PHARMACOLOGY AND THE NURSING PROCESS

Lilley
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Snyder

Ninth Edition

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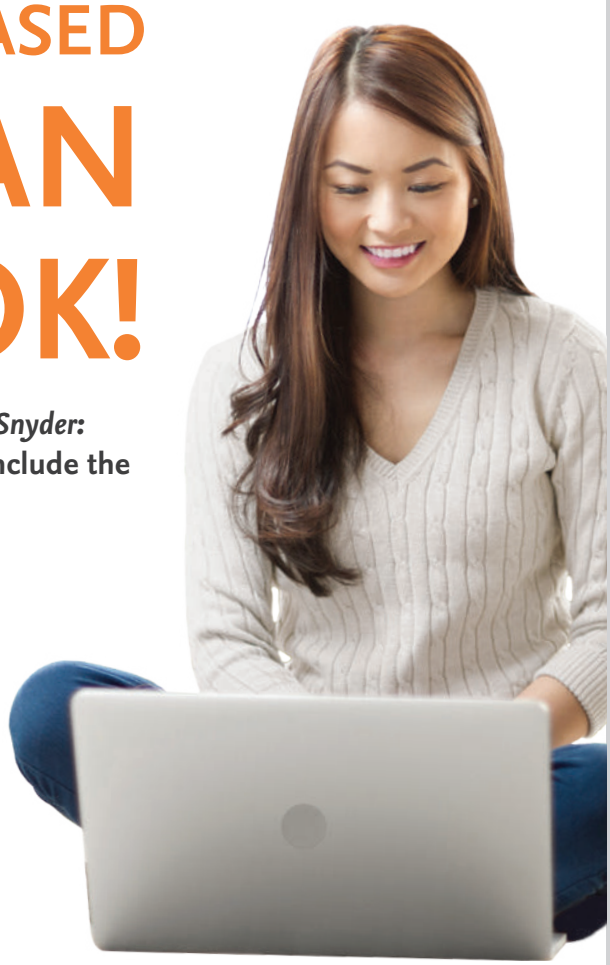

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BRIEF CONTENTS

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Linda Lilley received her diploma from Norfolk General School of Nursing, BSN from the University of Virginia, Master of Science (Nursing) from Old Dominion University, and PhD in Nursing from George Mason University. As an Associate Professor Emeritus and University Professor at Old Dominion University, her teaching experience in nursing education spans over 25 years, including almost 20 years at Old Dominion. Linda's teaching expertise includes drug therapy and the nursing process, adult nursing, physical assessment, fundamentals in nursing, oncology nursing, nursing theory, and trends in health care. The awarding of the university's most prestigious title of University Professor reflects her teaching excellence as a tenured faculty member. She has also been a two-time university nominee for the State Council of Higher Education in Virginia award for excellence in teaching, service, and scholarship. Linda received the 2012 Distinguished Nursing Alumni Award from Old Dominion University School of Nursing for her "continued work on the successful pharmacology textbook published by Elsevier" and to recognize her "extraordinary work and the impact [the book] has had on baccalaureate education." While at Old Dominion University, Linda mentored and taught undergraduate and graduate students as well as registered nurses returning for their BSN. Linda authored the MED ERRORS column for the *American Journal of Nursing* between 1994 and 1999, as well as numerous other peer-reviewed, published articles in professional nursing journals. Since retiring in 2005, Linda continues to be active in nursing, serving as a member on dissertation committees with the College of Health Sciences and maintaining membership and involvement in numerous professional and academic organizations. Since January of 2014, Dr. Lilley continues to serves on the volunteer review panel for the monthly newsletter publication *Nurse Advise-ERR* (ISMP affiliated; the ISMP [Institute for Safe Medication Practices] is a nonprofit organization educating the healthcare community and consumers about safe medication practices). Linda has served as a consultant with school nurses in the city of Virginia Beach and as a member on the City of Virginia Beach's Health Advisory Board. Linda also served as an appointed member on the national advisory panel on medication error prevention with the U.S. Pharmacopeia in Rockville, Maryland. She continues to educate nursing students and professional nurses about drug therapy and the nursing process and speaks on the topics of drug therapy, safe medication use, humor and healing, and grief and loss.

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Shelly Rainforth Collins received her Doctor of Pharmacy degree from the University of Nebraska, College of Pharmacy in 1985, with High Distinction. She then completed a clinical pharmacy residency at Memorial Medical Center of Long Beach in Long Beach, California. She worked as a pediatric clinical pharmacist (neonatal specialist) at Memorial Medical Center before moving to Mobile, Alabama, where she was the Assistant Director of Clinical Pharmacy Services at Mobile Infirmary Medical Center. After moving to Chesapeake, Virginia, she served as the Clinical Pharmacy Specialist/Coordinator of Clinical Pharmacy Services at Chesapeake Regional Medical Center in Chesapeake, Virginia for 19 years. Her practice focused on developing and implementing clinical pharmacy services as well as medication safety and Joint Commission medication management standards and national patient safety goals. She is president of Drug Information Consultants, a business offering consultation and expert witness review for attorneys on medical malpractice cases. She holds certifications in Medication Therapy Management, Anticoagulation Management, and Immunizations. Shelly was awarded the Clinical Pharmacist of the Year Award in 2007 from the Virginia Society of Healthsystem Pharmacists. She led a multidisciplinary team that won the Clinical Achievement of the Year Award from George Mason University School of Public Health in 2007 for promoting safety with narcotics in patients with sleep apnea; this program has also received national recognition. She was awarded the Service Excellence Award from Chesapeake Regional Medical Center. Shelly's professional affiliations include the American Society of Healthsystem Pharmacists, the Virginia Society of Healthsystem Pharmacists, and the American Pharmacists Association.

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Julie Snyder received her diploma from Norfolk General Hospital School of Nursing and her BSN and MSN from Old Dominion University. After working in medical-surgical nursing, she worked in nursing staff development and community education. Later, she transferred to the academic setting and taught fundamentals of nursing, pharmacology, physical assessment, and adult medical-surgical nursing at a university school of nursing. Julie has recently worked as a Quality Initiative Coordinator and a Clinical Nurse Educator in a local hospital. She is now a Lecturer at the School of Nursing of Regent University in Virginia Beach, Virginia. She has been certified by the ANCC in Nursing Continuing Education and Staff Development and currently holds ANCC certification in Medical-Surgical Nursing. She is a member of Sigma Theta Tau International and was inducted into Phi Kappa Phi as Outstanding Alumni for Old Dominion University. She has worked for Elsevier as a reviewer, ancillary writer, and author since 1997. Julie's professional service has included serving on the Virginia Nurses' Association Continuing Education Committee, serving as Educational Development Committee chair for the Epsilon Chi chapter of Sigma Theta Tau, serving as an item writer for the ANCC, working with a regional hospital educators' group, and serving as a consultant on various projects for local hospital education departments. In addition, she has conducted pharmacology review classes for recent nursing graduates.

