PA axial projection should be caudad.
35. A. Choice 2 is incorrect because the affected scapula should be centered to the IR.
36. D. Be sure to review all of the fractures listed in the chapter.
37. A. Be sure to review all of the fractures listed in the chapter.
38. C. This is characterized by degeneration of one or several joints. The patient is likely to be in great discomfort.
39. B. A giant cell myeloma is a type of tumor that is easy to penetrate.
40. C. These patients require slow and careful handling.
41. B. Choice 2 is incorrect because the plantar surface rests on the IR. Choice 4 is incorrect because the central ray is directed to the base of the third metatarsal.
42. A. Choice 2 is incorrect because the plantar surface of the foot should be perpendicular to the cassette. Choice 4 is incorrect because the central ray enters the foot at the base of the fifth metatarsal.
43. B. Choice 2 is incorrect because this rotates the ankle too far. Choice 3 is incorrect because rotation should be adjusted 15 to 20 degrees for the mortise joint. Choice 4 is incorrect because rotation should be at 45 degrees for the bony structure.
44. D. Choice 3 is incorrect because the patient should be rolled toward the affected side. Choice 6 is incorrect because the fibula should appear posterior to the tibia on the radiograph.
45. C. Choice 3 is incorrect because the patella must be perpendicular to the IR. Choice 4 is incorrect because the central ray should be directed 5 degrees cephalad.
46. A. All of these conditions are needed for an accurate study of the patella in the tangential projection.
47. D. Choice A is the opposite of the correct answer. Choice B is incorrect; both joints should be included. Choice C is incorrect; the patient should be supine.
48. D. Direction of the central ray for some projections can be very specific. Notice how similar the choices are for this question. Be sure to know central ray directions for all major projections.
49. B. Hangman's fracture is caused by acute hyperextension of the head on the neck; the arch of C2 is fractured and there is anterior subluxation of C2 onto C3.
50. B. Note the opposite way of asking question 49. Be prepared for questions to be asked either way.
51. D. Such patients require special care and handling while positioning. Let them take it at their own speed.
52. C. The pars interarticularis is between the superior and inferior articular processes of a vertebra.
53. A. Any cervical injury must be handled with the utmost care.
54. B. Choice 4 is incorrect because the lateral projection of the cervical spine is always taken with the cervical collar in place until the finished image has been cleared by a physician. Choice 5 is incorrect because it would distort the image.
55. C. Choice 2 is incorrect because no angulation is placed on the central ray. Why not a falling load generator? It is not possible on such a machine to get long exposure times, which you want to have for the "breathing technique" used for a lateral projection of the thoracic spine. If all generators in a department are the falling load type, you must do the best you can. Little blurring will occur, however, because the exposure time is so short.
56. D. Choice 2 is incorrect because the hips and knees should be flexed.
57. C. Choice A is the opposite of the correct answer. Choice B is incorrect; the part should be elevated 25 to 30 degrees from the table. Choice D is incorrect; there is no angle on the central ray.

58. A. Be sure to keep the central ray paths clear among all the projections you have learned.
59. D. Emphysema is a condition in which air is trapped in the alveoli, which hyperinflates the lungs and makes them much easier for x-rays to penetrate.
60. A. There is a fine line between just learning medical terminology and knowing something about pathologic conditions. Be sure to review the major pathologic conditions presented in this chapter. Pathology is on the ARRT exam.
61. D. This is another way to ask about emphysema.
62. D. Because emphysema makes the lungs so easy to penetrate, automatic exposure controls sometimes cannot shut off fast enough, which causes the film to be too dense.
63. B. Even if you are not sure about an answer, this one is a good example of how to narrow your choices. Notice the similarity between the word “bronchial” in the stem of the question and the word “bronchogenic” in choice B. If you encounter questions about which you are not totally sure, look for such similarities. In many cases they will lead you to the correct answer.
64. C. These letters stand for *chronic obstructive pulmonary disease*.
65. A. Choice 2 is incorrect because the shoulders should be rotated anteriorly, moving the scapulae out of the field of the ribs. Choice 4 is incorrect because respiration should be on full inspiration.
66. C. Choice A is incorrect because the body should be rotated only 15 to 20 degrees. Choice B is incorrect because this is an anterior oblique. Choice D is incorrect because breathing causes a blurring of lung detail. A falling load generator should not be used because it inhibits the ability to use long exposure times that run several seconds.
67. B. Choice A is incorrect because a PA projection causes superimposition of the spine and a lateral projection is not possible. Choice C is incorrect because respiration should be suspended. Choice D is incorrect because an AP projection would increase magnification.
68. D. Rickets is a condition that is easy to penetrate.
69. B. Paget’s disease is a nonmetabolic bone disease.
70. C. Osteoporosis is very easy to penetrate. Manual technique should be used if possible. An AEC often cannot terminate the exposure fast enough, resulting in an overexposed image. Be knowledgeable about manual techniques you may use in these types of situations.
71. A. Hydrocephalus is harder to penetrate.
72. C. These patients may be frail and brittle. Be sure to take your time with them.
73. D. D is the more complete answer when compared with choice C. There is no angle on the central ray.
74. B. Be sure to read carefully and distinguish between parallel and perpendicular. Even though head radiography has been largely replaced by computed tomography, basic skull positioning may still appear on the Registry exam.
75. D. However, there are still situations where the radiographer may be called upon to perform skull imaging using conventional positioning.
76. C. Choice B is incorrect because of the degree of angulation. Choice D is incorrect because it indicates that the head is resting on the nose.
77. A. Read choices B, C, and D carefully and note that only one or two words are different from those in the correct answer. It is not likely that the questions on the certification exam will have answers this similar. The question is worded this way to help you really sort out the specific details of this projection. How did you do? Do you see why choice A is correct?
78. D. Choices A and B are clearly incorrect because this is a submentovertical projection. Choices C and D differ only in the perpendicular versus parallel placement of the IOML.
79. C. Whereas the Waters projection also shows all of the paranasal sinuses, the upright projection will best indicate fluid levels.
80. C. This will be demonstrated during an upper GI series.
81. D. Intestinal obstructions are sometimes difficult to image properly because the obstruction may be more difficult to penetrate while the backed-up gas may be quite easy to penetrate. Again, using a manual technique may be beneficial.
82. B. Other portions of the bowel may be perfectly normal. These patients are usually in some degree of discomfort.
83. D. Bowel obstructions make the patient extremely ill and uncomfortable. Consider using a manual technique.
84. A. This form of cancer requires immediate intervention. Being familiar with the various pathologic conditions you will encounter makes radiography that much more interesting. Look up any conditions with which you are unfamiliar.
85. C. The other conditions are all in the bowel.
86. D. This condition is characterized by large amounts of gas; use care when choosing the exposure technique.
87. A. Patients with diverticula may be nearly asymptomatic or in great discomfort.
88. C. This condition may be characterized by projectile vomiting. Have emesis basins at hand.
89. B. This is a very painful condition for the patient. Work quickly.
90. B. Take careful note of the degree and direction of rotation.
91. D. This is the most accurate and complete answer. The others are incomplete.
92. C. Because this is an LPO, the patient must be supine. That rules out choices A and D.
93. A. Choices B and D can immediately be eliminated because they place the patient prone. A lateral decubitus position requires the patient to be lying on the side.

94. C. This stands for *endoscopic retrograde cholangiopancreatography*.
95. D. These are harder to penetrate.
96. C. Wilms' tumor is seen primarily in children.
97. A. PKD is harder to penetrate.
98. C. Wilms' tumor is harder to penetrate.
99. B. Patients are typically in extreme pain.
100. C. Questions on RPO and LPO kidneys tend to be confusing because it is hard to remember which kidney ends up perpendicular or parallel. Be sure to review these projections.

Chapter 6 - Challenge Tests - Test #1

Answers to Challenge Test Number 1

1. B. These changes may include absorption and scatter radiation. Radiation that emerges from the patient is called *exit radiation*.
2. C. Photoelectric interaction produces contrast as a result of the differential absorption of the incoming x-ray photons in the body's tissues. X-rays are completely absorbed in some areas of the patient. Choices A and B are types of scattering. Pair production does not occur in radiography.
3. A. Compton interaction produces scattered photons that emerge from the patient in divergent paths and may expose the radiographer or radiologist. The photoelectric effect is responsible for total absorption of the incoming x-ray photon during attenuation. Coherent scattering and pair production occur when x-ray energies are beyond the moderate range used in radiography.
4. B. This stands for Gray in-air.
5. A.
6. C.
7. D. LET varies because of different levels of ionization. It occurs with high-ionization radiations, such as neutrons and alpha particles, and during x-ray and gamma-ray procedures.
8. D. The becquerel measures the quantity of radioactive material.
9. C. This describes a dose-response curve, such as linear-nonthreshold.
10. B. Medical x-rays are an artificial source of ionizing radiation; diagnostic procedures account for the largest source of artificial radiation exposure to humans. Natural background radiation is that contained in the environment.
11. A. There is a definite safe, or threshold, dose at which cataractogenesis does not occur. Choice C does not make logical sense because the question states that cataractogenesis does not occur at low levels of radiation exposure. Occupational dose is the amount of radiation to which radiographers are exposed. Study tip: When there are opposite choices (e.g., threshold and nonthreshold), one of them is usually the correct answer.
12. A. Be sure to review stochastic and deterministic. The severity, not the probability, of deterministic effects increases with increased dose. Direct effect and indirect effect differentiate whether the initial ionizing event occurs on the most radiosensitive molecule (direct effect) or on another molecule (indirect effect).
13. A. Occupational cumulative exposure is determined by multiplying years of age times 10 mSv. Study tip: Be sure to read each choice carefully and entirely before choosing an answer.
14. D. This limit is important to keep in mind when considering ALARA.
15. D. Lead, not aluminum, equivalent will absorb most of the scatter radiation energy. Because the secondary barrier is located where only scatter or leakage occur, $\frac{1}{32}$ -inch lead equivalent is sufficient. Primary barriers require $\frac{1}{16}$ -inch lead equivalent.
16. C. Photons lose considerable energy after scattering.
17. A. The dose is determined by the inverse square law. The distance was halved; therefore, the dose went up 4 times (not 2 times).
18. A. The minimum source-to-skin distance for fixed fluoroscopes is 15 inches; for portable fluoroscopes, 12 inches (although 15 inches is preferred). Be sure to review these required distances.
19. A. Gonadal shielding is even more effective for males, reducing the gonad dose by up to 95%.
20. D. Target theory states that for a cell to die after radiation exposure, its master, or target, molecule (DNA) must be inactivated. Direct effect occurs when radiation transfers its energy directly to the DNA. The doubling dose is the dose of radiation necessary to produce twice the frequency of genetic mutations as would have occurred in the absence of the radiation. Be sure to review these concepts.
21. B. The dose equivalent at which blood count is depressed is much higher than diagnostic levels but may occur during radiation therapy or interventional procedures.
22. D. This is the definition of free radicals, which can cause biological damage to the cell. Some free radicals may chemically combine to form hydrogen peroxide. Radiolysis results in an ion pair in the cell: a positively charged water molecule and a free electron.
23. D. According to target theory, substantial research indicates that DNA, contained in the cellular nucleus, is the master molecule. Hydrogen peroxide is a poison that can cause damage to the cell. A free radical is a highly reactive ion with unpaired electrons in the outer shell. RNA transmits genetic instructions from the nucleus to the cytoplasm of the cell.
24. A. *Cytogenesis* refers to the origin and development of cells. *Spermatogenesis* is the development of spermatozoa. *Organogenesis* refers to the formation and differentiation of organs during embryonic development. Germ cell division is called *meiosis*.

25. D. Although all of these effects may occur, the most common result of LET is no effect. However, ALARA must still be practiced.
26. C. Adult nerve tissue and even immature cells, which are very radiosensitive, require doses of radiation higher than those used in medical diagnostic procedures, although ALARA must still be practiced.
27. D. Such doses still pose a risk to the embryo-fetus, so ALARA must still be practiced.
28. D. *As low as reasonably achievable* is a concept used in radiography to protect both the patient and the radiographer.
29. A. Epithelial tissue and reproductive cells, including immature sperm cells, are highly radiosensitive. On the other hand, adult nerve tissue requires very high doses to cause damage, although ALARA must still be practiced because once cells are damaged, repair may not take place.
30. B. In general, these take large doses to manifest themselves.
31. D. Repeats double the dose to the patient for each exposure.
32. C. This is what may cause harmful effects.
33. D. Ionization is multifaceted. Study tip: Be sure to read all choices before choosing an answer. Choice A is true, but you must read all the choices to see that choice D is the correct answer.
34. A. Cell damage may be exhibited as loss of function or abnormal function.
35. C. Damage from somatic effects is evident in the organism being irradiated. Most of the time these effects are benign. Genetic damage is passed to the next generation.
36. A. Somatic effects are evident in the organism being irradiated.
37. C. There is no control over natural background radiation, which has been present in the environment since the formation of the universe. Choices A, B, and D all refer to artificially produced radiation, that made by humans. Study tip: Choices A, B, and D are basically the same; they are too similar for one of them to be the correct answer. Choice C is the only unique answer.
38. C. Natural background radiation, which has been present since the formation of the universe, accounts for 50% of human exposure. The greatest single source is radon.
39. B. You can safely assume that natural background radiation would be below the annual recommended limits of exposure from diagnostic imaging. Although all choices are below this limit, choice B is correct. Background exposure is not high but is always present.
40. C. Radon, which exists as a gas, accounts for 55% of human exposure to natural background radiation.
41. D. The huge increase in the use of CT since the 1980s has primarily caused this increase.
42. B. The primary protective barrier in the wall extends from the floor to a height of 7 feet.
43. A. This accounts for the largest increase in radiation exposure since 1980.
44. D. Mitosis describes division of somatic cells.
45. A. Although there are several reasons for using collimation and gonadal shielding, the single most important is to attempt to keep mutations from occurring.
46. B.
47. D.
48. C. Air kerma is the x-ray energy being deposited in a specific location.
49. B, F.
50. D. Coulombs per kilogram is used less frequently.
51. B.
52. B.
53. B.
54. B.
55. A.
56. D.
57. C.
58. D.
59. B. One millisecond
60. C.
61. D.
62. D.
63. A.
64. C.
65. A.
66. B.
67. A.
68. A.
69. B.
70. A.
71. C.
72. B.
73. C.
74. B. Window width adjusts gray scale.
75. C.
76. B. Window width adjusts contrast. Window level adjusts brightness.
77. D.
78. A.
79. D.
80. D.
81. D. This is inverse square law.
82. D. The image cannot be minified.
83. C.
84. D.
85. B. Daily is best.
86. C.
87. B.
88. B.
89. A.
90. A.
91. C. The total amount of lead in the grid
92. A.