PHARMACOLOGY AND THE NURSING PROCESS

Ninth Edition

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PREFACE

Now in its ninth edition, *Pharmacology and the Nursing Process* provides the most current and clinically relevant nursing pharmacology content in a visually appealing, understandable, and practical format. The accessible size, clear writing style, and full-color design of *Pharmacology and the Nursing Process* are ideal for today's busy nursing student. The book not only presents drug information that nursing student needs to know but also provides information on what professional nurses may encounter during drug administration in a variety of health care settings, including accounts of real-life medication errors and tips for avoiding those errors. Edition after edition, the book has become increasingly inviting and engaging for the adult learner to read and study. Features that help set the book apart include:

- A focus on the role of prioritization in nursing care
- A strong focus on drug classes to help students acquire a better knowledge of how various drug classes work in the body, allowing them to apply this knowledge to individual drugs
- Ease of readability to make this difficult content more understandable
- Integrated learning strategies content that helps students understand and learn the particularly demanding subject of pharmacology while also equipping them with tools that they can use in other courses and as lifelong learners who are building an evidence-based practice

For this edition, the author team has continued to focus closely on providing the most "need-to-know" information, enhancing readability, and emphasizing the nursing process and prioritization throughout.

Sharing the goal of creating a nursing pharmacology textbook that is not only academically rigorous but also practical and easy to use, the authors bring together a unique combination of experience. The author team is comprised of an Associate Professor Emeritus with a PhD in nursing and more than 25 years of teaching experience, a clinical pharmacist with a PharmD and over 30 years of experience in hospital and long-term care pharmacy practice, and a nurse educator who holds a MSN in nursing education and has 30 years of teaching experience.

ORGANIZATION

This book includes 58 chapters presented in 10 parts, organized by body system. The 9 "concepts" chapters in Part 1 lay a solid foundation for the subsequent drug units and address the following topics:

- The nursing process and drug therapy
- Pharmacologic principles
- Lifespan considerations related to pharmacology
- Cultural, legal, and ethical considerations
- Preventing and responding to medication errors
- Patient education and drug therapy
- Over-the-counter drugs and herbal and dietary supplements
- Gene therapy and pharmacogenomics
- A photo atlas that describes drug administration techniques, including more than 100 drawings and photographs

Parts 2 through 10 present pharmacology and nursing management in a time-tested body systems/drug function framework. This approach facilitates learning by grouping functionally related drugs and drug groups. It provides an effective means of integrating the content into medical-surgical/adult health nursing courses or for teaching pharmacology in a separate course.

The 49 drug chapters in these 9 parts constitute the main portion of the book. Drugs are presented in a consistent format with an emphasis on drug classes and key similarities and differences among the drugs in each class. Each chapter is subdivided into two discussions, beginning with (1) a brief overview of anatomy, physiology, and pathophysiology and a complete discussion of pharmacology, followed by (2) a comprehensive yet succinct application of the nursing process.

Pharmacology is presented for each drug group in a consistent format:

- Mechanism of Action and Drug Effects
- Indications
- Contraindications
- Adverse Effects (often including Toxicity and Management of Overdose)
- Interactions
- Dosages

Drug class discussions conclude with  Drug Profiles—brief narrative "capsules" of individual drugs in the class or group, including Pharmacokinetics tables for each drug. High-alert medications are identified with a  symbol to increase awareness of high-alert medications.

The pharmacology section is followed by a Nursing Process discussion that relates to the entire drug group. This nursing content is covered in the following, familiar nursing process format:

- Assessment
- Human Need Statements
- Planning (including Goals and Outcome Criteria)
- Implementation
- Evaluation

At the end of each Nursing Process section is a Patient-Centered Care: Patient Teaching section that summarizes key points for nursing students and/or practicing nurses to include in the education of patients about their medications. This section focuses on teaching how the drugs work, possible interactions, adverse effects, and other information related to the safe and effective use of the drug(s). The role of the nurse as patient educator and advocate continues to grow in importance in professional practice, so there is emphasis on this key content in each chapter in this edition. This arrangement of content can be especially helpful to faculty who teach pharmacology through an integrated approach because it helps the student identify key content and concepts.

NEW TO THIS EDITION

To further improve the hallmark readability and user-friendliness of *Pharmacology and the Nursing Process*, each line of the text has been edited to improve readability.

The ninth edition of *Pharmacology and the Nursing Process* continues to feature additional Quality and Safety Education for Nurses (QSEN) competencies by providing the following:

- Use of human need theory with human need statements to replace previously identified nursing diagnoses included in the Nursing Process sections of each chapter
- Revised case studies with the relevant QSEN content included
- Selected case studies featuring collaboration and teamwork content
- Additional Safety and Quality Improvement: Preventing Medication Errors boxes
- Further explanation and discussion of the QSEN initiative as it relates to safety and quality of patient care included in the Medication Errors chapter and in boxes throughout the book

The QSEN initiative is also highlighted in this edition's *TEACH for Nurses* Lesson Plans (see Supplemental Resources).

The pharmacology and nursing content in each of the 58 chapters has been thoroughly revised and critically reviewed by nursing instructors, practicing nurses, and a clinical pharmacist to reflect the latest drug information and nursing content. Key updates include:

- New seizure classifications
- New oral anticoagulant reversal agents
- Black box warnings added in bold to highlight safety
- Recently approved drugs that are included and discussed
- Substance abuse terminology changing to Substance Use Disorder
- Revised Review Questions at the end of each chapter, including alternate-item format and dosage calculation questions to assist the student in preparation for the NCLEX® examination.

ADDITIONAL TEACHING/LEARNING FEATURES

The book also includes a variety of innovative teaching/learning features that prepare the student for important content to be covered in each chapter and encourage review and reinforcement of that content. Chapter opener features include the following:

- Learning Objectives
- Summary of Drug Profiles in the chapter, with page number references
- Key terms with definitions (key terms being in **bold blue** type throughout the narrative to emphasize this essential terminology)

The following features appear at the end of each chapter:

- Patient Teaching Tips related to drug therapy
- Key Points summarizing important chapter content
- Critical Thinking Questions, with answer guidelines provided on the Evolve website
- Review Questions, with answers provided in the back of the book for quick and easy review
- List of Evolve Resources available to students

In addition to the special boxes listed previously, other special features that appear throughout the text include:

- Case Studies, with answer guidelines provided on the Evolve website
- Dosages tables listing generic and trade names, pharmacologic class, usual dosage ranges, and indications for the drugs

For a more comprehensive listing of the special features, please see the inside back cover of the book.

SUPPLEMENTAL RESOURCES

A comprehensive ancillary package is available to instructors (and their students) who adopt *Pharmacology and the Nursing Process*. The following supplemental resources have been thoroughly revised for this edition and can significantly assist teaching and learning of pharmacology.

Study Guide

The carefully prepared student workbook includes the following:

- Student Study Tips that reinforce the Learning Strategies in the text and provide a "how to" guide to applying test-taking strategies
- Worksheets for each chapter, with NCLEX®-style questions (now with more application-based, alternate-item, and dosage calculation questions), critical thinking and application questions, and other activities
- Case Studies followed by related critical thinking questions
- An updated Overview of Dosage Calculations with helpful tips for calculating dosages, sample drug labels, practice problems, and a quiz
- Answers to all questions (provided in the back of the book) to facilitate self-study

Evolve Website

Located at *http://evolve.elsevier.com/Lilley/*, the Evolve website for this book includes the following:

For students:

- More than 600 NCLEX® Examination Review Questions
- Printable, expanded Key Points for each chapter
- Content Updates
- Answers to Case Studies from the book

For instructors:

- *TEACH for Nurses* Lesson Plans that focus on the most important content from each chapter and provide innovative strategies for student engagement and learning. These new Lesson Plans include strategies for integrating nursing curriculum standards (QSEN, concept-based learning, and the BSN essentials), links to all relevant student and instructor resources, and an original instructor-only Case Study in each chapter.
- ExamView Test Bank that features more than 800 test questions (including alternate-item questions) with rationales and answers coded for NCLEX® Client Needs category, nursing process step, and cognitive level (new and old Bloom's taxonomy). The robust ExamView testing application, provided at no cost to faculty, allows instructors to create new tests; edit, add, and delete test questions; sort questions by NCLEX® Client Needs category, cognitive level, and nursing process

step; and administer and grade tests online, with automated scoring and gradebook functionality.
- PowerPoint Lecture Slides consist of more than 2100 customizable text slides for instructors to use in lectures.
- Audience Response System Questions (three or more discussion-oriented questions per chapter for use with i>Clicker and other systems) are folded into these presentations.
- An Image Collection with more than 200 full-color images from the book for instructors to use in lectures.
- Access to all student resources listed above.

Pharmacology Online

Pharmacology Online for *Pharmacology and the Nursing Process*, ninth edition, is a dynamic, unit-by-unit online course that includes interactive self-study modules, a collection of interactive learning activities, and a media-rich library of supplemental resources.

- *Self-Study Modules* go beyond the basic principles of pharmacology, with animations and NCLEX® Examination–style questions to help students assess their understanding of pharmacology concepts.
- *Interactive Case Studies* immerse students in true-to-life scenarios that require them to make important choices in patient care and patient teaching.
- "*Roadside Assistance*" video clips use humor and analogy in a uniquely fun and engaging way to teach key concepts.
- Interactive Learning Activities, Practice Quizzes for the NCLEX® Examination, and more are also included.

ACKNOWLEDGMENTS

This book truly has been a collaborative effort. We wish to thank the instructors and students who provided input on an ongoing basis throughout the development of the current and previous editions. Many thanks and appreciation for the hard work, support and dedication shown by Laura Goodrich, Senior Content Development Specialist; Sonya Seigafuse, Executive Content Strategist; and Clay Broeker, Book Production Specialist on this current edition. Their attention to detail, conscientiousness and professionalism has been exhibited in all of their interactions with us, the authors. Clay Broeker has been our production specialist for numerous editions, and we are so very appreciative of his continued work, dedication, and support on the ninth edition. He has always guided us with patience and professionalism through to publication on these projects. Special thanks to Kristin Geen, Jamie Blum, and Charlene Ketchum, who worked diligently and supported us on earlier editions. Laura Jaroneski lent her study skills expertise and has updated the unique and appropriate Learning Strategies features for students; for her collaboration, we are most grateful. Finally, we thank Joe Albanese for his contributions to the first edition of the book, Bob Aucker for his contributions to the first three editions, and Scott Harrington for contributions through the sixth edition.

Linda thanks her daughter Karen for her unwavering and constant support. Long hours and time spent researching and writing has preempted time with family, but Karen has always understood. Linda wishes to dedicate this book to Karen Leanne Lilley Harris because of her continued inspiration, encouragement, and support for all professional endeavors and accomplishments. The memory of Linda's parents, John and Thelma Lane, who passed away during the fourth edition, and in-laws J.C. and Mary Anne Lilley, who passed away during the fifth and sixth editions, has continued to provide inspiration and a sense of pride in all her work. Students and graduates of Old Dominion University School of Nursing have been eager to provide feedback and support, beginning with the class of 1990 and continuing through the class of 2005. Without their participation, the book would not have been so user-friendly and helpful to students embarking upon their study of drug therapy. Linda attributes her successes and accomplishments to a strong sense of purpose, faith, and family as well as a continued appreciation and value for the light-hearted side of life. To Jibby Baucom, Linda offers many thanks, because without her recommendation to Mosby, Inc. back in the 1990s, the book would never have been developed. Robin Carter, Kristin Geen, Lee Henderson, Jamie Blum, and Jackie Twomey have also been significant resources and more than just editors with Elsevier; they have been sources of strength and encouragement. Their excellent work ethic, positivity, and calming natures will be forever appreciated. The fifth through ninth editions have also involved Clay Broeker, who has been a tremendous resource in dealing with production issues; his contributions to all of these editions have been strong, exceptional, and forward-thinking. Elsevier has shared some of its best employees with Linda beginning with the first day of the first edition; for that, Linda is most thankful and extremely grateful.

Shelly wishes to dedicate this edition to her daughter Kristin Collins of Chesapeake, Virginia, and to her father Charles Rainforth of Hastings, Nebraska, the two most important people in her life. You both have been an inspiration, a support system, and most importantly, a source of constant love. Kristin, it has been such a joy watching you grow into the wonderful woman you have become. You are an amazing educator, and your students are, and will continue to be, inspired by your passion, grace, and dedication. I am so very proud of you!! The memory of Shelly's mother, Rogene Rainforth, who passed away during the seventh edition, continues to provide a sense of pride and love. Shelly wishes to thank her brother, Randy Rainforth, for supporting their father when distance separates the family. Shelly would also like to thank Linda Lilley and Julie Snyder for giving her the opportunity to be affiliated with such a wonderful book. To the amazing editorial staff at Elsevier, thank you.