93. B.
94. C.
95. C.
96. B.
97. C. It has a short SID.
98. A. It has a long SID.
99. C. Fewer Compton interactions are occurring.
100. C.
101. C.
102. C.
103. B.
104. C.
105. D.
106. A. Be sure to know all of the major anatomy of the urinary system and be able to identify it on radiographs and drawings.
107. B.
108. C.
109. A.
110. D. Be sure to know all of the major anatomy of the colon and be able to identify it on radiographs and drawings.
111. D.
112. C.
113. A.
114. B. Be sure to know all of the major anatomy of the stomach and be able to identify it on radiographs and drawings.
115. B.
116. D.
117. A.
118. C. Be sure to know all of the major anatomy of the lumbar spine and be able to identify it on radiographs and drawings.
119. A.
120. C. Be sure to know all of the major anatomy of the cervical spine and be able to identify it on radiographs and drawings.
121. D.
122. C.
123. B. Be sure to know all of the major anatomy of the hip and be able to identify it on radiographs and drawings.
124. B.
125. C.
126. D.
127. A. Be sure to know all of the major anatomy of the knee and be able to identify it on radiographs and drawings.
128. B.
129. D.
130. A.
131. C. Be sure to know all of the major anatomy of the hand and be able to identify it on radiographs and drawings.
132. D.
133. B.
134. C.
135. A.
136. B.
137. C.
138. D.
139. A. Be sure to know all of the major anatomy of the wrist and be able to identify it on radiographs and drawings.
140. D.
141. B.
142. C.
143. A. Be sure to know all of the major anatomy of the shoulder girdle and be able to identify it on radiographs and drawings.
144. D.
145. B.
146. A.
147. B.
148. C.
149. D. Be sure to know all of the major anatomy of the foot and be able to identify it on radiographs and drawings.
150. D.
151. C.
152. A.
153. B. Be sure to know all of the major anatomy of the elbow and be able to identify it on radiographs and drawings.
154. B.
155. C.
156. D.
157. A. Be sure to know all of the major anatomy of the skull and be able to identify it on radiographs and drawings.
158. D.
159. C.
160. B.
161. A. Be sure to know all of the major anatomy of the facial bones and be able to identify it on radiographs and drawings.
162. A.
163. C.
164. D.
165. C.
166. D.
167. B.
168. B.
169. D.
170. C.
171. C.
172. D.
173. B. Infectious waste containers are usually made of plastic, but not always. The best answer contains the detail most relevant to the radiographer: You should place infectious waste in containers or bags properly labeled as to the type of waste therein. Study tip: Look out for words like “always” and “never.” Choices containing these words are usually not the best answer.

174. C. Sharps should never be recapped.
175. A. Assault, battery, false imprisonment, and invasion of privacy are all types of intentional misconduct, but assault can be defined as anything the radiographer does that causes fear in a patient. Assault can be verbal as well as physical. A remark that causes a patient to feel apprehensive about being injured is considered assault.
176. D. Assault, battery, false imprisonment, and invasion of privacy are all types of intentional misconduct. Invasion of privacy is a violation of confidentiality of any patient information.
177. D. Negligence, the neglect or omission of reasonable care, is a kind of unintentional misconduct. This kind of misconduct is considered unintentional because it arises from an indirect action (not providing care), rather than an overt action (doing harm). Gross negligence is the kind that demonstrates reckless disregard for life or limb. *Respondeat superior* is the legal doctrine that states that an employer is liable for an employee's negligent act. *Res ipsa loquitur* is the legal doctrine that states that the cause of negligence is obvious.
178. B. Pulse is an important vital sign. To detect the presence of bradycardia, the pulse must be taken accurately. Tachycardia is defined as more than 100 beats per minute. Study tip: When two choices are similar (e.g., "More than 100 beats per minute" and "Fewer than 60 beats per minute"), one of them is often the correct answer.
179. A. All the choices except choice A are pieces of equipment, so they would not contain all equipment and drugs needed for respiratory or cardiac arrest. Be sure to know the location of the crash cart and its contents. Study tip: Be sure to read the questions carefully. Common sense can sometimes help you eliminate incorrect choices.
180. D. A sphygmomanometer is also called a *blood pressure cuff*.
181. Aqueous iodine compound may be used if surgery is imminent, for example, in the case of perforated ulcers or a ruptured appendix, where barium could be a surgical contaminant.
182. C. Most symptoms of contrast media reactions are observable, so patients must be carefully watched when contrast agents are used.
183. A. The difference between medical and surgical asepsis is that surgical asepsis removes all microorganisms. Study tip: When two choices are similar (e.g., "Medical asepsis" and "Surgical asepsis"), one of them is often the correct answer.
184. A. Always take a history of the patient! *MI* stands for *myocardial infarction*. *Bx* and *hs* are not medical abbreviations.
185. D. *MI* stands for *myocardial infarction*. *Hx* stands for *history*, and *CVA* stands for *cerebrovascular accident*. *HA* is not a medical abbreviation.
186. C. Because residual barium could compromise any exams that follow barium studies, barium studies should be scheduled last.
187. C. The Centers for Disease Control and Prevention has specific guidelines that must be followed.
188. A. No special equipment is needed to measure respirations.
189. D. The word *nasal* in the answer helps lead you to the correct response.
190. D. These are items commonly encountered throughout the day. Contact transmission is person to person. Airborne transmission involves such things as droplets and dust. Droplet transmission is a result of coughs and sneezes.
191. C. The activity of the heart is electrical; therefore stimulating the heart with current commonly jolts it back into proper rhythm.
192. D.
193. D. *Health Insurance Portability and Accountability Act (HIPAA)*. *CDC* stands for *Centers for Disease Control and Prevention*. *HHS* stands for the *Department of Health and Human Services*. *ALARA* stands for *as low as reasonably achievable*.
194. D. *Cardio* refers to the heart. Hypovolemic shock is a result of loss of great amounts of blood. Septic shock occurs when toxins produced during an infection cause a dramatic drop in blood pressure. Neurogenic shock causes blood to pool in the peripheral vessels.
195. B.
196. B.
197. A.
198. B.
199. B.
200. A.

Chapter 6 – Challenge Tests – Test #2

Answers to Challenge Test Number 2

1. C. More energy is deposited by particulate forms of radiation than by waveforms of radiation.
2. D. All are examples of radiation effects on the individual being exposed.
3. D. Choice A is incorrect because photoelectric interaction produces contrast.
4. C.
5. A. Choice B is incorrect because no level of radiation is considered completely safe. Choice C is incorrect because no such immunity has been proved. Choice D is incorrect because the effective dose limit for the general public is 5 mSv per year.
6. B. High-LET radiation is depositing a lot of energy in the tissues, causing much ionization.
7. C. It is assumed that for every dose of radiation, a response occurs in the atoms of the person being irradiated.
8. B. Cells such as epithelial, ovarian, and sperm cells

9. D. Because the cellular cytoplasm is substantially larger than the cellular nucleus, it is more likely to be struck by incoming x-ray photons. Thus most of the cellular response to radiation is indirect. The direct effect results from x-ray photons directly striking the cellular nucleus.
10. A. Indirect effect occurs when radiation strikes the cytoplasm of the cell. Target theory states there is a master molecule that governs cellular activities, that is, DNA.
11. B.
12. D. Be sure to review the units of radiation measurement.
13. B. This is human-produced radiation.
14. A.
15. A.
16. C. Be sure to get the amount and unit of measurement correct!
17. D. This is the definition of mean marrow dose (MMD). It is not called the bone dose. The doubling dose is the amount of radiation that causes the number of mutations in a population to double. The GSD is the genetically significant dose.
18. A. This describes the GSD, or genetically significant dose (not called genetic dose). The doubling dose is the amount of radiation that causes the number of mutations in a population to double. Mean marrow dose is the average dose to active bone marrow as an indicator of somatic effects on population.
19. B. Shielding of lead (Pb) equivalent, not aluminum (Al) equivalent, is used to protect from scatter radiation. The requirement for a lead apron is at least 0.25-mm Pb equivalent; it should be 0.5-mm Pb equivalent, which is what the question asks. There is a difference between “shall” and “should.”
20. B. The requirement for a thyroid shield, if used, during fluoroscopy is 0.5-mm lead, not aluminum, equivalent.
21. D. Primary protective barriers consist of $\frac{1}{16}$ -inch lead equivalent, not aluminum equivalent. Secondary protective barriers consist of $\frac{1}{32}$ -inch lead equivalent.
22. C. Primary protective barriers in the wall must extend to a height of at least 7 feet because this height is taller than most people.
23. C. The secondary protective barrier extends from where the primary protective barrier ends to the ceiling with a $\frac{1}{2}$ -inch overlap.
24. D. The protective curtain hanging from the fluoroscopy tower must be at least 0.25-mm Pb, not Al, equivalent. Be sure to remember all the shielding requirements.
25. D. Be sure to remember all the shielding requirements.
26. C. Filters made of aluminum and copper are placed in the film badge to measure the x-ray energy striking the film badge. This is a measure of the beam's quality, not quantity. Film badges do not measure the source or type of x-ray beam.
27. D. A film badge should not be worn longer than 1 month, at which time a film badge report with readings is returned to the institution.
28. B. Lithium fluoride crystals, which release energy as visible light when heated, are used to record dose in TLDs.
29. B. TLDs are heated and release visible light energy to indicate dose. This energy is read by a photomultiplier tube.
30. B. OSL dosimeters are very sensitive. This feature, along with their wide dynamic range, greater accuracy, and long-term stability, makes them ideal for personnel monitoring.
31. C. The recording material in an OSL dosimeter is aluminum oxide, which is then scanned by a laser beam. Film badges use film as the recording material; TLDs use lithium fluoride.
32. C. The energy stored in an OSL dosimeter is released by exposure to a laser. The energy is then released as visible light. The energy stored in a TLD is released by heat.
33. C. OSL dosimeters can be worn for up to a quarter, although in many cases they may be changed monthly.
34. D. One of the key advantages of OSL dosimeters is the capability of reanalysis for confirmation of dose, which is especially important if a dose is in question.
35. C. The flat contact shield, which consists of a piece of lead placed over the gonads, is most commonly used. It may be as simple as a lead apron properly placed. The shadow shield, which is suspended from the x-ray housing and does not come in contact with the patient, is used when sterile technique is required. A collimator is not considered a gonadal shielding device.
36. D. Low mAs reduce the amount of radiation striking the patient. Choosing the optimum kVp for the part being radiographed increases the quality of the x-ray beam. Low kVp, high mAs would result in the opposite.
37. D. The fastest practical speed for the part being radiographed should be used to reduce patient dose. Slow speed increases patient dose.
38. A. Be sure to review the source-to-skin distance requirements.
39. D. Added filtration is adjusted by a medical radiation physicist, not by the radiographer. Compensating filtration devices, such as wedge filters, are manipulated by the radiographer.
40. B.
41. C. Radiation effects manifested in the next generation are called genetic effects.
42. C. Radon is present in the environment as a gas, frequently found in the basements of older homes.

43. C. As a result of differential absorption of the beam, photoelectric effect produces contrast on the image.
44. C. Air kerma has replaced coulombs per kilogram.
45. B. W_R is used to modify the absorbed dose amount to account for greater damage caused by high-LET radiations. X-rays have lower LET so the W_R is only 1.
46. A.
47. A.
48. B.
49. D. The cytoplasm is larger than the nucleus.
50. B.
51. B.
52. B.
53. A.
54. D.
55. D. Answer B is incorrect because of "silicone," which is not the same substance used in rectifiers.
56. C.
57. D.
58. B.
59. B.
60. D.
61. A.
62. C.
63. D.
64. C.
65. A.
66. B. 2% of the SID
67. B. Some sources indicate it must be within 4-6 kVp.
68. D.
69. B.
70. D. Highest mAs and highest kVp
71. B. Lowest mAs and lowest kVp
72. C.
73. A.
74. A.
75. C. The 15% rule
76. A.
77. A.
78. B.
79. C.
80. A.
81. A.
82. B. It's important to choose the correct algorithm for each exam.
83. C.
84. B.
85. A.
86. D. Picture Archiving and Communication System
87. A.
88. C.
89. B.
90. D.
91. B.
92. B.
93. A. The line-focus principle in action
94. A. This is a directly proportional relationship.
95. B. This is the inverse square law.
96. A.
97. B.
98. B. The beam is more penetrating.
99. A. Scatter is absorbed by the grid.
100. A.
101. B.
102. B. This results in magnification of the image.
103. A.
104. D.
105. C.
106. A. Be sure to review the placement of the carpal bones.
107. D. Two similar answers, such as A and D, usually indicate that one of them is the correct answer.
108. D. The Jefferson fracture is a comminuted fracture of the ring of the atlas.
109. C. A boxer's fracture is a transverse fracture of the neck of the fifth metacarpal.
110. B. A Colles' fracture is a transverse fracture through the distal radius.
111. A. Talipes is another term for clubfoot.
112. D. Ankylosing spondylitis is an inflammatory disease of the spine that causes fusion of the joints involved.
113. D.
114. D.
115. A.
116. B.
117. C.
118. C. Be sure to know all of the major anatomy of the hand and wrist and be able to identify it on radiographs and drawings.
119. B.
120. A.
121. D.
122. B.
123. A. Be sure to know all of the major anatomy of the elbow and be able to identify it on radiographs and drawings.
124. D.
125. A.
126. B.
127. B.
128. D. Be sure to know all of the major anatomy of the vertebrae and be able to identify it on radiographs and drawings.
129. C.
130. B.
131. D.
132. C. Be sure to know all of the major anatomy of the lower leg and be able to identify it on radiographs and drawings.
133. D.
134. B.
135. A.
136. C.
137. A.