Julie wishes to dedicate this edition to her husband, Jonathan, for his love and patience during long hours of revisions. She thanks her parents Willis and Jean Simmons and her daughter Emily Martin and son-in-law Randy Martin for their unfailing love, support, and encouragement. She appreciates the support of the staff nurses who work alongside and provide leadership for our nursing students in the clinical settings. Thanks also to Rick Brady for his previous assistance with the photo shoot for the Photo Atlas of Drug Administration and to Scott Brown for his work in updating the photographs in the current edition. Julie also thanks the administration of Chesapeake Regional Healthcare and the 2017 RN Residents (Divina Mendoza, Sara Allison, Napre Hayag, Jennifer Duty, and Rina Nina Fetalvaro) for lending the facility and their time for this edition's photo shoot. The support and the encouragement of family, friends, and colleagues are vital to projects like this. Thanks also to Shelly Rainforth Collins for her clinical insight and endless willingness to address questions. Julie continues to deeply appreciate the encouragement, mentoring, support, and friendship of Dr. Linda L. Lilley over the years; her drive to make this book a success is inspirational. Most importantly, Julie gives thanks to God, our source of hope and strength. Finally, to those who teach, although your work may seem to go unnoticed or unappreciated, your impact will always be remembered through the accomplishments of your students. Thank you for teaching our future nurses.

WE WELCOME YOUR FEEDBACK

We always welcome comments from instructors and students who use this book so that we may continue to make improvements and be responsive to your needs in future editions.

Linda Lane Lilley
Shelly Rainforth Collins
Julie S. Snyder

LEARNING STRATEGIES

Opening your pharmacology textbook and glancing at the table of contents can seem overwhelming. You may wonder how you ever will be able remember so much information as well as the best approach in tackling such a daunting topic. The good news is that there are many learning strategies available to help you not only learn about pharmacology but also apply this knowledge to the nursing care of patients.

To the learner, as the title of the book implies, pharmacology is very important to the nursing process. You will come to understand that learning in nursing is not about memorization but rather about application of learning. While there will be many times when memorization is required to begin to understand a new field of knowledge, the ultimate goal will always be to take your learning to a higher level. Learning strategies will be presented here that will guide you with techniques and suggestions on how to define and clarify the way you study and learn so that it will become second nature to transform your thinking into deeper, long-term learning with subsequent application to your professional nursing practice.

As you begin your nursing education, you will soon realize that learning does not stop once you receive your degree and pass your state-licensing exam. As a professional nurse, you will come to understand that new information is always being added in the medical, pharmacology, and nursing professions. In the area of pharmacology, there are always new drugs being adopted, as well as discontinued, for use by the US Food and Drug Administration. The strategies that you learn here can be used again and again to assist you in remaining current in new discoveries, new information, and new standards of practice within the nursing profession.

You must be an active participant in your learning. Your instructor/faculty member acts more like a guide that assists you in attaining your fullest potential, allowing you to see the bigger picture or concept being taught. When students are taught this way, they gain more from their lessons because they are putting their learning into action. Also, that learning becomes embedded in their long-term memory because it is connected with a more complex thought process and has associated actions. You will need to be an active participant if you wish to fully comprehend and be able to apply pharmacology to your nursing knowledge/practice. Nurses spend a large part of their day giving medications to their patients. Anybody can open a pill packet, drop the pill in a cup, and give it to a person. However, safe medication administration demands an enormous amount of knowledge and understanding about why a patient is receiving a medication, specific actions that need to be taken before you give the medication, expected outcomes anticipated from the dose of medication, and specific patient teaching needs. Other important things to know prior to giving medications include how to perform drug calculations for the correct dosage and understanding the possible side effects or contraindications of the medication. As you read your pharmacology textbook and listen to your instructors teaching on the subject, you will begin to understand why learning pharmacology is more than just memorizing drug facts.

NURSING PROCESS

In Chapter 1, you are introduced to the five phases of the **Nursing Process.** Throughout this textbook, you will see the nursing process applied to each category of drugs. This is a very important concept for you to understand. As you will recall from the introduction on learning strategies, administering medications to patients involves more that the physical act of giving medications. The nurse needs to know the rationale and apply critical thinking with each patient encounter. The nursing process is a way to ensure that medications are administered accurately and safely. Nurses effortlessly use the nursing process every day, and students who are new to the nursing process learn best by using it frequently.

Assessment

Every patient encounter begins with an **Assessment.** As you are learning pharmacology, the importance of the assessment will become clear. You will want to ask yourself some questions: Why is this drug being prescribed for this patient? What symptoms does the patient have? What assessments do I need to perform prior to administering the medication (e.g., checking the patient's blood pressure or laboratory values)? Does the patient have any allergies to this medication? Has the patient taken this medication before?

Human Need Statements

Each patient will receive a **Human Need Statement** based on the assessment. These human need statements relate to the medical condition, such as freedom from pain, related to hip surgery. There are also human need statements related to the actual medication the patient is receiving, such as altered safety needs, risk for injury, related to possible adverse reactions to drugs altering blood clotting. After the human need statement is identified, the nurse will administer the medication to relieve the pain from hip surgery; the medication administration will be part of the implementation. In the second example, the medication administration will be critically evaluated to watch for the adverse effects of altered blood clotting.

Planning

Once you have established the human need statement, you need to decide on a **Plan** of care for the patient. What is the outcome that you want the patient to achieve? For our first example, pain relief is an appropriate outcome. It may further be defined by the pain level (e.g., less than 5 out of 10 on the pain scale). For the second example, the outcome would state that the patient not experience any bleeding episodes. As explained in Chapter 1, these outcomes will be patient specific and have a time frame associated with them.

Implementation

With **Implementation,** you devise the actions or interventions that will provide the means in which the patient will achieve the outcome. For the patient with the human need of freedom from pain, an appropriate intervention would be to provide pain medication as prescribed. For the patient with a risk of bleeding, educating the patient about signs and symptoms of unusual bleeding would be appropriate. In these two examples, you see that implementation may be something we do for/with the patient, including patient education. Patient education is a very important component of pharmacology and the nursing process.

Evaluation

The last step of the nursing process is **Evaluation**. This is when you look at the outcomes and determine the effectiveness of the implementation phase. Did the patient with hip pain obtain relief from the administration of the pain medication? Did the patient at risk for bleeding have any episodes of bleeding and/or did he or she understand the teaching provided? If the outcome was not met, you will need to reevaluate the outcome statement and/or the interventions. Now you can see how the nursing process is an ongoing and constantly evolving process.

VOCABULARY

Learning pharmacology in nursing means that there is an abundance of new terminology that you, the student, will encounter in your reading. It is important that you study the vocabulary so that you will have a deeper understanding of the content being taught. You may already be familiar with some of the vocabulary from other courses. Each chapter opens with a list of **Key Terms**—significant vocabulary that will be introduced in that chapter. Oftentimes these words will appear in future chapters, so it is imperative that time is spent not just memorizing the terms but putting the terms into use and applying their meaning. Remember that application is important in nursing. The vocabulary words will appear in the text in **blue boldface** font, alerting you to the fact that it is a key term. Each vocabulary word is defined in the Key Terms section at the beginning of the chapter. When you see the word again in the content of the chapter, it is further defined either by explanation or application. For example, in Chapter 19, the term **first-dose phenomena** is defined as a *severe and sudden drop in blood pressure after the administration of the first dose of an alpha-adrenergic blocker*. When you see the term in the text, it is used under the heading "adverse effects," so it is helpful for you to realize that the first-dose phenomena is not something good. It is further explained in the text that this adverse effect may cause patients to fall or pass out. This example demonstrates that when you are learning a key term, it is helpful to fully comprehend the implications and application to nursing practice. Taking your learning further, you may now associate this term with patient safety and the human need statement of "Altered need for safety, risk for falls." Suddenly, a simple key term means so much more to you as a student. You can now see the application to the nursing process.

Other key terms are straightforward vocabulary words that may be learned and understood by looking at the prefix or suffix. For example, *osteoarthritis* and *osteoporosis* both begin with the prefix *osteo,* which means "bone." Learning the meaning of prefixes like *osteo* will help you decipher other words too. The words *agonist* and *antagonist* are similar; both have the word *agonist* in them. You will want to question how these words are related as well as what difference exists between the two words.

Many students find that writing out flash cards helps them to study and learn the key terms. If you choose this method, remember to also include some type of application of the word or phrase. That way, you are not just memorizing but rather making connections to previous learning and relating it to the nursing process. Memorizing is lower-level learning, whereas application is higher-level learning.

Some e-books have built-in flash cards of all the vocabulary words, making the process of self-quizzing easy. Just remember that these may not be as in-depth as the flash cards you make yourself. There are also applications that may be downloaded on a computer, smart phone, or tablet that will allow you to bring them up on your device anywhere to study instantly. That way, you can learn at your own pace and at any time.

TEXT NOTATION

Text notation is a way for students to pick out the important content as they are reading the chapters. Many students accomplish this by underlining or highlighting the text as they read. A major mistake is to begin underlining or highlighting the text the first time through. What happens on the first read through is that everything seems important, and before you know it you have marked whole paragraphs as important. The best way to prevent this from occurring is to first read through the material once without underlining or highlighting. You need to see where the author is leading you and what content is being presented in the chapter. Then you need to be aware of the author's language. You can usually tell when a concept is important. Many times, those key terms are part of the content you will need to underline or highlight. While reading the text a second time, you will be able to be more selective in what you underline or highlight. When students highlight in an effective manner, it makes the learning easier because they can just review chunks of content versus studying entire sections. Highlighting is a feature that is included in most online textbooks. Therefore, if you read your textbook in online format, highlighting is very easy. In some e-books, you can choose different highlight colors to mean different things; for example, yellow is important, red needs clarification, and blue is a definition. Some e-books also automatically take your highlighted text and place it into your notes, turning your note taking into a study guide.

When using e-books, students have the capability of adding notes as they read along. This will enhance learning and make studying for tests easier. Students can add information that they obtain in the classroom right into the notes in their e-book. Also, students can add a note with a question about the content if there is something that is not clear; later in class, the note can be used as a reminder to ask the instructor for clarification.

ENHANCED TYPEFACE

Throughout your textbook, the authors have used several types of enhanced typeface and color to draw your attention or focus in on something that they feel is important to understand. When key terms first appear in text, they are set in a blue boldface font. This will help you make connections to the definitions you read in the beginning of the chapter with the application of the terms used in the text. In the text, there are also words or phrases in italics; these are words or phrases that are not included in the key terms but are important in their own right. They signal a term or phrase that a student needs to learn to further comprehend the content.

The chapter headings are like signs that tell you what is going to be discussed. The authors begin each section with a heading, and these will appear in the same order in every chapter. In this way, students can recognize the general flow of the content. This helps organize the drug information in a consistent manner. You will notice that there are subheadings that also occur in an orderly fashion.

STUDY TIME

When a student learns a new topic for the first time, the brain looks for a connection to previous learning. If it finds a connection, then learning the content will be easier. To effectively learn a topic like pharmacology, students will have to spend a significant amount of time studying. It is a good idea if students have a set routine and put aside a specific time to study. Many students find that if they review their lecture notes the same day as the class, it helps them to remember the new concepts that were just introduced. You will need to find out what type of study schedule works best for you. You should not wait until just before a test or exam to study what you have been learning. A better plan is to work with the material frequently. This will enhance the connections formed in your brain as you review the material and help it become part of your long-term memory and learning.

LEARNING STYLES

One of the best ways to study effectively is to understand the way you learn best, otherwise termed *learning styles.* Everyone has a particular way that they learn best. Many references identify the learning styles as visual, auditory, and kinesthetic, while other sources define up to seven learning styles, with inclusion of verbal (linguistic), logical (mathematical), solitary (intrapersonal), and social (interpersonal). There are several ways for you to find out your learning style(s). Textbooks and reference books are available, but Internet/web-based resources also provide a wealth of information. A few sites that may prove helpful include *http://vark-learn.com/the-vark-questionnaire/* and *www.educationplanner.org/students/self-assessments/learning-styles-quiz.shtml*. Self-assessment learning style tests are available on Internet/web-based sites.

Here is a brief overview of each of the seven learning styles. The *visual* (spatial) learning style prefers using pictures, images, and spatial understanding, such as using mind maps and working with pictures instead of words. The *aural* style learner prefers sound and music, including recordings, rhymes, and mnemonics and setting the learning of information to jingles. *Verbal* (linguistic) students learn best with both the spoken and written word, including reading of content aloud, recording of and listening to lectures and to themselves, and participating in role playing. The *physical* (kinesthetic) style learner best comprehends/utilizes information with the use of their hands and through the sense of touch; these learners benefit from the use of physical objects as much as possible, including writing and drawing. *Logical* (mathematical) learners like to use logical reasoning and a systems approach; they like to find the reason behind the content and create/use lists of key points in their material. Students who fit the *social* (interpersonal) learning style prefer learning in groups or with other people; if this is your style, try role playing or working in groups as often as you can. The *solitary* (intrapersonal) style student learns most effectively on his or her own and uses self-study; he or she will align goals with personal beliefs and values *(www.edudemic.com/styles-of-learning)*. Some of these seven learning styles will overlap, and you may find you learn more effectively with use of more than one learning style. There is no right or wrong way to learn. By identifying your learning style, you can enhance the learning of content and get the most out of the learning experience.

USE OF APPLICATIONS

Technology has come to play an important part in how students learn and study. As discussed previously, there are many applications (or "apps") available on smart phones and tablets that students may use to learn, study, and manage their time. You will want to start with your textbook and see what types of technology, learning strategies, and ancillary tools are offered as part of your textbook purchase. The student resources for this textbook include interactive review questions and downloadable files of the key points from each chapter to help you study for tests. Additionally, there are several types of practice questions, critical thinking questions, and case studies that are available in this textbook and online. These questions may be used for independent study or in a group situation. If you are a student who embraces technology, use your smart phone or tablet to conduct a search for apps to download and assist you in learning and/or quizzing yourself on various topics within pharmacology.