138. D. Be sure to know all of the major anatomy of the shoulder girdle and be able to identify it on radiographs and drawings.
139. D. Choice A is incorrect because this is a radiograph of a lower leg. Choice B is incorrect because the tibia and fibula cannot be superimposed. Choice C is incorrect because both joints should be included.
140. C. Although it is seldom performed, this T-tube cholangiogram shows the hepatobiliary ductwork.
141. B. Be sure to review the anatomy visualized on the elbow obliques.
142. C. This is the only choice that places the skull in a true lateral.
143. A. Note the placement of the petrous ridge.
144. B.
145. C.
146. B.
147. D.
148. C. Be sure to know all of the major anatomy of the “Scotty dog” and be able to identify it on radiographs and drawings.
149. C. Breathing technique, also known as autotomography, involves placing superimposing structures in motion while the x-ray tube and IR remain stationary.
150. B. Knowing the effect of injuries helps with positioning of the patient and prevents further injury.
151. D. This is a PA axial projection of the clavicle, so the tube angulation is caudad. The tube angulation is cephalad for the AP axial projection.
152. C. Note the use of a range in the answer. This is what you will probably encounter on the ARRT exam.
153. D.
154. B. Place the proximal femur (the thicker part of the thigh) under the cathode portion of the x-ray beam. A trough filter is used for chest radiography.
155. A. Know those exact centering points.
156. D. If this were a PA oblique projection, choice B would be correct.
157. B. This is an AP oblique.
158. B. This is a PA oblique.
159. C. The second inspiration would be deeper than just a single inspiration. This is a more complete and descriptive answer than choice A.
160. A. Be sure you know why certain projections are used.
161. B. Choice 3 is incorrect because the central ray exits at the nasion when the frontal bone is being examined. Choice 4 is incorrect because the MSP is perpendicular to the cassette.
162. A.
163. D.
164. A.
165. D.
166. B.
167. D.
168. B.
169. B.
170. A.
171. C.
172. B.
173. D.
174. C. Breaths not beats
175. D. The key word is *must*, although radiographers should also be proficient in taking blood pressure. As radiographers’ scope of practice expands, so will the need to be proficient in the use of a wide range of medical instruments. Be aware that in some states oxygen is considered a medication.
176. C. Be familiar with all tubes you may encounter in patient care.
177. D. These are also called “health care acquired.”
178. B. Retrograde flow of urine commonly causes bladder infections. The urinary system is the primary site of nosocomial infections.
179. A. Be sure to wash hands before beginning the exam.
180. B. This question asks which item is not required for valid consent. A consent form is not always used.
181. B.
182. B.
183. A. Always observe standard precautions with every patient.
184. A. Handwashing is the number one method for preventing the spread of infection.
185. B. This protects the patient and the radiographer from injury.
186. C. Be sure to know what other departments consult for relevant information.
187. D. This is a better answer than A, especially because alcohol is not always used.
188. A. Be sure to review the facts about sterile technique.
189. D. Portable machines go everywhere. Be certain that they are cleaned according to protocol.
190. B. This protects both the patient and the equipment from contamination.
191. D. Patient care is an integral part of the radiographer’s responsibility.
192. C. Choice 2 is incorrect because this is beyond the radiographer’s scope of practice. Choice 4 is incorrect because in a trauma situation, other health care workers need to be in the room and should be provided with lead protection.
193. D. This helps reduce cramping.
194. D. Some are nonionic, which rules out A and B. Contrast agents are not pure iodine, which rules out choice C.
195. B. Be aware of the possible complications when using these agents. Know all the details of these pharmaceuticals.
196. A. Although it does not occur often, recent exams involving iodinated contrast media should be brought to the radiologist’s attention.
197. C. You can never assume there will be no reactions. Choice B is incorrect because other contrasts could

include barium studies, which would not have a risk of reaction.

198. D.
 199. D. Barium is a surgical contaminant.
 200. D. As a professional, you need to know the continuing education requirements of your chosen field. Be sure to know your state's statutory requirements as well. Consult <http://www.arrt.org>.

Chapter 6 - Challenge Tests - Test #3

Answers to Challenge Test Number 3

1. D. Remnant radiation exits the body (choice A); gamma radiation is not produced in the x-ray tube (choice B). Choice C, nonionizing radiation, is incorrect because x-rays are ionizing radiation.
2. C. Choice A is incorrect because Compton produces scatter radiation. Choice B is incorrect because coherent scatter is produced at extremely low kVp levels. Choice D is incorrect because pair production occurs only at levels above 1.02 MeV.
3. A. Choice B is incorrect because coherent scatter occurs at extremely low kVp levels and does not produce a recoil electron. Choice C is incorrect because the photoelectric effect does not scatter the photon. Choice D is incorrect because pair production does not occur in diagnostic radiography.
4. A.
5. B.
6. A.
7. A.
8. A.
9. D. The *t* refers to tissue.
10. C. Linear energy transfer
11. A.
12. D. Choice A is incorrect because contrast is produced by photoelectric effect, not Compton interaction.
13. B.
14. B. Genetic effects may express themselves in future generations as mutations.
15. D. Be sure to know all the dose limits.
16. B. National Council on Radiation Protection and Measurements. Choice A, the International Commission on Radiological Protection, is incorrect. Choice C is incorrect, but the Nuclear Regulatory Commission does have enforcement power. Choice D is incorrect because the American Society of Radiologic Technologists is the professional organization for radiation science professionals.
17. C. Choices A and D are incorrect because there is no threshold dose regarding radiation protection. Choice B is incorrect because we do not assume a nonlinear response for radiation protection.
18. B. Choice A is incorrect because the inverse square law states that the intensity of radiation is inversely proportional to the square of the distance from the source of radiation. Choice C is incorrect because the reciprocity law states that $mAs = mAs$. Choice D is incorrect because Ohm's law states that voltage is equal to current times resistance in a circuit.
19. A. Indirect effect occurs when radiation strikes the cytoplasm. This causes the formation of free radicals and hydrogen peroxide, which damage the cell. Choice B is incorrect because the law of Bergonié and Tribondeau describes the radiosensitivity of cells. Choice C is incorrect because target theory explains that DNA is the master molecule of the cell. Choice D is incorrect because indirect effect causes about 95% of the cellular response.
20. D. Direct effect occurs when radiation directly hits the cellular nucleus. Indirect effect occurs when radiation strikes the cytoplasm of the cell.
21. B.
22. B.
23. B.
24. A.
25. D. Choice A is incorrect because this term is no longer used. Choice B is incorrect because *ALARA* stands for *as low as reasonably achievable*.
26. C.
27. B. The exposure switch on a portable x-ray machine must be attached to a cord that is at least 6 feet long. This does NOT mean six feet is a safe distance. A lead apron must still be worn when performing mobile radiography.
28. B. Under no circumstances should the radiographer be exposed to the primary beam.
29. D. For proper radiation protection, x-ray tubes operating above 70 kVp must have total filtration of at least 2.5-mm aluminum equivalent. Lead is not used as a filter material.
30. B. Choice A is incorrect because gonadal shielding may obstruct the area of interest in some projections. Choice C is incorrect because male patients must also be shielded. Choice D is incorrect because the gonads must be protected outside of pregnancy as well.
31. D. The secondary protective barrier must overlap the primary protective barrier by at least ½ inch to prevent leakage after the building has settled.
32. A. The primary beam is never aimed at the control booth. The exposure switch in the x-ray control booth must have a cord short enough that the radiographer has to be behind the secondary protective barrier to operate the switch.
33. B. The exposure switch in the x-ray control booth must have a cord short enough that to operate the switch, the radiographer must be in the control booth, not simply behind the x-ray tube. The control booth is a secondary, not a primary, protective barrier.
34. B. Waiting rooms and stairways are considered uncontrolled areas. They are shielded to keep exposure under

0.5 rem annually. Controlled areas are those occupied by persons who are trained in radiation safety and are wearing personnel monitoring devices. There is no specific area known as the off-limits area or the radiation area.

35. D.
36. A. Controlled areas are those occupied by persons who are trained in radiation safety and are wearing personnel monitoring devices. Uncontrolled areas are general public areas, such as stairways and waiting rooms. There is no specific area known as the off-limits area or the radiation area.
37. D. Workload, measured in mA minutes per week, takes into account the volume and types of exams performed in the room. The use factor is the amount of time the beam is on and directed at a particular barrier. There is no specific shielding factor.
38. C. Workload, measured in mA minutes per week, takes into account the volume and types of exams performed in the room. Half-value layer is the thickness of absorbing material required to reduce the x-ray beam to half its original intensity. The amount of time the beam is on and directed at a particular barrier is called the use factor.
39. A. The amount of time the beam is on and directed at a particular barrier is called the use factor. Workload, measured in mA minutes per week, takes into account the volume and types of exams performed in the room. Occupancy is a determinant of barrier thickness that simply takes into account who occupies a given area. There is no specific shielding factor. Be sure to review the determinants of barrier thickness factors.
40. C. It is measured at a distance of 1 meter because that is where the patient would be.
41. B. The cytoplasm contains water and the organelles, each of which plays a role in the functioning of the cell.
42. A. RBE varies with the type of radiation and its LET.
43. B. A is the inverse square law; C is Ohm' law.
44. C. Muscle cells are the least radiosensitive cells in the body.
45. A. However, following ALARA at all times is of paramount importance. Embryologic effects are most likely to occur during the first trimester.
46. A. This should be the only source of occupational exposure.
47. A.
48. D. The requirement is no less than 12 inches.
49. B.
50. B.
51. C.
52. B. The filter is made of aluminum.
53. B.
54. D.
55. C.
56. C.
57. D.
58. D.
59. C. This is to repel the electrons.
60. D.
61. C.
62. D.
63. A.
64. C.
65. A. 2% of the SID
66. C.
67. A.
68. B.
69. C.
70. C.
71. C.
72. C.
73. B. Be familiar with the various modes of postprocessing.
74. A.
75. A. Patient dose may be lower.
76. C.
77. A. Digital communication in medicine
78. A. Too few photons creating the image
79. B.
80. B.
81. C.
82. B.
83. D. H/D
84. D.
85. A.
86. D. 2% of the SID
87. D. Be sure to read all choices carefully.
88. C.
89. B. The average wavelength of the beam decreases.
90. D.
91. D.
92. D.
93. D.
94. B.
95. B.
96. D.
97. A.
98. D.
99. C.
100. D.
101. B. This is a direct relationship.
102. C. Less Compton scatter produced
103. D. Be sure to review the Bucky factors.
104. D.
105. C.
106. B.
107. A.
108. B. Be sure to review these definitions. You are not likely to be asked more than one on the Registry exam, but you will want to get it correct.
109. D.
110. C.
111. A.

112. D.
 113. B. Review the various types of joints so you will be able to handle any question you are asked about them.
 114. D.
 115. D.
 116. A.
 117. D.
 118. C. Be sure to review the major anatomy of the skull. Even though routine skull series are seldom performed, having been replaced by computed tomography, skull questions are still asked on the ARRT exam.
 119. A.
 120. B.
 121. D.
 122. B.
 123. C.
 124. B.
 125. D.
 126. D.
 127. D.
 128. D.
 129. C.
 130. D.
 131. D. It is important to be able to “label” anatomy whether on drawings, on radiographs, or, as these questions illustrate, by using words.
 132. C.
 133. A.
 134. B.
 135. D.
 136. D.
 137. B.
 138. C.
 139. A.
 140. A.
 141. D. Be comfortable with answering questions regarding the alimentary canal and the urinary system. These types of questions are asked on the certification exam.
Study tips: For the following series of questions, be sure to know the exact centering point that you learned in positioning class and from [Chapter 5](#) of this text. Also be aware that in some Registry exam questions you may be given ranges of angles from which to choose, making it easier to choose the correct answer. This may occur because not all positioning textbooks agree on certain angles.
 142. D.
 143. D.
 144. B. This is difficult for a patient with an elbow injury.
 145. A. Distinguish between PA and AP. Be sure to read the question carefully. Remember that the humerus and forearm must also be in the same plane.
 146. D.
 147. D.
 148. D.
 149. B.
 150. A.

151. D.
 152. A.
 153. D.
 154. C.
 155. B.
 156. C.
 157. D.
 158. D.
 159. D.
 160. B.
 161. C.
 162. A.
 163. C.
 164. B.
 165. D.
 166. A.
 167. A.
The preceding series of positioning questions has illustrated the level of knowledge you need going into the Registry exam. Be sure to review carefully and accurately. Do not panic. Just review some every day until you have mastered these facts.
 168. B.
 169. A.
 170. B.
 171. B.
 172. B.
 173. B.
 174. A.
 175. D. Torts are a part of personal injury law.
 176. C. Invasion of privacy involves violating confidentiality or improperly exposing the patient’s body to viewing or radiation. Assault and battery involve threats and striking the patient.
 177. B.
 178. C.
 179. B. *Respondeat superior* means “let the master answer.” Gross negligence is a reckless disregard for life or limb. Slander is spoken defamation.
 180. A. The heartbeat is regular but rapid.
 181. C. Diastolic pressure is the blood pressure of the heart at rest.
 182. D. Be sure to know the correct amount per unit time. Choice A would be damaging. The other choices would be inadequate. Read carefully.
 183. B. The crash cart contains everything needed for a code blue, a defibrillator restores errant heartbeat, and the sphygmomanometer measures blood pressure.
 184. C. The crash cart contains everything needed for a code blue, a defibrillator restores errant heartbeat, and the sphygmomanometer measures blood pressure.
 185. D. Choice A is incorrect because hypovolemic shock is caused by a loss of fluids. Choice B is incorrect because septic shock follows massive infection. Choice C is incorrect because neurogenic shock causes blood to pool in peripheral vessels.