FLASH CARDS

Flash cards are another method of learning about pharmacology and medications. The kinesthetic learner learns best with these strategies. Students can make up their own flash cards, listing important information about a particular drug they need to learn. Some students write out cards and use different colored inks for the information, like green for drug indications and dosage, red for side effects, orange for contraindications, and blue for nursing implications. Students can use a program on their computers to make the flash cards and bring them up on their smart phone to study later. There are also Internet sites

and mobile apps that have premade pharmacology flash cards you can use to quiz yourself.

When you know how you learn the best, you can use those strategies to make the most of your time learning and studying pharmacology. Remember that your textbook is a great place to start. Review the additional learning resources that are available from the publisher, and then you can seek out any of the other techniques mentioned in this section to help you successfully master your study time.

STUDY GROUPS

Study groups can be a very successful way to learn and study pharmacology. When working with groups, you have the ability and advantage of getting another person's perspective on a topic. Sometimes another student can explain something in a way that makes it easier for you to understand. A group working together can divide a lesson or assignment so that everyone brings something to the table, with everyone learning from one another.

First, you need to find a study group that is compatible with your learning needs and availability. You also want to make sure that the students in your group will use the time together to actually study, discuss, and quiz each other on the material and not waste time engaging in social "chit chat." The majority of the time together needs to focus on the task at hand. If the group you joined does not meet your needs, do not hesitate to leave it and find a different group. When and where students meet for a study group is also important. The environment needs to be conducive to learning for everyone in the group. Many collegiate/academic and public libraries have study rooms that students can use. Often there is a master sign-up sheet found at the front desk of the library. If the school cafeteria has a quiet section, then that may be another possible location for a study group. A beneficial time to plan a study group would be right after or close to the time after the pharmacology lecture. This planning of time would allow everyone to review and discuss new information. If any information is not clearly understood, it may then be cleared up prior to further study.

CHAT ROOMS AND DISCUSSION GROUPS

Because we live in such a mobile society and students lead busy lives with school, raising families, and working, finding time for a study group can be difficult. In these instances, using chat rooms and discussion boards are a great alternative to face-to-face group meetings. Some social media sites allow for the formation of chat rooms where students can all log in to discuss their pharmacology content. These chat rooms need to be set up by a student and are usually free of charge. Feedback from other students from other schools can also be achieved in these social media sites. Chat rooms may be accessed from home, making group meetings/activities more convenient.

Many colleges and universities already incorporate online learning and learning management systems. The learning management systems go by various names and are usually used by instructors and professors to upload course content, assignments, and grades. These systems usually have the capability to set up discussion boards. The discussion board facilitates group learning by allowing a forum for a student to post a question on a concept or topic that needs clarification and/or reinforcement. Other students can go to the site and post answers, add questions of their own, or share tips on learning (for example, posting a link to a website with useful mnemonics or other learning strategies). Discussion boards can be designed so the whole class participates or set up for small individual groups. Many of these sites are controlled and monitored by the course instructors. Discussion groups can be accessed from anywhere that a student has an Internet connection.

TIME MANAGEMENT

Time management is an extremely important task to master as a nursing student. You are embarking on a profession in which the learning, educational, and clinical preparation are all very intense. Additionally, the course work is heavy, and time seems to always be running out. However, take heart, because many students have preceded you and made it to the other side. Those students will be the first ones to tell you they could not have done it without strict time management, writing out a schedule, and following it.

To be successful at time management, you need to start with a tool to keep you on task. One of the most commonly used tools is the school planner or calendar. You will want to get one that has enough space for each day to accommodate all of the information you need to manage. If you are just juggling classes, a small planner will do. However, if you are a parent in charge of school-age kids and/or attending school and working, you will need a planner that easily accommodates all important dates. The best way to be successful is to plan things out. If a pharmacology test falls on the day after your child's school play or after a long work weekend, you will need to see it in advance. The only way to "see it" is to plot it on a planner, often weeks or months at a time. Nothing makes failure inevitable like being unaware of upcoming work, projects, quizzes, tests, and/or exams and being caught unprepared. Students often make their planners as creative and functional as they can by using stickers, different colored inks, and sticky notes, as well as organizing sections of information. Smart phones and tablets may also be used to help students manage their time and stay on task. Mobile devices have timers and/or alarms that students can set so that they are certain to allow time to study or complete an assignment on time. But remember … planners and other scheduling devices need to be used daily and frequently to be effective!

When beginning to use a planner, whether on a handwritten calendar or a smart device, start by filling in all deadlines for papers and assignments, as well as test dates. If you have a study group, put those hours down too. Fill in your family's schedule, and your own work schedule. When you have everything plotted, begin to look for conflicts or dates when school deadlines and home or work obligations overlap. Make plans immediately for what you need to do to be successful in your courses. Maybe you need to ask someone else to fill in for you at work. Time management means making difficult decisions, but these decisions will pay off in the long run. Students find that nursing school can be stressful, but preventing conflicts in their schedules before

they happen reduces the stress and the feeling of being overwhelmed. When you have your life in the next 10 to 16 weeks laid out before you, it becomes easier to see when you can catch a break and get some down time. It doesn't seem quite so overwhelming when it is spread out. Sure, there may be a few weeks that look like they will be impossible, such as during midterm and final exams, but knowing what to expect puts it all in perspective. Time management really means you are in control. If you do not plan it, it is easy for your time to begin to control you. You can be as detailed or as sketchy in your planner as you need to be, but the important thing is to make it whatever you need to keep your life running as smoothly as possible. If you have to plot every chapter that you need to read, than plot it. If you only need the assignments and test dates recorded, then just record those. Don't forget to remind yourself of holidays or days off on your planner. You need a break, and your family needs you too. Put the books aside for one day. Plan on it.

PRACTICE QUESTIONS

The practice questions provided in your textbook are one of the best gifts the authors have given to you. These questions allow you a chance to check your understanding of the content, the concepts, and the overall application of pharmacology to nursing. It is best to use them often when you are reading and as you work in your study groups. Do not just save them for when you are studying for a test. The authors have included NCLEX®-style review questions online and at the end of each chapter. They have included critical thinking and prioritization questions as well as case studies in each chapter. There are also questions available for additional practice on the website *http://evolve.elsevier.com/Lilley*. These are the type of questions you will be expected to answer on the NCLEX® examination for licensure. Make sure you take time to not only understand why the answer is correct but what made the incorrect answers wrong. You want to understand the rationale behind the reasoning. Again, it is all about making connections and really understanding the content. If you do not understand why an answer is correct, talk it out with your peers or question your instructor.

Critical thinking is the hallmark of nursing, and, in order for nurses to practice safely, they need to be able to effectively prioritize. The questions on the NCLEX® examination test both of these nursing skills. The questions on this examination are written at a higher level. Many of the test questions will be at the application or analysis level. This means that pure memorization of the concepts will not be useful. You will be expected to apply and analyze your knowledge about the concept. If you want to be successful on your NCLEX® examination, then the more you practice these types of questions, the better you will become. In turn, learning this skill will help you to be successful on your pharmacology examinations in the classroom.

An excellent way to study for these types of questions is to work with your study group and ask each other questions that apply or analyze the concepts. Try to write your own questions to quiz the group. Use the chapter objectives and the key points at the end of the chapter to guide you. Remember to ask questions based on the nursing process because those types of questions will help you critically think and actively apply your knowledge. Complete the NCLEX® questions that are provided in your textbook and the online resources. This will provide you with practice answering the application- and analysis-type questions.

In addition to the NCLEX® questions available in your textbook and online, there are numerous NCLEX® review resources available for you to use. NCLEX® review books are available, and most have their questions categorized by topic, so you can practice answering questions according to the topic in your pharmacology book. Others have a single section on pharmacology. On your computer, using a search engine like Google can lead to many websites where you can practice answering questions about pharmacology. There are also applications for tablets and smart phones to practice answering pharmacology NCLEX® questions on the go.

Although your actual NCLEX® examination is a few years away, it does not hurt to keep practicing. The more you answer these types of questions, the easier they become.

APPLICATION OF PHARMACOLOGY AND MAKING CONNECTIONS

As you learn about the different classifications of drugs, pay attention to the information in boxes placed within the text, tables, figures, and case studies in your chapters. You will discover connections between this information, your previous learning experiences, and the courses you are currently taking. including clinical rotations.

If you are taking anatomy and physiology (AP) concurrently with nursing pharmacology, you will want to make connections between how the different drugs affect the various body systems. You will discover shared terminology and vocabulary between your AP course and the anatomy, physiology, and pathophysiology review at the beginning of the chapters. Recognizing these commonalities will make learning easier. If you are enrolled in beginning nursing courses concurrently with your pharmacology, you will notice that nursing textbooks mention drug therapy when discussing patient care. For example, in most nursing programs, the respiratory system is one of the first systems you will learn. Students learn how to conduct a thorough respiratory assessment. When learning about abnormal respiratory conditions, various medications will be included in the treatment plan. Looking at Chapter 37, the disorders of asthma, chronic bronchitis, and emphysema are discussed. The chapter then provides the information on the types of medications that are used in the treatment of these disorders. This is the same information you will encounter in your nursing textbooks. Make the connections. In Chapter 37, there is a *Case Study* box about *Bronchodilators and Corticosteroids for Chronic Obstructive Pulmonary Disease*. Using this strategy allows you to make the connections between the patient, Ms. B's disease, and her pharmaceutical treatment plan. The questions contained in the scenario allow you to further connect your learning in pharmacology and other nursing courses. Perhaps you cared for a patient in your clinical rotation with COPD. This case study allows you to see the similarities and

differences between two patients with the same diagnosis. This is an important connection to make.

These examples demonstrate that nursing pharmacology is not meant to be learned in isolation. Looking for these types of connections among your other courses will assist in your learning. Making connections means you are not just memorizing information for your test day but retaining the conceptual relationships for a deeper understanding. When you become aware of medications and their actions in the human body and their indications as treatment for various diseases, you are applying your knowledge. You can take that application a step further and use it to produce concept maps for patient care or use the deeper understanding to assist your learning in other courses.

As you move through your nursing education program, it will become evident that what you are reading and studying in pharmacology will show up again and again. Making these connections early in your nursing program will assist you in learning more complex disease processes and the required nursing care. When you finish the nursing pharmacology course, do not sell the book; it will become a great reference for you to use throughout your nursing education program.

STUDYING FOR TESTS

Studying for tests or examinations is part of a process. It should never be a cram session. It is best to think in terms of "preparing" for rather than "studying" for a test or examination. If you have been following the learning strategies outlined above, then you have been preparing for the test or examination all along. You have been making connections and forming long-term memory.

When you sit down to prepare for a test, your success depends on several things. First, remember you are not cramming. Second, you are not rereading all of the corresponding chapters again. Third, you are not writing new notes to "add" to your learning. All of these activities are counterproductive at this point. They add too much information to your existing files. The information that you need for the test or examination is pushed farther down, and too much extra information causes your memory files to over-expand. Too much new information just before a test makes retrieving what you already know much more difficult. So instead of rereading the entire chapter, find the section in the chapter for which you feel you need clarification and read only that portion. If writing helps you learn, make note cards from your current notes. Extracting new notes from the book introduces too much new information too late. If you have been making flash cards, composing questions, and quizzing each other in your study group, then you should have a lot of information already stored in your brain (files). The other problem with cramming, rereading, and taking new notes is that it increases your anxiety. You begin to doubt your existing knowledge. You find all sorts of information that you feel you suddenly have to know. Anxiety impedes learning and prevents the free flow of memory.

When preparing for a test or examination, if you are confident in your understanding of a topic, leave it be and move on to something else. Rereading and reviewing material that you have mastered takes time away from reviewing content that you are not so sure of. It is okay; the other information will still be there when you need it. Put the notes and books away early, and get a good night's sleep. In the morning, leave the book and notes alone unless you absolutely need to look at something. Otherwise, you may have the urge to cram. If your study group likes to meet before the test/examination, decide if that will help or hurt you. If meeting with your group and answering questions confirms that you are ready for the test/examination, then do it. However, if someone mentions a fact you do not know, will that increase your anxiety and cause you to panic and doubt your readiness? If it will, leave the group; be confident that you already know what you need to be successful. If listening to music frees your mind and calms your nerves, do that instead and enter the classroom just before the test/examination so that your peers will not disturb your calm demeanor. Before you take the test/examination, reassure yourself that you know the material and will do well. There is power in positive thinking.

TEST-TAKING STRATEGIES

When you take your test or examination, have a system. It is strongly suggested that if you do not have an answer within a few minutes, you skip the question and move on. You do not want to increase your anxiety or waste time, because most instructors will set a specific time frame for completion of the test. When you read a multiple-choice question, make sure you understand exactly what the question is asking. Many students find highlighting or underlining key words in the *stem* (the question) helps them to quickly decide what it is really asking. If you know that you are looking for an intervention versus a sign or a symptom, it will help you determine which answer to choose.