186. B. *Gastric* indicates that it flows into the stomach. Knowledge of medical terminology will greatly assist in ruling out some answers and carefully considering others.
187. D. You do not want urine to flow backward into the bladder, causing an infection.
188. A. Great care must be taken when performing a portable chest x-ray exam on a patient who is receiving mechanical ventilation.
189. D. Be sure to observe the F or C. You would not want to mix barium in water at 100° C.
190. A. Choice C does not make sense. Air is a gas, and iodine is not inert.
191. D.
192. A.
193. D. This can be caused by the mere suggestion of a reaction.
194. D. Literally, inflammation of a vein
195. D. Contact is person to person, airborne is droplets and dust, and droplet is coughs and sneezes.
196. C. As explained in question 195
197. A. As explained in question 195. Be sure to keep all of these facts straight.
198. B. Medical asepsis is not the complete removal, and gas sterilization is a way to sterilize equipment, not a patient care environment.
199. A.
200. D. Be sure to review the major medical terms you learned early in your program.

Bibliography

<https://www.arrrt.org/>

- Bontrager K, Lampignano J: *Textbook of radiographic positioning and related anatomy*, ed 8, St. Louis, 2013, Elsevier.
- Bushong S: *Radiologic science for technologists*, ed 10, St. Louis, 2012, Elsevier.
- Callaway WJ: Graduate technologists and customer service, *Radiol Manage* 14:50, 1992.
- Carter C, Vealé B: *Digital radiography and PACS*, ed 2, St. Louis, 2013, Mosby.
- Ehrlich R, Coakes D: *Patient care in radiography: with an introduction to medical imaging*, ed 8, St. Louis, 2013, Elsevier.
- Eisenberg R, Johnson N: *Comprehensive radiographic pathology*, ed 5, St. Louis, 2012, Elsevier.
- Fauber T: *Radiographic imaging and exposure*, ed 4, St. Louis, 2013, Elsevier.
- Gurley L, Callaway WJ: *Introduction to radiologic technology*, ed 7, St. Louis, 2011, Elsevier.
- Jensen S, Peppers M: *Pharmacology and drug administration for imaging technologists*, ed 2, St. Louis, 2006, Mosby.
- Johnston J, Fauber T: *Essentials of radiographic physics and imaging*, ed 2, St. Louis, 2015, Elsevier.
- Long B, Rollins J, Smith B: *Merrill's atlas of radiographic positioning and procedures*, ed 13, St. Louis, 2016, Elsevier.
- Mace J, Kowalczyk N: *Radiographic pathology for technologists*, ed 5, St. Louis, 2009, Elsevier.
- National Council on Radiation Protection and Measurements: *Limitation of exposure to ionizing radiation*, NCRP Report No. 116, Bethesda, 1993, NCRP.
- National Council on Radiation Protection and Measurements: *Medical x-ray, electron beam and gamma-ray protection for energies up to MeV (equipment design, performance and use)*, NCRP Report No. 102, Bethesda, 1989, NCRP.
- National Council on Radiation Protection and Measurements: *Quality assurance for diagnostic imaging*, NCRP Report No. 99, Bethesda, 1988, NCRP.
- National Council on Radiation Protection and Measurements: *Ionizing radiation exposure of the population of the United States*, NCRP Report No. 160, Bethesda, 2006, NCRP.
- Papp J: *Quality management in the imaging sciences*, ed 5, St. Louis, 2015, Elsevier.
- Sherer M, Visconti P, Ritenour E, Haynes K: *Radiation protection in medical radiography*, ed 7, St. Louis, 2014, Elsevier.

Illustration Credits

Figures 3-1, 3-2, 4-2, 4-3, 4-4, 4-7 through 4-16—From Fauber TL: *Radiographic imaging & exposure*, ed 4, St. Louis, 2012, Mosby.

Figure 4-1—From Buschong SC: *Radiologic science for technologists: physics, biology and protection*, ed 10, St. Louis, 2012, Mosby.

Figures 4-5 and 6-15—From Malott JC, Fodor J III: *The art and science of medical radiography*, ed 7, St. Louis, 1993, Mosby.

Figures 5-19 through 5-62 and 6-17 through 6-26—From Frank E: *Merrill's atlas of radiographic positions and radiologic procedures*, ed 12, St. Louis, 2011, Mosby.

Figure 2-1—From Cummings, et al.: *Perspectives in athletic training*, ed 1, St. Louis, 2009, Mosby.

Figure 2-2—From Freedman: *Contemporary esthetic dentistry*, ed 1, St. Louis, 2012, Mosby.

Figures 6-1 through 6-14—From Bontrager KL: *Textbook of radiographic positioning and related anatomy*, ed 8, St. Louis, 2013, Mosby.

Index

- A**
ABC. *see* Automatic brightness control (ABC)
Abdomen
 anatomy of, 96
 radiographic procedures for, 140, 141f
Abdominal aorta, 110
Abdominal viscera, 114f
Abduction, 97
Absenteeism, administrators and, 224
Absorbed dose, unit of, 40
AC. *see* Alternating current (AC)
Academic degrees, 208–209, 209b
Acanthiomeatal line (AML), 91, 93
Acceleration, 58
Accreditation, 203
Acromegaly, 116
Acromioclavicular articulations, radiographic
 procedures for, 121
Acute cholecystitis, 140
Acute radiation syndromes, 8
Added filtration, 47
Addison's plane, 96
Adduction, 97
Adenoids, 111
Administrators, expectations of, 223–224
Adult respiratory distress syndrome, 130
Advance directive, 15, 19
Advanced degrees, 208, 209b
AEC. *see* Automatic exposure control (AEC)
AERC. *see* Automatic exposure rate control
 (AERC)
Air gap technique, 78
Air kerma, 39–40
 patient protection for, 48
Airborne precautions, 15, 25
Airborne transmission, 15, 24
ALARA. *see* As low as reasonably achievable
 (ALARA)
Alignment, 92
Alimentary tract, 112
Allergic shock, 16, 27
Alternating current (AC), 59
Alveolar ducts, 112
Alveolar process, 99
American Registry of Radiologic Technologists
 (ARRT), 221
 examination, 154
 Mission and Standards of Ethics, 19, 19b–21b
 Standard Definitions, 70t
AML. *see* Acanthiomeatal line (AML)
Amphiarthroses, 97
Anaphase, 44
Anaphylactic reactions, to contrast agents, 16
Anaphylaxis, 27
Anastomosis, 109
Anatomic markers, 92
Anatomic nucleus, 58
Anatomy, 95–116, 116b
 of abdomen
 anatomic divisions of, 96
 clinical divisions of, 96
 of thorax in, 102–103
 and contrast, 74
 of digestive system, 112–114
 digital image receptor exposure and, 73
 of heart, 109–111
 of lymphatic system, 111
 of nervous system, 108–109
 planes of the body in, 95–96
 of respiratory system, 111–112
 of skeletal system, 96–108
 appendicular skeleton in, 103–108
 articulations in, 97
 axial skeleton in, 97–103
 descriptive terminology for, 96
 division of, 96–97
 facial bones in, 99–100
 lower extremity in, 103–108
 marrow in, 96
 ossification in, 96
 skull in, 97–99, 98f
 skull morphology in, 97
 types of, 96
 upper extremity in, 103
 vertebral column in, 100–102
 of urinary system, 114–116
Anatomy (*Continued*)
 of urinary system, 114–116
Angulation, 116
Ankle
 anatomy of, 106–108
 radiographic procedures for, 123–124,
 123f–124f
Ankylosing spondylitis, 116
Annual dose limits, 42–44, 44b
Annual living expenses, 197, 198f
Anode, 62
ANS. *see* Autonomic nervous system (ANS)
Anterior, 91
Anthraxosis, 131
Anus, 114
Aorta, 109
Aortic arch, 109–110
Aperture diaphragm, 47
Appearance, at interview, 217–218
Appendicular skeleton, 97, 103–108
Application process, examination, 11
Aqueous iodine compounds, 16, 29
Arachnoid, 109
ARRT. *see* American Registry of Radiologic
 Technologists (ARRT)
Arterial systemic circulation, 109–110
Arteries, 109
Arterioles, 109
Arteriovenous shunt, 109
Arthrography, 145–146
Articular processes, 100
Articulations, 97
Artificially produced radiation, 39
As low as reasonably achievable (ALARA), 39,
 43, 47
 in pediatric radiography, 95
Asbestosis, 131
Ascending colon, 114
Asepsis, 7
 medical, 15, 24
 surgical, 15, 24–25
ASIS, 103
Assault, 15, 17
Asthenic body habitus, 94
Asthma, 130
Atelectasis, 130
Atomic mass, 58
Atomic number, 58, 74
Atria, 109
Attenuation, 39, 41, 58
Auditory area, 108
Auditory tube, 111
Autoclaving, 25
Automatic brightness control (ABC), 48, 66
 on image intensifier, 68
Automatic brightness stabilization, 66
Automatic collimation, 47
Automatic exposure control (AEC), 9, 60–61
 quality control of, 68
Automatic exposure rate control (AERC), 48
Automatic gain control, 66
Autonomic nervous system (ANS), 108
Autotransformer, 59–60
Avulsion fracture, 116
Axial, 91
Axial plane, 96
Axial skeleton, 96–97
Axillary artery, 110
Azygos vein, 111
B
Baccalaureate degrees, 208, 209b
Background radiation
 medical, 41
 natural, 39, 41
Ball and socket joint, 97
Bandages, 95
Barium, 29
Battered child syndrome, 116
Battery, 15, 17
Beam characteristics, 64–65
Beam limitation, and patient exposure, 47
Beam-part-receptor alignment latitude, 71
Beam restriction
 and contrast, 74
 and digital image receptor exposure, 73
Becquerel, 39
Bile ducts, 114
Bimalleolar fracture, 116
Biohazardous materials, handling and disposal of,
 31–32, 31f
 defined, 16
Biohazardous waste container, 31f
Biohazardous waste symbol, 31f
Biological effects, of ionizing radiation, 45
 direct, 45
 indirect, 45
Black/white reversal, 71

Note: Pages followed by *b*, *t*, or *f* refer to boxes, tables, or figures, respectively.

- Bladder
 - anatomy of, 114
 - carcinoma of, 143
- Blood cells, radiosensitivity of, 45
- Blood pressure, 15, 26–27
- Body habitus, 94, 94b
- Body part placement, 92
- Boiling, for surgical asepsis, 24
- Bone marrow, 96
- Bones, 96
- Bony cyst, 116
- Bowing fracture, 116
- Boxer's fracture, 116
- Brachiocephalic artery, 109
- Brachycephalic skull, 97
- Bradycardia, 15
- Brain, anatomy of, 108
- Bremsstrahlung (brems) radiation, 63, 63f
- British system, 58
- Broca's area, 108
- Bronchial adenoma, 130
- Bronchiectasis, 130
- Bronchioles, 112
- Bronchogenic carcinoma, 130
- Bucky factor, 77
- Bucky slot shield, for fluoroscopy, 50
- Bursae, 97
- Bursitis, 116

- C**
- Calcaneus, radiographic procedures for, 123
- Calendar, for scheduling study time, 3, 4f
- Callus, 116
- Capillaries, 109
- Capitulum, anatomy of, 103
- Carcinogenesis, 46
- Cardiac arrest, 16, 27
- Cardiac cycle, 109
- Cardiac notch, 112
- Cardinal principles of radiation protection, 40, 49
- Cardiogenic shock, 16, 27
- Cardiovascular reactions, to contrast agents, 16, 30
- Career paths, 195–209
 - academic degrees in, 208–209, 209b
 - career planning inventory for, 196–200, 198f, 200b
 - continuing education requirements in, 203–205
 - key points on, 205b
 - meeting professional and governmental requirements for, 203–204
 - opportunities for, 204–205
 - Continuing Qualification Requirements in, 205
 - goal setting for, 200–203, 203b
 - in radiologic specialties, 205–208
 - diagnostic medical sonography as, 205–206
 - as imaging manager, 208
 - key points on, 209b
 - nuclear medicine as, 206
 - other, 207
 - radiation therapy technology as, 206–207
 - as radiography educator, 207–208
 - as radiologist assistant, 207
- Career planning inventory, 196–200, 198f, 200b
- C-arms, 67
- Carotid arteries, 110
- Carpal bones, 103
- Cart transfer, 23
- Cartilaginous joints, 97
- Cataractogenesis, 46
- Catheter(s)
 - intravenous (IV), 16
 - urinary, 28
 - venous, 28
- Cathode assembly, 62
- Caudal, 91
- CDC Standard Precautions, 7
- Cecum, 114
- CED. *see* Cumulative effective dose (CED)
- Celiac artery, 110
- Cell division, 44
- Cell line death, 45
- Cell membrane, 44
- Cells, 44, 46b
 - biological effects on, 45
 - division of, 44
 - genetic effects of radiation on, 46–47
 - main parts of, 44
 - radiosensitivity of, 45–46
 - somatic effects of radiation on, 46
- Central, 91
- Central fissure, 108
- Central nervous system (CNS), 108
- Central nervous system syndrome, 46
- Centrosomes, 44
- Cerebellum, 108
- Cerebral arterial circle, 110
- Cerebral cortex, 108
- Cerebrum, 108
- Certification exam, 14b
- Cervical spine
 - anatomy of, 100–101
 - injuries in, 95
 - oblique, 162f
 - topography of, 93
- Cervical vertebrae, radiographic procedures for, 126–127, 126f–128f
- CGS system, 58
- Challenge tests, 154–194
 - on image production, 157–159, 171–174, 172f, 186–189
 - on patient care, 166–168, 181–183, 192–194
 - on procedures, 160–166, 160f–166f, 174–181, 175f–179f, 189–192
 - on safety, 154–157, 168–171, 183–186
 - scoring of, 168, 168t, 183, 183t, 194, 194t
- Characteristic radiation, 64, 64f
- Charting, medicolegal aspects of, 18
- Chemical(s), handling and disposal, 31
- Chemical energy, 58
- Chemical sterilization, 24
- Chest, radiographic procedures for, 131–133, 132f
- Chest tube, 16, 28
- Child, radiography in, 94–95, 95b
- Cholelithiasis, 960
- Chronic bronchitis, 130
- Chronic obstructive pulmonary disease (COPD), 130
- Circle of Willis, 110
- Circulatory system, 109
- Circumduction, 97
- Classical scatter, 42
- Clavicle
 - anatomy of, 103
 - radiographic procedures for, 122
- Clinical coordinator, 208
- Closed fracture, 116
- Clothing, for interview, 217
- Clubfoot, 116
- CNS. *see* Central nervous system (CNS)
- Coccygeal vertebrae, anatomy of, 102
- Coccyx, radiographic procedures for, 130
- Code of Ethics, of American Registry of Radiologic Technologists, 19b–21b
- Coherent scatter, 42
- Colles' fracture, 116
- Collimation, automatic, 47
- Collimator, 47
- Collimator field to radiation field alignment, 68
- Colon
 - anatomy of, 114
 - AP projection, barium enema of, 160f
 - cancer of, 960
 - radiographic procedures for, 142–143, 142f
- Comfort, of patient, 23
- Comminuted fracture, 116
- Common iliac arteries bifurcate, 110
- Common vehicle transmission, 15, 24
- Communication
 - interpersonal, 6–7
 - nonverbal, 15–16
 - with patient, 16–17
 - verbal, 15–16
- Complete fracture, 116
- Compound fracture, 116
- Compression fracture, 116
- Compton effect, 39
- Compton interactions, 41–42, 42f
- Compton scattering, 41, 42f
- Computed radiography, image characteristics, 71–72, 72b
- Conductor, 59
- Condyle, 96
- Condylloid joint, 97
- Congenital hip anomaly, 116
- Consent
 - implied, 15, 18
 - informed, 15
- Contact precautions, 15, 25
- Contact transmission
 - direct, 15, 24
 - indirect, 15
- Continuing education, 203–205
 - key points on, 205b
 - meeting professional and governmental requirements for, 203–204
 - opportunities for, 204–205
- Continuing Qualification Requirements (CQR), 205
- Continuous x-ray spectrum, 64
- Contrast, 74–75, 74b
- Contrast agent(s)
 - aqueous iodine compounds as, 16, 29
 - iodinated
 - ionic, 16, 29
 - nonionic, 29
 - patient care preceding injection of, 29
 - negative, 16, 29
 - positive, 16, 29
- Contrast enhancement, 71
- Contrast improvement factor, 77
- Contrast media, 29–30
 - barium as, 29
 - complications and reactions to, 30
 - iodinated, 29
 - key review points on, 30b
 - pharmacology and, 29–30
- Contrast resolution, 74
- Contributory negligence, 17
- Controlled area, 50
- COPD. *see* Chronic obstructive pulmonary disease (COPD)
- Coronal plane, 91, 96
- Coronary sinus, 111
- Corpus callosum, 108
- Cortex, 114
- Coulombs/kilogram, 40
- Cover letter
 - appearance of, 215–216
 - for general mailing, 210, 210f
 - in response to job posting, 215, 215f
- Coworkers, expectations of, 226–227
- CQR. *see* Continuing Qualification Requirements (CQR)

- Cranial, 91
 Cranial nerves, 109
 Cranium
 anatomy of, 97
 radiographic procedures for, 134, 134f–136f
 Crash cart, 16
 Credentials, on resume, 212f–214f, 215
 Crest, 96
 Cribriform plate, 99
 Crohn's disease, 140
 Crossed grids, 77, 77f
 Crosshatch grids, 77
 Croup, 130
 Cuboid bone, 108
 Cumulative effective dose (CED), 39, 44
 Cylinder cones, 47
 Cystic artery, 110
 Cystic fibrosis, 131
 Cystitis, 143
 Cystography, 144–145
 Cystourethrography, 144–145
 Cytoplasm, 44
- D**
 DAP. *see* Dose area product (DAP)
 DC. *see* Direct current (DC)
 Decubitus position, 91
 Deltoid tuberosity, 103
 Deoxyribonucleic acid (DNA), 44
 Depressions, in bone, 96
 Descending aorta, 110
 Descending colon, 114
 Deterministic effects, 39, 43
 Diagnostic medical sonography, 205–206
 Diaphysis, 96
 Diarthroses, 97
 Diastolic pressure, 15, 26
 DICOM. *see* Digital imaging and communications in medicine (DICOM)
 Digestive system. *see* Gastrointestinal system
 Digital fluoroscopy, 66, 67f
 Digital image acquisition, 68–79
 computed radiography for, 68–69, 68f
 digital radiography for (DR), 69, 69f
 imaging informatics as, 69–70
 properties of, 72–74
 workstation monitors as, 69
 Digital imaging and communications in medicine (DICOM), 69
 Digital imaging characteristics, 9
 Digital imaging equipment, 68–70, 70b–71b
 quality control of, 70
 Digital radiography (DR), 69, 69f
 artifacts in, 71–72
 image characteristics, 71–72, 72b
 Digits, radiographic procedures for, 117
 Direct contact precautions, 15, 24
 Direct current (DC), 59
 Direct effect, 39, 45
 Direct question, 13
 Direction, as markers, 92
 Discrete x-ray spectrum, 64
 Disk herniation, 116
 Dislocation, 116
 Displacement, 116
 Distal, 91
 Distance
 barrier thickness and, 50
 digital image receptor exposure and, 73
 radiation exposure and, 40, 49
 Distortion, 76, 76b
 factors controlling, 76
 Distracters, 13
 Diversity, 15–16
 Diverticulitis, 140
 DNA. *see* Deoxyribonucleic acid (DNA)
- DNR. *see* Do not resuscitate order (DNR)
 Do not resuscitate order (DNR), 15, 18
 Dolichocephalic skull, 97
 Dorsal decubitus, 91
 Dorsal recumbent, 91
 Dose, 49
 cumulative effective, 39, 44
 doubling, 46
 equivalent, 39
 genetically significant, 39, 48
 mean marrow, 40, 48
 Dose area product (DAP), 48
 Dose limits
 annual, 42–44, 44b
 effective, 39, 43
 Dose-response curves, 39
 Dose-response evaluations, agencies involved
 in, 42
 Dose-response relationships, 43
 linear-nonthreshold, 43, 43f
 linear-threshold, 43, 43f
 nonlinear-nonthreshold, 43, 43f
 nonlinear-threshold, 43, 43f
 Dosimeters
 optically stimulated luminescence (OSL), 51
 thermoluminescent, 51
 Doubling dose, 46
 DR. *see* Digital radiography (DR)
 Droplet precautions, 15, 25
 Droplet transmission, 15, 24
 Dry heat, for surgical asepsis, 25
 Duodenum, 113
 Dura mater, 108
 Durable power of attorney, 15, 19
- E**
 Early somatic effects of radiation, 40, 46
 Edema, tracheolaryngeal, 27
 Edge enhancement, 71
 Education, on resume, 212f–214f, 215
 Effective dose, 40
 cumulative, 39, 44
 limit, 39, 43
 unit of, 40
 Effective focal-spot size, 68
 Elbow
 AP projection of, 165f
 fractures, 116
 radiographic procedures for, 119–120, 120f
 Electrical circuits, 59
 Electrical current, 59
 Electrical energy, 58
 Electrical generator, 59
 Electrical motor, 59
 Electrical resistance, 59
 Electrification, 59
 methods of, 59
 Electrocardiogram, 109
 Electrodynamics, 59
 Electromagnet, 59
 Electromagnetic energy, 58
 Electromagnetic induction, 59
 Electromagnetism, 59
 Electromotive force (EMF), 59
 Electron, recoil, 42
 Electron shells, 58
 Electron-binding energy, 58
 Electronic medical record (EMR), 70
 Electronic timer, 60
 Electrostatics, 59
 law of, 59
 Elongation, 76
 Embryologic effects, 46
 Emergencies, medical, 27–28
- EMF. *see* Electromotive force (EMF)
 Emphysema, 131
 Employment expectations, 221–227
 of administrators, 223–224
 on entering health care workforce, 221
 key points on, 226b
 of new coworkers, 226–227
 organizational structure and professional responsibility in, 223–227
 of physicians, 224
 of radiology manager, 224–225
 of students under supervision, 225–226
 task inventory for, 221–223
 Employment experiences, on resume, 211, 212f–214f
 Empyema, 131
 EMR. *see* Electronic medical record (EMR)
 Endocardium, 109
 Endocrine gland, 114
 Endoplasmic reticulum, 44
 Endoscopic retrograde cholangiopancreatography (ERCP), 143
 Energy, 58
 chemical, 58
 conservation of, 58
 electrical, 58
 electromagnetic, 58
 kinetic, 58
 nuclear, 58
 potential, 58
 thermal, 58
 Entry-level radiographer, 223
 Epiphysis, 96
 Epithelial tissue, radiosensitivity of, 45
 Equipment
 for digital imaging, 68–70, 70b–71b
 computed radiography as, 68–69, 68f
 digital radiography for (DR), 69, 69f
 imaging informatics as, 69–70
 quality control of, 70
 workstation monitors as, 69
 for fluoroscopy
 digital, 66, 67f
 mobile, 67, 67b
 non-digital, 65
 operation and quality, 9–10
 for x-ray production, 60–62, 60f
 automatic exposure control (AEC) as, 60–61
 autotransformer as, 60
 electronic timer as, 60
 falling load generator, 61
 glass envelope with window as, 62
 mA control (filament control) as, 61
 mAs timer as, 60
 milliammeter (mA meter), 61
 prereading voltmeter as, 60
 quality control of, 67–68, 68b
 rectifier as, 61
 step-up transformer as, 61
 timer as, 60–61
 tube housing as, 62
 x-ray tube as, 62, 62f
 Equivalent dose, 39
 unit of, 40
 ERCP. *see* Endoscopic retrograde cholangiopancreatography (ERCP)
 Errors, technical, artifacts related to, 72
 Esophageal varices, 960
 Esophagitis, 140
 Esophagus, 113
 cancer of, 140
 radiographic procedures for, 140–141
 Ethmoid bone, anatomy of, 99
 Eustachian tube, 111
 Ewing's sarcoma, 116

- Examination
 certification, 14b
 content categories in
 analysis of, 6
 biological aspects of radiation, 8
 equipment operation and quality control
 as, 9–10
 image acquisition and evaluation as, 9, 9t
 radiation protection as, 8–9
 materials needed for, 12–13
 physically and mentally preparing for, 12
 procedure for, 10–11
 extremity, 11
 head, spine, and pelvis, 10
 thorax and abdomen, 11
 results of, 14
 specifications for, 6, 6t
 strategies for taking, 13–14, 13b
- Exhibit question, 13–14
- Exit radiation, 39, 41
- Exocrine gland, 114
- Expectations
 of administrators, 223–224
 of new coworkers, 226–227
 of physicians, 224
 of radiology manager, 224–225
 of students under supervision, 225–226
- Expiration, 112
 as marker, 93
- Exposure factors, 47–48
- Exposure linearity, 68
- Exposure maintenance formula, 73
- Exposure modification, 94, 94b
- Exposure reproducibility, 68
- Exposure switch, for fluoroscopy, 50
- Extension, 97
- External iliac artery, 110
- External jugular vein, 111
- External marker, 93
- External occipital protuberance, 99
- F**
- Facial bones
 anatomy of, 99–100
 parietoacanthial (Waters) projection of, 166f
 radiographic procedures for, 136, 137f
- Falling load generator, 61
- False imprisonment, 15, 17
- Fatty marrow, 96
- Femoral artery, 110
- Femur
 anatomy of, 106, 106f
 radiographic procedures for, 125–126
- Fibrous joints, 97
- Fibula, anatomy of, 106, 106f
- Filament circuit, 61–62
- Film badges, 51
- Filtration
 beam characteristics and, 64–65
 contrast and, 74, 75f
 patient exposure and, 47
 added, 47
 inherent, 47
 total, 47
- Filtration-beam quality, 68
- Financial planning worksheet, 197, 198f
- Fingers, radiographic procedures for, 117
- Fixed KVp-variable mAs technique charts, 63
- Flat contact shield, 47
- Flat panel image-intensifier, 66
- Flexion, 97
- Floating ribs, 103
- Fluoroscopy, 65–67, 67b
 equipment for
 digital, 66, 67f
- Fluoroscopy (*Continued*)
 mobile, 67, 67b
 non-digital, 65
 exposure rate, 68
 patient protection for, 48
- Flux gain, 66
- Focal spot, 62
- Focal spot size
 effective, 68
 and spatial resolution, 75, 75f
- Focused grids, 77, 77f
- Foley catheter, 28
- Follow-up letter, 220, 220f
- Fontanelles, 97
- Foot
 anatomy of, 106–108, 107f
 oblique, 164f
 radiographic procedures for, 122–123, 123f
- Foramen, 96
- Foramen lacerum, 99
- Foramen magnum, anatomy of, 99
- Foramen ovale, 99
- Foramen rotundum, 99
- Foramen spinosum, 99
- Forearm, 103, 105f
 radiographic procedures for, 119, 119f–120f
- Foreshortening, 76
- Fossa, 96
- Fracture healing, 116
- Fractures, 116–117. *see also* specific types
- Free radicals, 45
- Frequency, 58
- Frontal bone, anatomy of, 97
- Frontal lobe, 108
- G**
- Gallbladder, 114
- Gamma rays, 58
- Gas sterilization, 25
- Gastric duodenal artery, 110
- Gastritis, 140
- Gastrointestinal (GI) syndrome, 46
- Gastrointestinal system
 anatomy of, 112–114
 radiographic procedures for, 140–146
- GCF. *see* Grid conversion factor (GCF)
- Geiger-Mueller detector, 51
- Generator
 electrical, 59
 falling load, 61
- Genetic effects, 39, 46–47
- Genetically significant dose (GSD), 39, 48
- Geometric properties, of radiographic images,
 effect of variables on, 79t
- Giant cell myeloma, 117
- Glabella-meatal line, 91, 93
- Glass envelope with window, 62
- Gliding joint, 97
- Gliding movement, 97
- Glomerulonephritis, 143
- Gloving, 25
- Goal setting, in career planning, 200–203, 203b
- Goal statement, on resume, 211, 212f–214f
- Golgi apparatus, 44
- Gonadal shield(ing), 47, 94, 94b
- Gout, 117
- Governmental requirements, for continuing
 education, 203–205
- Gray_a, 39
- Grayt, 39–40
- Great saphenous vein, 111
- Greater sciatic notch, 103
- Greater wings, of sphenoid bone, 99
- Greenstick fracture, 116
- Grid conversion factor (GCF), 77
- Grid errors, 78
- Grid frequency, 77
- Grid motion, 77–78
- Grid radius, 77
- Grid ratio, 76
- Grids, 76–79, 76f, 78b
 characteristics, 77
 construction of, 76–77
 and contrast, 74
 crossed, 77, 77f
 focused, 77, 77f
 linear, 77
 moving, 77
 patient exposure with, 48
 and radiographic quality, 78
 selectivity of, 77
 stationary, 77–78
 use of, 76
- Groove, 96
- Gross negligence, 17
- GSD. *see* Genetically significant dose (GSD)
- Guessing, at answers, 14
- H**
- H₂O₂. *see* Hydrogen peroxide (H₂O₂)
- Half-value layer, 47, 65
- Hand
 anatomy of, 103, 105f
 PA radiograph of, 163f
 radiographic procedures for, 118
- Handheld ionization chamber, 51
- Handwashing, 15
- Hangman fracture, 117
- Hazardous materials, 31–32, 32f
 handling and disposal of, 31–32, 31f
 key review points on, 32b
- Head, of bone, 96
- Health Insurance Portability and Accountability
 Act (HIPAA), 15, 18
- Heart, anatomy of, 109–111
- Heartbeat, 109
- Heat units, 65
- Heel, anatomy of, 106
- Hematopoietic syndrome, 46
- Hepatic artery, 110
- Heterogeneous beam, 39, 41, 64
- Hiatal hernia, 140
- High-voltage transformer, 61
- Hilus, 112
- Hinge joint, 97
- Hip
 anatomy of, 103–105
 inferosuperior projection, 162f
 radiographic procedures for, 126, 126f
- HIPAA. *see* Health Insurance Portability and
 Accountability Act (HIPAA)
- HIS. *see* Hospital information system (HIS)
- Histogram, 71
- Histoplasmosis, 131
- History, patient, 15, 22–23, 23b
- Hospital information system (HIS), 69
- Humerus
 anatomy of, 103, 104f
 radiographic procedures for, 120–121
- Hyaline membrane disease, 131
- Hydrocephalus, 117
- Hydrogen peroxide (H₂O₂), 45
- Hyoid bone, 100
- Hypersthenic body habitus, 94
- Hypodermic needle
 gauge of, 16
 use of, 30
- Hyposthenic body habitus, 94
- Hypovolemic shock, 16, 27
- Hysterosalpingography, 146

- I**
- ICRP. *see* International Commission on Radiologic Protection (ICRP)
- Ileum, 113
- Ileus, 140
- Ilium, anatomy of, 103
- Image identification, 9
- Image production, 58–90
- challenge tests on, 157–159, 171–174, 172f, 186–189
 - contrast and, 74–75
 - digital image, 68–79
 - artifacts, 71–72
 - computed radiography for, 68–69, 68f
 - digital radiography for (DR), 69, 69f
 - image characteristics, 71–72, 72b
 - imaging informatics as, 69–70
 - properties of, 72–74
 - workstation monitors as, 69
 - distortion and, 76, 76b
 - grids in, 73, 76–79, 76f, 78b
 - review questions, 79–85
 - spatial resolution in, 75–76, 75b
 - window level in, 71
 - window width in, 71
- Image production and evaluation, 9
- Image receptor, artifacts related to, 71–72
- Image receptor exposure, digital, 72–74, 73b
- controlling and influencing factors of, 72–74
- Image intensifier, 66, 66f
- on ABC, 68
 - flat panel, 66
- Image-producing radiation, 39, 41
- Imaging informatics, 69–70
- Imaging manager, 208
- Imaging plate (IP), in computed radiography, 68
- Imaging specialties, 207
- Immobilization, in pediatric radiography, 94–95
- Implied consent, 15, 18
- Imprisonment, false, 15, 17
- Incomplete fracture, 116
- Incomplete statement, 13
- Indirect contact transmission, 15
- Indirect effect, 40
- Infection control, 7, 24–26
- cycle of, 7
 - gloving for, 25
 - isolation technique for, 25–26
 - key review points on, 26b
 - medical asepsis for, 24
 - routes of transmission and, 24
 - standard precautions for, 24
 - sterile techniques for, 25
 - surgical asepsis for, 24–25
- Infection control barriers, 15
- Infectious waste, handling and disposal of, 31–32
- Inferior mesenteric artery, 110
- Inferior nasal concha, 100
- Inferior vena cava, 111
- Informed consent, 15
- Infraorbitomeatal line (IOML), 91, 93
- Inherent filtration, 47
- Innominate bone, 103–105, 106f
- Input phosphor, 66, 66f
- Inspiration, 112
- as markers, 93
- Instructor, 208
- Insulator, 59
- Intentional misconduct, 17
- Internal iliac artery, 110
- Internal jugular vein, 111
- Internal markers, 93
- International Commission on Radiologic Protection (ICRP), 39, 42–43
- Interphase, 44
- Interview, 217–220
- outcomes and follow-up of, 220, 220f, 220b
 - personal appearance at, 217–218
 - preparation for, 218
 - process of, 218–220
 - purpose of, 217
 - questions to ask during, 218b
 - questions you may be asked during, 218
 - appropriate, 219, 219b
 - inappropriate, 219, 219b
- Intravenous (IV) catheter, 16
- Intravenous urography, 144, 144f
- Intussusception, 140
- Invasion of privacy, 15, 17
- Inventory, task, 221–223
- Inverse square law, and digital image receptor exposure, 58, 73
- Involuntary motion, 93
- Iodinated contrast agents
- ionic, 16, 29
 - nonionic, 16, 29
 - patient care after injection, 29
 - patient care following injection, 29–30
- IOML. *see* Infraorbitomeatal line (IOML)
- Ionic contrast agents, 29
- Ionization, 58
- Ionizing radiation, 39, 41, 41b, 58
- biological effects of, 45
- Irritable bowel syndrome, 140
- Ischium, 103–105
- Isolation precautions, 24
- Isolation technique, 25–26
- Isotopes, 58
- J**
- Jefferson fracture, 116
- Jejunum, 113
- Job application, 216
- Joints, 97
- Jugular foramen, 99
- Jugular notch, anatomy of, 102
- Jugular veins, 111
- K**
- Kidneys, anatomy of, 114, 115f
- Kilovoltage peak (kVp)
- digital image receptor exposure and, 72–73
 - subject contrast and, 74, 74f–75f
- Kinetic energy, 58
- Knee
- AP projection of, 162f
 - radiographic procedures for, 124, 125f
- Kyphosis, 102
- L**
- Laboratory assistant, 208
- Lacrimal bone, 100
- LAO. *see* Left anterior oblique (LAO)
- Large bowel obstruction, 140
- Large intestine, anatomy of, 114
- Laryngopharynx, 112
- Larynx, 112
- Last image hold (LIH), 48
- Late somatic effects of radiation, 40, 46
- Lateral, 91
- Lateral decubiting grid, 78
- Lateral epicondyle, of humerus, anatomy of, 103
- Law of Bergonié and Tribondeau, 40, 45
- Law of conservation of energy, 58
- Law of conservation of matter, 58
- Laws of electrostatics, 59
- Laws of magnetism, 59
- Lead apron, 49
- Left anterior oblique (LAO), 91
- Left gastric artery, 110
- Left lateral decubitus, 91
- Left lateral recumbent, 91
- Left posterior oblique (LPO), 91
- Leg
- anatomy of, 106
 - radiographic procedures for, 124, 124f
- Legionnaires' disease, 131
- Length, 58
- Lesser wings, of sphenoid bone, 99
- LET. *see* Linear energy transfer (LET)
- Libel, 15, 17
- Licensure, 203
- Life span, shortening of, 46
- LIH. *see* Last image hold (LIH)
- Line focus principle, 62
- Line voltage compensation, 59
- Linear energy transfer (LET), 39–40
- Linear grids, 77
- Linear-nonthreshold relationship, 43, 43f
- Linear-threshold relationship, 43, 43f
- Lines, 93
- Liver, 114
- Long bone radiography, 95
- Longitudinal fissure, 108
- Look-up table (LUT), 71
- Lordosis, 102
- Lower extremity
- anatomy of, 103–108
 - veins of, 111
- Lower gastrointestinal system, radiographic procedures for, 142–143
- LPO. *see* Left posterior oblique (LPO)
- Lumbar spine
- anatomy of, 101
 - topography of, 93
- Lumbar vertebrae
- radiographic procedures for, 128–130, 129f
 - superoinferior projection of, 161f
- Lungs, 112
- LUT. *see* Look-up table (LUT)
- Lymph, 111
- Lymph nodes, 111
- Lymphatic system, 111
- Lymphocytes, 111
- Lymphoid tissue, 111
- Lysosomes, 44
- M**
- mA control (filament control), 61
- Magnetic field, 59
- Magnetic poles, 59
- Magnetics, laws of, 59
- Malpractice, conditions needed to establish, 17
- Mandible
- anatomy of, 100, 100f
 - radiographic procedures for, 138
- Mandibular fossa, 99
- Manubrial notch, 102
- Manubrium, anatomy of, 102
- Marrow, 96
- Mass, 58
- atomic, 58
- Master's degrees, 208, 209b
- Material safety data sheets (MSDS), 16
- Matrix, 71
- Matrix size, 71
- Matter, 58
- law of conservation of, 58
- Maxilla, anatomy of, 99–100
- Maxillary sinus, anatomy of, 100
- Mean marrow dose, 40, 48
- Meatus, 96
- Medial, 91
- Medial epicondyle, of humerus, anatomy of, 103
- Median sagittal plane (MSP), 91, 95

- Mediastinum, 109
 Medical asepsis, 15, 24
 Medical background radiation, 41
 Medical emergencies, 27–28
 Medicolegal aspects, of practice, 17–19
 key review points on, 21b–22b
 Medulla, 114
 Medulla oblongata, 108
 Meiosis, 44
 Meninges, 108–109
 Mental foramen, 100
 Mesencephalon, 108
 Mesocephalic skull, 97
 Metacarpal bones, anatomy of, 103
 Metaphase, 44
 Metaphyseal plate, 96
 Metatarsals, anatomy of, 108
 Midcoronal plane, 91, 95–96
 Midsagittal plane, 95
 Milliammeter (mA meter), 61
 Milliampere-second (mAs), and digital image
 receptor exposure, 72
 Milliampere-second (mAs) timer, 60
 Minification gain, 66
 Minimizing patient exposure, in radiation
 protection, 8
 Misconduct
 intentional, 17
 unintentional, 17
 Mission statement, of American Registry of
 Radiologic Technologists, 19b–21b
 Mitochondria, 44
 Mitosis, 44
 Mobile radiographic units, 67, 67b
 Mobile radiography
 isolation technique for, 25–26
 patients in radiology departments, 26
 patients with neutropenia, 26
 Monitoring
 patient, 28
 of radiation exposure, 51, 51b
 to area, 51
 to personnel, 51
 Motion
 involuntary, 93
 spatial resolution and, 75
 voluntary, 93–94
 Motion control, 93–94, 94b
 Mouth, 112
 Movements, 97
 Moving grids, 77
 MSDS. *see* Material safety data sheets (MSDS)
 MSP. *see* Median sagittal plane (MSP)
 Multiple myeloma, 117
 Muscle, radiosensitivity of, 45
 Mutation, 40, 45
 Mutual induction, 59
 Myelin sheath, 108
 Myelography, 145
 Myocardium, 109
- N**
- Nasal bones
 anatomy of, 100
 radiographic procedures for, 136–137
 Nasal cavity, 111
 Nasogastric (NG) tubes, 16, 28
 Nasopharynx, 111
 National Academy of Sciences/National Research
 Council Committee on the Biological Effects
 of Ionizing Radiation (NAS/NRC-BEIR), 39
 National Council on Radiation Protection and
 Measurements (NCRP), 39, 43
 report #102, 39
 report #116, 39, 43–44
- Natural background radiation, 41
 Negative contrast agent, 29
 Negligence, 15, 17
 contributory, 17
 gross, 17
 Nerve cell, 108
 Nerve tissue, adult, radiosensitivity of, 46
 Nervous system, 108–109
 Neurogenic shock, 16
 Neuron, 108
 No code, 18
 Non-digital fluoroscopy, 65
 Nonionic contrast agents, 29
 Nonlinear-nonthreshold relationship, 43, 43f
 Nonlinear-threshold relationship, 43, 43f
 Nonverbal communication, 15–16
 NRC. *see* Nuclear Regulatory Commission
 (NRC)
 Nuclear energy, 58
 Nuclear medicine, 206
 Nuclear Regulatory Commission (NRC),
 39, 43
 Nucleus
 anatomic, 58
 of cell, 44
 Numeric markers, 93
 Nyquist frequency, 75
- O**
- Object to image receptor distance (OID), and
 spatial resolution, 75
 Oblique, 91
 Oblique cervical spine, 162f
 Oblique fracture, 116
 Obturator foramen, 105
 Occipital bone, anatomy of, 99
 Occipital condyles, 99
 Occipital lobe, 108
 Occupancy, and barrier thickness, 50
 Occupational Safety and Health Administration
 (OSHA), 16
 Octet rule, 58
 OER. *see* Oxygen enhancement ratio (OER)
 Off-level grid, 78
 Ohm's law, 59
 OML. *see* Orbitomeatal line (OML)
 Optically stimulated luminescence (OSL)
 dosimeters, 51
 Orbit
 anatomy of, 99f
 radiographic procedures for, 135, 136f
 Orbitomeatal line (OML), 91, 93
 Organizational structure, 223–227
 Oropharynx, 112
 Os coxae, 103–105
 OSHA. *see* Occupational Safety and Health
 Administration (OSHA)
 Osseous matrix, 96
 Ossification, 96
 Osteitis deformans, 117
 Osteoarthritis, 117
 Osteoblastic metastases, 117
 Osteochondroma, 117
 Osteogenesis imperfecta, 117
 Osteogenic sarcoma, 117
 Osteolytic metastases, 117
 Osteoma, 117
 Osteomalacia, 117
 Osteomyelitis, 117
 Osteopetrosis, 117
 Osteoporosis, 117
 Ova, radiosensitivity of, 46
 Overdose, of contrast agents, 30
 Oxygen administration, 15, 27
 Oxygen enhancement ratio (OER), 45
- P**
- PACS. *see* Picture archiving and communications
 system (PACS)
 Paget's disease, 117
 Pair production, 42
 Palatine bones, 100
 Pancreas, 114
 Paranasal sinuses, radiographic procedures for,
 138–139, 139f
 Parietal bones, anatomy of, 97
 Parietal lobe, 108
 Parotid glands, 112
 Particulate radiation, 58
 Patella
 anatomy of, 106
 radiographic procedures for, 124–125, 125f
 Pathologic fracture, 116
 Pathology
 contrast and, 74
 digital image receptor exposure and, 73
 Patient assessment, for changing conditions, 26–28
 key review points on, 28b–29b
 in medical emergencies, 27–28
 patient monitoring and support equipment
 for, 28
 vital signs for, 26–27
 Patient care, 6–11, 15–38
 assessment of changing patient conditions in,
 26–28
 complications and reactions to, 30
 key review points, 28b–29b
 in medical emergencies, 27–28
 patient monitoring and support equipment
 for, 28
 vital signs for, 26–27
 basic care terminology for, 15
 challenge tests on, 166–168, 181–183,
 192–194
 communication with patient in, 16–17
 key review points on, 17b
 for contrast media, 29–30
 key review points on, 30b
 hazardous materials in, 31–32, 32f
 handling and disposal of, 31–32, 31f
 key review points on, 32b
 infection control in, 24–26
 gloving for, 25
 isolation technique for, 25–26
 key review points on, 26b
 medical asepsis for, 24
 routes of transmission and, 24
 standard precautions for, 24
 sterile techniques for, 25
 surgical asepsis for, 24–25
 interactions and management, 6–7
 ethical and legal aspects of, 6
 handling and disposal of toxic/hazardous
 material, 7
 infection control, 7
 interpersonal communication of, 6–7
 medical emergencies, 7
 pharmacology, 7
 physical assistance and monitoring, 7
 safety, 7–8
 medicolegal aspects of practice, 17–19
 key review points on, 21b–22b
 patient comfort in, 23
 patient history in, 22–23, 23b
 patient preparation in, 22
 key review points on, 22b
 patient transfer in, 23
 cart, 23
 key review points on, 24b
 from wheelchair to x-ray table, 23
 from x-ray table to wheelchair, 23

- Patient care (*Continued*)
 review questions of, 32
 scheduling of radiographic examinations in, 22, 22b
 venipuncture in, 30–31
 key review points on, 31b
- Patient comfort, 23
- Patient education, 15–17
- Patient exposure and protection, 47–49, 49b
 for air kerma, 48
 beam limitation and, 47
 exposure factors, 47–48
 filtration and, 47
 for fluoroscopy, 48
 gonadal shields and, 47
 grids and, 48
 with repeat exposures, 48
 technical standards for, 48
- Patient history, 15, 22–23, 23b
- Patient identification, 92
- Patient monitoring, 28
- Patient preparation, 22
 key review points on, 22b
- Patient support equipment, 28
- Patient transfer, 23
 cart, 23
 key review points on, 24b
 from wheelchair to x-ray table, 23
 from x-ray table to wheelchair, 23
- Patient's bill of rights, 18
- Patient's rights, 18–19
- PBL. *see* Positive beam limitation (PBL)
- Pediatric radiography, 94–95, 95b
- Pelvic region, topography of, 93
- Pelvis
 anatomy of, 105
 radiographic procedures for, 126
- Penalties, for noncompliance with continuing education requirements, 204
- Peptic ulcer disease, 965
- Peripheral nervous system (PNS), 108
- Perpendicular plate, 99
- Personal appearance, at interview, 217–218
- Personal data, on resume, 211, 212f–214f
- Personal protective equipment (PPE), 16
- Personnel exposure, monitoring of, 51
- Personnel monitoring devices, 40
- Personnel protection, in radiation protection, 8–9
- Phalanges
 of foot, 108
 of hand, 103
- Pharmacology, 29–30
- Pharyngeal tonsils, 111
- Pharynx, 111–112
- Photodisintegration, 42
- Photoelectric effect, 39, 41, 42f
- Photoelectric interaction, 41, 42f
- Photoelectron, 41
- Photon, 58
- Photon interactions with matter, 8
- Photon-tissue interactions, 41–42, 42f, 42b
- Photostimulable phosphor (PSP), 68
- Physicians, expectations of, 224
- Pia mater, 109
- Picture archiving and communications system (PACS), 69
- Pivot joint, 97
- Pixel, 71
- Pixel density, 71
- Pixel pitch, 71
 and spatial resolution, 75
- Pixel size, and spatial resolution, 75
- Planes of the body, 95–96
- Pleura, 112
- Pleural effusion, 131
- Pneumoconiosis, 131
- Pneumonia, 131
- Pneumothorax, 131
- PNS. *see* Peripheral nervous system (PNS)
- Polycystic kidney disease, 960
- Popliteal vein, 111
- Position, 91
- Positive beam limitation (PBL), 47
- Positive contrast agent, 16, 29
- Posterior, 91
- Postprocessing, 71
- Potential energy, 58
- Pott's fracture, 116
- Power, 58
- PPE. *see* Personal protective equipment (PPE)
- Precautions
 additional, 7
 airborne, 15, 25
 contact, 15, 25
 droplet, 15, 25
 standard, 15
 transmission-based isolation, 24
- Precise visualization, 92
- Prefixes, 92
- Prefrontal area, 108
- Prereading voltmeter, 60
- Primary bronchi, 112
- Primary radiation, 39, 41
- Prioritization, of study topics, 2–6
- Privacy, invasion of, 15, 17
- Probabilistic effects, 39, 43
- Probationary status, for noncompliance with continuing education requirements, 204
- Procedures, 91–153
 anatomy in, 95–116, 116b
 of abdomen, 96
 of digestive system, 112–114
 of heart, 109–111
 of lymphatic system, 111
 of nervous system, 108–109
 planes of the body in, 95–96
 of respiratory system, 111–112
 of skeletal system, 96–108
 of urinary system, 114–116
 basic principles of, 92–93, 93b
 body habitus in, 94, 94b
 exposure modification in, 94, 94b
 for gastrointestinal system, 140–146
 for abdomen, 140, 141f
 for colon, 142–143, 142f
 endoscopic retrograde cholangiopancreatography, 143
 for esophagus, 140–141
 general survey exams in, 140
 lower, 142–143
 for small bowel, 142
 for stomach, 141–142, 141f
 for surgical cholangiogram, 143
 upper, 140–142
 gonadal shielding in, 94, 94b
 imaging, challenge tests on, 160–166, 160f–166f, 174–181, 175f–179f, 189–192
 motion control in, 93–94, 94b
 pediatric radiography in, 94–95, 95b
 radiographic, 116–146, 146b
 for skeletal system, 116–130
 for acromioclavicular articulations, 121
 for ankle, 123–124, 123f–124f
 for calcaneus, 123
 for cervical vertebrae, 126–127, 126f–128f
 for clavicle, 122
 for coccyx, 130
 for digits, 117
 for elbow, 119–120, 120f
 for femur, 125–126
- Procedures (*Continued*)
 for foot, 122–123, 123f
 for forearm, 119, 119f–120f
 for hand, 118
 for hip, 126, 126f
 for humerus, 120–121
 for knee, 124, 125f
 for leg, 124, 124f
 for lumbar vertebrae, 129f
 for patella, 124–125, 125f
 for pelvis, 126
 for sacroiliac joints, 130
 for sacrum, 130
 for scapula, 122, 122f
 for scoliosis series, 130
 for shoulder, 121, 121f
 for thoracic vertebrae, 127–128, 128f–129f
 for thumb, 118
 for toes, 122
 for wrist, 118–119, 118f–119f
 terminology in, 91, 92b
 for thorax, 130–139
 for chest, 131–133, 132f
 for cranium, 134, 134f–136f
 for facial bones, 136, 137f
 for mandible, 138
 for nasal bones, 136–137
 for orbit, 135, 136f
 for paranasal sinuses, 138–139, 139f
 for ribs, 133
 for skull, 134–139
 for sternoclavicular joints, 133
 for sternum, 133, 133f
 for temporomandibular articulations, 138
 for zygomatic arches, 137–138
 topography in, 93, 93b
 for trauma, 95, 95b
 for urinary system, 143–146
 cystography, 144–145
 cystourethrography, 144–145
 intravenous urography, 144, 144f
 retrograde pyelography, 145, 145t
- Process, 96
- Professional accomplishments, on resume, 212f–214f, 215
- Professional associations, on resume, 212f–214f, 215
- Professional credentials, on resume, 212f–214f, 215
- Professional judgment, in using social media, 224
- Professional requirements, for continuing education, 203–205
- Professional responsibility, organizational structure and, 223–227
- Program director, 208
- Projection, 91
 of bones, 96
- Prophase, 44
- Protective curtain, for fluoroscopy, 50
- Proximal, 91
- PSP. *see* Photostimulable phosphor (PSP)
- Psychogenic factors, in reactions to contrast agents, 16, 30
- Pubic bone, 103
- Pulmonary metastases, 131
- Pulmonary veins, 111
- Pulse, 15, 26
- Pyelonephritis, 143
- Pyloric stenosis, 140
- Q**
- Quadrants, of abdomen, 96
- Quality assurance, 67
- Quality control, 68
 of digital imaging equipment, 70
 of imaging equipment and accessories, 10
 of x-ray producing equipment, 67–68, 68b

- Quantum mottle, 71
- Questions
to ask during interview, 218b
direct, 13
you may be asked during interview, 218
appropriate, 219, 219b
inappropriate, 219, 219b
- R**
- Radial artery, 110
- Radiation
artificially produced, 39
background
medical, 41
natural, 39, 41
Bremsstrahlung (brems), 63, 63f
characteristic of, 64, 64f
early somatic effects of, 40, 46
exit (remnant, image-producing), 39, 41
ionizing, 39, 41, 41b, 58
biological effects of, 45
late somatic effects of, 40, 46
primary, 39, 41
units of measurement for, 40, 40b
- Radiation exposure
monitoring of, 51, 51b
to area, 51
to personnel, 51
to patient, 47–49, 49b
for air kerma, 48
beam limitation and, 47
exposure factors, 47–48
filtration and, 47
to fluoroscopy, 48
gonadal shields and, 47
grids and, 48
with repeat exposures, 48
technical standards for, 48
to radiation worker, 49–51, 50b
cardinal principles of, 40, 49
with fluoroscopic equipment, 50
with portable radiographic equipment and procedure, 50–51
sources of, 49–50
structural protective barriers for, 50
x-ray tube housing for, 50
- Radiation physics, principle of, 7–8
- Radiation protection
annual dose limits in, 42–44, 44b
basic principles of, 40–41
cardinal principles of, 40, 49
cells and, 44, 46b
biological effects of ionizing radiation, 44
division of, 44
genetic effects of radiation on, 46–47
somatic effects of radiation on, 46
for patient, 47–49, 49b
for air kerma, 48
beam limitation and, 47
exposure factors, 47–48
filtration and, 47
to fluoroscopy, 48
gonadal shields and, 47
grids and, 48
with repeat exposures, 48
technical standards for, 48
photon-tissue interactions and, 41–42, 42f, 42b
for radiation worker, 49–51, 50b
cardinal principles of, 40, 49
with fluoroscopic equipment, 50
with portable radiographic equipment and procedure, 50–51
sources exposure and, 49–50
structural protective barriers for, 50
x-ray tube housing for, 50
- Radiation protection (*Continued*)
radiosensitivity of, 45–46
responsibility for, 40–41
review questions for, 51
units of radiation measurement in, 40, 40b
- Radiation therapy technology, 206–207
- Radiation weighting factor (W_R), 40
- Radiation worker exposure and protection, 49–51, 50b
cardinal principles of, 40, 49
with fluoroscopic equipment, 50
with portable radiographic equipment and procedure, 50–51
sources of exposure and, 49–50
structural protective barriers for, 50
x-ray tube housing for, 50
- Radioactivity, unit of, 40
- Radiographer, and patient protection, 40
- Radiographic examinations, scheduling of, 22, 22b
- Radiographic images
geometric properties, effect of variables on, 79t
medicolegal aspects of, 18–19
- Radiographic quality
factors affecting, 9
technique charts of, 9
- Radiography educator, 207–208
- Radiologic specialties, 205–208
diagnostic medical sonography as, 205–206
as imaging manager, 208
key points on, 209b
nuclear medicine as, 206
other, 207
radiation therapy technology as, 206–207
as radiography educator, 207–208
as radiologist assistant, 207
- Radiologist assistant, 207
- Radiologists, expectations of, 224
- Radiology information system (RIS), 69
- Radiology manager, expectations of, 224–225
- Radiolysis, of water, 40, 45
- Radiosensitivity, 8
of cells, 45–46
- Radius, anatomy of, 103
- RAO. *see* Right anterior oblique (RAO)
- RBE. *see* Relative biologic effectiveness (RBE)
- RCEEM. *see* Recognized Continuing Education Evaluation Mechanism (RCEEM)
- Reasonably prudent person doctrine, 17
- Recognized Continuing Education Evaluation Mechanism (RCEEM), 204
- Recoil electron, 42
- Rectification, 59
full-wave
with 6-12 diodes, for three-phase equipment, 61
with four diodes, for single-phase generator, 61
- Rectifier, 61
- Rectum, 114
cancer of, 960
- Red bone marrow, 96
- Reduction division, 44
- References, on resume, 212f–214f, 215
- Referring physicians, expectations of, 224
- Relative biologic effectiveness (RBE), 39, 45
- Remnant radiation, 39, 41
- Renal artery, 110
- Renal calculus, 143
- Renal carcinoma, 143
- Renal cysts, 960
- Replication division, 44
- Reproductive cells, radiosensitivity of, 46
- Res ipsa loquitur*, 15, 17
- Resistance, electrical, 59
- Resolution
contrast, 74
spatial, 75–76, 75b
controlling and influencing factors on, 75–76
- Respiration, 26
assessment of, 26
defined, 15
mechanics of, 112
- Respiratory arrest, 16, 27
- Respiratory bronchioles, 112
- Respiratory rate, 26
- Respiratory system, 111–112
- Respiratory tract, 111
- Respondeat superior*, 15, 17, 33
- Results, of examination, 14
- Resume, 210–216
appearance of, 215–216
contents of, 210–211
cover letter for
appearance of, 215–216
for general mailing, 210, 210f
in response to job posting, 215, 215f
education on, 212f–214f, 215
employment experiences on, 211, 212f–214f
goal statement on, 211, 212f–214f
job application and, 216
key points on, 216b
personal data on, 211, 212f–214f
professional accomplishments, associations, and credentials on, 212f–214f, 215
purpose of, 210
references on, 212f–214f, 215
sample, 211, 212f–214f
- Retrograde pyelogram, 160f
- Retrograde pyelography, 145, 145t
- Review
determining length of, 2–3
key points, 6b
planning process of, 3–4
preparation for, 1–14
prioritization of study topics for, 2–6
scheduling study time, 4–5, 4f
strongest subjects, 3
study habits for, 5
weakest subjects, 3
weakest to strongest topics, 3–4
- Rheumatoid arthritis, 117
- Ribosomes, 44
- Ribs
anatomy of, 102–103
radiographic procedures for, 133
- Rickets, 117
- Right anterior oblique (RAO), 91
- Right lateral decubitus, 91
- Right lateral recumbent, 91
- Right lymphatic duct, 111
- Right posterior oblique (RPO), 91
- RIS. *see* Radiology information system (RIS)
- Roots, 92
- Rotation, 97
- Routines, 93
- RPO. *see* Right posterior oblique (RPO)
- Rules of Ethics, of American Registry of Radiologic Technologists, 19b–21b
- S**
- Sacral vertebrae, anatomy of, 101
- Sacroiliac joints, radiographic procedures for, 130
- Sacrum
radiographic procedures for, 130
region of, topography of, 93
- Saddle joint, 97
- Safety, 39–57
challenge tests on, 154–157, 168–171, 183–186
Sagittal plane, 91, 95

- Saliva, 112
- Salivary glands, 112
- Scapula
anatomy of, 103, 104f
radiographic procedures for, 122, 122f
- Scatter
coherent, 42
Compton, 41, 42f
- Scheduling
of radiographic examinations, 22, 22b
study time, 4–5, 4f
- Scoliosis, 102, 117
radiographic procedures for, 130
- Seat belt fracture, 117
- Secondary bronchi, 112
- Self-induction, 59
- Sella turcica, 99
- Semiconductor, 59
- Septic shock, 16, 27
- Shadow shield, 47
- Shape distortion, 76, 76f
- Shielding, 49
- Shields
Bucky slot, 50
flat contact, 47
gonadal, 47
shadow, 47
- Shock, 16, 27
allergic, 16, 27
cardiogenic, 16, 27
hypovolemic, 16, 27
neurogenic, 16, 27
septic, 16, 27
- Shoulder
anatomy of, 103
AP projection of, 164f
radiographic procedures for, 121, 121f
- SI system, 58
- SI units of measurement, 8
- Siderosis, 131
- Sievert, 39–40
- Sigmoid colon, 114
- Silicosis, 131
- Sine waves, 58–59
- Single-phase, two-pulse alternating current, 59
- Sinus, 96
- Size distortion, 76
- Skeletal system
anatomy of, 96–108
appendicular skeleton in, 103–108
articulations in, 97
axial skeleton in, 97–103
bones in, 96
bones of thorax in, 102–103
division of, 96–97
facial bones in, 99–100
lower extremity in, 103–108
marrow in, 96
ossification in, 96
skull in, 97–99, 98f
skull morphology in, 97
upper extremity in, 103
vertebral column in, 100–102
functions of, 96
- Skeleton
appendicular, 97, 103–108
axial, 97–103
division of, 96–97
- Skull
anatomy of, 97–99, 98f
cranium in, 97
ethmoid bone in, 99
frontal bone in, 97
occipital bone in, 99
parietal bones in, 97
- Skull (*Continued*)
sphenoid bone in, 99
temporal bones in, 97–99
brachycephalic, 97
dolichocephalic, 97
injuries of, 95
lateral projection of, 165f
mesocephalic, 97
radiographic procedures for, 134–139
- Slander, 15, 17
- Small bowel obstruction, 140
- Small intestine
anatomy of, 113
radiographic procedures for, 142
- Small saphenous vein, 111
- Social media, professional judgment in using, 224
- Software, artifacts related to, 72
- Solenoid, 59
- Somatic effects, 8, 39, 46
early, 40, 46
late, 40, 46
- Somesthetic area, 108
- Sonography, diagnostic medical, 205–206
- Source-to-image receptor distance (SID), and
spatial resolution, 75
- Spatial frequency resolution, 71
- Spatial resolution, 75–76, 75b
controlling and influencing factors on, 75–76
- Specialties, 205–208
diagnostic medical sonography as, 205–206
as imaging manager, 208
key points on, 209b
nuclear medicine as, 206
other, 207
radiation therapy technology as, 206–207
as radiography educator, 207–208
as radiologist assistant, 207
- Speed of travel, 58
- Sperm cells, immature, radiosensitivity of, 46
- Sphenoid bone, anatomy of, 99
- Sphygmomanometer, 15
- Spina bifida, 117
- Spine, 96
cervical
anatomy of, 100–101
injuries in, 95
topography of, 93
iliac, anterior inferior, 103
lumbar
anatomy of, 101
topography of, 93
thoracic
anatomy of, 101
topography of, 93
- Spinous process, 100
- Spiral fracture, 116
- Spleen, 111
- Splenic artery, 110
- Splints, 95
- Spondylolisthesis, 117
- Spondylolysis, 117
- Squamous portion, 97
- Standard of ethics, of American Registry of
Radiologic Technologists, 19
- Standard precautions, 15
- State accreditation, 203
- State licensure, 203
- Stationary grids, 77
- Stem, of test item, 13
- Step-down transformer, 59
- Step-up transformer, 59, 61
- Sterile technique, 25
- Sterilization
chemical, 24
gas, 25
- Sternoclavicular joints, radiographic procedures
for, 133
- Sternocostal articulations, 102f
- Sternum
anatomy of, 102
radiographic procedures for, 133, 133f
- Sthenic body habitus, 94
- Stochastic effects, 39, 43
- Stomach
anatomy of, 113, 113f
AP projection of, 161f
radiographic procedures for, 141–142, 141f
- Stress fracture, 116
- Structural protective barriers, for radiation
worker, 50
determinants of, 50
primary, 50
secondary, 50
x-ray tube housing for, 50
- Students under supervision, expectations of,
225–226
- Study calendar, 3, 4f
- Study habits, 5
- Styloid process, 99
- Subarachnoid space, 109
- Subclavian arteries, 110
- Subject contrast, 74, 74f–75f
- Sublingual glands, 112
- Subluxation, 116
- Submandibular glands, 112
- Subtraction, 71
- Suction unit, 16, 27
- Suffixes, 92
- Sulcus, 96
- Superior mesenteric artery, 110
- Superior orbital fissure, 99
- Superior vena cava, 111
- Support equipment, 28
- Suprapubic catheter, 28
- Suprarenal artery, 110
- Surgical asepsis, 15, 24–25
- Surgical cholangiogram, 143
- Swallowing, 113
- Symphysis pubis, 103
- Synarthroses, 97
- Synovial joints, 97
- Systolic pressure, 15, 26
- T**
- Tachycardia, 15
- Talipes, 116
- Talus, anatomy of, 106
- Tangential, 91
- Target interactions, 8
- Target theory, 45
- Task inventory, 6, 221–223
- Technical errors, artifacts related to, 72
- Telophase, 44
- Temperature, 15, 26
- Temporal bones, anatomy of, 97–99
- Temporal lobe, 108
- Temporomandibular articulations, radiographic
procedures for, 138
- Terminal bronchioles, 112
- Tertiary bronchi, 112
- Test items, 13
- Test-taking skills, 12–14
- Thermal energy, 58
- Thermionic emission, 62
- Thermoluminescent dosimeters (TLDs), 51
- Thoracic aorta, 110
- Thoracic duct, 111
- Thoracic spine
anatomy of, 101
topography of, 93

- Thoracic vertebrae, radiographic procedures for, 127–128, 128f–129f
- Thorax
bones of, 102–103
radiographic procedures for, 130–139
- Three-phase alternating current, 59
- Thumb, radiographic procedures for, 118
- Thymus, 111
- Thyroid, effects of radiation on, 46
- Tibia, anatomy of, 106, 106f
- Time
administrators and, 224
indicators, 92
and radiation exposure, 49
- Timer, 60–61
electronic, 60
mAs, 60
- Tissue density, and contrast, 74
- Tissue thickness, and contrast, 74
- Tissue weighting factor (W_T), 40
- TLDs. *see* Thermoluminescent dosimeters (TLDs)
- Toes
anatomy of, 106–108
radiographic procedures for, 122
- Tongue, 112
- Tonsils, 111
- Topography, 93, 93b
- Torts, 15, 17
- Total filtration, 47
- Trachea, 112
- Tracheolaryngeal edema, 27
- Transfer, 23
cart, 23
key review points on, 24b
from wheelchair to x-ray table, 23
from x-ray table to wheelchair, 23
- Transformer, 59
- Transmission
airborne, 15, 24
common vehicle, 15, 24
contact
direct, 15, 24
indirect, 15
droplet, 15, 24
routes of, 24
vector-borne, 15, 24
- Transmission-based precautions, 7
types of, 25
- Transverse arches, 108
- Transverse colon, 114
- Transverse fracture, 116
- Transverse plane, 91, 96
- Transverse processes, 100
- Trauma
defined, 16
patient care for, 27–28
procedures for, 95, 95b
- Trimalleolar fracture, 116
- Trochanter, 96
- Trochlea, anatomy of, 103
- Tube window, 62
- Tubercle, 96
- Tuberculosis, 131
- Tuberosity, 96
- Tutorial, 13
- U**
- Ulcerative colitis, 960
- Ulna, anatomy of, 103
- Ulnar artery, 110
- Uncontrolled area, 50
- Undisplaced fracture, 116
- Unintentional misconduct, 17
- Units of radiation measurement, 40, 40b
- Upper extremity, anatomy of, 103
- Upper gastrointestinal system, radiographic procedures for, 140–142
- Upside down grid, 78
- Ureters, 114
- Urethra, 115
- Urinary catheters, 28
- Urinary system, 114–116
radiographic procedures for, 143–144
- U.S. Departments of Education and Labor, 208
- Use factor, 50
- V**
- Valid consent, 18
- Valves, 111
- Variable kVp-fixed mAs technique charts, 63
- Variable technique, 63
- Vector-borne transmission, 15, 24
- Veins, 109
- Velocity, 58
- Venipuncture, 30–31
key review points on, 31b
- Venous catheters, 28
- Venous systemic circulation, 110–111
- Ventilators, 16, 28
- Ventral, 91
- Ventral decubitus, 91
- Ventral recumbent, 91
- Ventricles, 109
- Venules, 109
- Verbal communication, 15–16
- Vertebrae
anatomy of, 100
cervical
anatomy of, 100–101, 101f
radiographic procedures for, 126–127, 126f–128f
lumbar
anatomy of, 101, 102f
radiographic procedures for, 128–130, 129f
morphology of, 100
sacral, anatomy of, 101
thoracic
anatomy of, 101, 102f
radiographic procedures for, 127–128, 128f–129f
- Vertebral artery, 110
- Vertebral column, anatomy of, 100–102
- Vertebral veins, 111
- View, 91
- Visual area, 108
- Vital signs, 26–27
- Vocal chords, 112
- Voltmeter, prereading, 60
- Voluntary motion, 93–94
- Volvulus, 140
- Vomer, anatomy of, 100
- W**
- Water, radiolysis of, 40, 45
- Wave-particle duality, 58
- Wheelchair
transfer from, 23
transfer to, 23
- Wilms' tumor, 144
- Window width, 71
- Work, 58
- Workforce, entering into, 221
- Workload, 50
- W_R . *see* Radiation weighting factor (W_R)
- Wrist
anatomy of, 103, 105f
PA radiograph of, 163f
radiographic procedures for, 118–119, 118f–119f
- W_T . *see* Tissue weighting factor (W_T)
- X**
- X-ray beam, 8
characteristics, 64–65
- X-ray control booth, 50
- X-ray emission spectrum, 64
continuous, 64
discrete, 64
- X-ray production, 7, 63–65
Bremsstrahlung (brems) radiation in, 63, 63f
characteristic radiation in, 64, 64f
conditions necessary for, 60, 65b
equipment for, 60–62, 60f
automatic exposure control (AEC) as, 60–61
autotransformer as, 60
electronic timer as, 60
falling load generator, 61
glass envelope with window as, 62
mA control (filament control) as, 61
mAs timer as, 60
milliammeter (mA meter), 61
prereading voltmeter as, 60
quality control for, 67–68, 68b
rectifier as, 61
step-up transformer as, 61
timer as, 60–61
tube housing as, 62
x-ray tube as, 62, 62f
heat units in, 65
x-ray beam characteristics, 64–65
x-ray properties in, 64
- X-ray table
transfer from cart to, 23
transfer from wheelchair to, 23
transfer to wheelchair from, 23
- X-ray tube, 62, 62f
- X-ray tube housing, 50
- Z**
- Zygomatic arches, radiographic procedures for, 137–138
- Zygomatic bone, 100