Many students believe the correct answer will be obvious and stand out from the rest, but this is not true, especially when it comes to NCLEX®-style questions for which several answers will seem correct. Your job is to choose the *best* answer. The answer choices are called *distracters*. The wrong answers are there to distract you from choosing the correct answer. Good distracters are very similar to the correct answer, and they allow your instructor to determine whether or not you really understand the concept. A strategy to assist in choosing the best answer is to cover all of the answers as you read the question, which forces you to think critically about the question, recall what you know, and then supply an answer. As you reveal the answers, many times the answer you recalled is one of the options. Choose that answer. Then read the remaining answers to be sure you still like yours. Only change your mind if you are 100% sure that another answer is better. Recheck the stem to make sure your choice indeed answers precisely what the question is asking. This technique works well for the student who has difficulty choosing between two answers. When a student sees all the answers at once and two answers sound correct, it is easy for doubt to set in. Thinking about the concept and the answer your memory provides before seeing the choices helps avoid this dilemma.

There will be times when recalling information will not help, or when you will have no idea where the question is leading. In this case, look at each answer and then look for clues in the

stem. Sometimes reading all of the answers will alert you to what the answer should be by tugging at your memory, or you may notice that one of the answers is totally wrong. You can start eliminating answers that you know are incorrect. If you get down to two answers, you have a 50% chance of being correct, which is better than leaving it blank. So take your best guess.

Be aware of look-alike answers. There may be a subtle difference between the two, so read them carefully. It should then be obvious which one is the distracter. Beware of absolutes like "always," "never," or "must" because very few things in life are absolute. These can be easily eliminated most of the time. In pharmacology, you will often be tested on the terminology or vocabulary involved. You need to be very careful when choosing answers for these types of questions. Again, watch the spelling. You will notice that many terms are similar in spelling and meaning. To know what the question is asking, you may also have to pay attention to the exact spelling of key terms when you make flash cards. Simple words like *hypotension* and *hypertension* may be misread or transposed when you are feeling anxious.

If you have difficulty with a question and you truly do not know what it is asking, seek the assistance of your instructor. There is a 50-50 chance he or she can help you. The faculty member might tell you that the query you are posing cannot be answered without giving away the answer or may rephrase the question in a way that makes it easier for you to understand. If you ask what a term means and the vocabulary word is one that you should know, you will most likely not receive any help. Therefore, again, commit your key terms to memory!

Many schools now use electronic testing. Be sure to follow the instructions given at the beginning of the exam and "flag" questions if you are allowed to skip questions then return to them later. Be sure to mark your answers carefully. Use the calculator that is provided for dosage calculation questions to avoid making a simple math error. If you are recording your answers on an answer sheet, make sure you write each one correctly. If you skip one row, the whole answer sheet will be off. When you are taking tests and examinations, remain aware of the time so that you will not have to scramble to complete the last few pages. Not all proctors give a warning when time is almost up.

Once you have finished, turn in the test. Rereading and reviewing your answers invites the temptation to change answers. Be confident that you did your best. When you receive the results, you can complete a performance evaluation to better understand the outcome.

PERFORMANCE EVALUATION

After you have taken your test or examination in pharmacology, it is suggested that you conduct a learning self-evaluation. This evaluation needs to be completed whether or not you performed well on the examination and no matter the score. Some appropriate questions include the following: How well did you actually perform on the examination? Which areas did you struggle with? Which types of answers came effortlessly to you? Which questions or content areas did you understand quickly and easily versus a limited or incomplete comprehension? To move forward with successful performances on tests, look at your strengths and weaknesses and apply them to acquire greater understanding of the content. If you are not able to determine the rationale for a poor performance on a test, or if you lack understanding of lectures, readings, and assignments, do not hesitate to speak with your faculty member, who may be able to identify your problematic areas and is equipped to provide advice for identifying and then focusing on the right content. After you have done a thorough self-evaluation, it will be easy to know where you need to change. Reviewing your learning strategies will help ensure your success. Above all, never hesitate to talk with your instructor. It is easier for a faculty member to offer assistance and tutoring to get you back on track early in the term, rather than trying to help when there are only a few points left between you passing and failing the course.

FUTURE APPLICATION

By this point, you are well aware of just how essential the acquisition of pharmacology knowledge is to the profession of nursing. While the administration of medications is a task that anyone can perform with minimal direction, it takes immense knowledge and understanding of pharmacology to administer medications correctly and safely. One of the features of your pharmacology textbook that has not been discussed in your learning strategies is the safety aspect of medication administration. In Chapter 1, the authors explain QSEN and how quality and safe nursing care are extremely important. Nursing programs are being challenged to begin the inclusion of QSEN in their curriculum. It is in the hope that preparing future nurses with the necessary knowledge, skills, and attitudes will enable them to carry those skills into the institutions where they practice and apply them to improve the quality and safety of patient care. Throughout your textbook, you will learn and apply the QSEN competencies. You will read about Evidence-Based Practice. You will see examples of teamwork and collaboration. Patient-centered care is woven throughout your textbook. It cannot be stressed enough how crucial medication safety is to patient care. As you learn more about medications and the characteristics of the different classifications of drugs, it will become apparent that nurses play a vital role in safe medication delivery and the prevention of medication errors.

In Chapter 5, you will learn about the impact medication errors have on patients and why the prevention and reporting of errors is crucial. As nurses, you will realize that you are the last checkpoint in the chain of safe administration. You cannot fulfill this role if you do not have a strong understanding of the medications and pharmacotherapeutics. As you study your textbook, pay particular attention to the boxes on patient safety. This information is critical to your current lesson and your future nursing practice. To safely administer medications, always use the Nine Rights of medication administration, and watch for high-alert medications and look-alike, sound-alike drugs. Also, remember to only use approved abbreviations. In Chapter 5, you will also learn how technological advances (with computerized order entry and bar coding for medications), while closing the gap on medication errors, is still not foolproof. Technology is only as good as the people using it, so you must still be very

diligent and careful. Learn to live by the mantra, "When in doubt, check it out." If something does not "feel right," or if your patient questions a medication, that should be your signal to stop and investigate. Never hesitate to call a pharmacist if something does not sound right. Pharmacists and technicians are human, and they make mistakes. As the final check, nurses can catch a mistake before it reaches the patient. That is why it is imperative that you have a good understanding of pharmacology so that you can easily detect when something is not right. The pharmacology concepts you are learning will reappear in your various nursing courses. The information you learn now will have implications for your future nursing practice, and a certain percentage of pharmacology questions will appear on your NCLEX® examination.

New medications are being developed every day. In the future, when you encounter a medication that is brand new or just new to you, you'll want to look it up and learn about it as you do now in your pharmacology course. When you become a nurse, the learning never ends. You never want to be in a situation in which your patient asks you a question about his or her medication and you do not know the answer. One way to stay current with pharmacology is to subscribe to nursing journals. Articles may highlight new drugs, or there may be a news section to convey this information. You can also subscribe to various online resources like *Medscape.com*, which provides articles and news briefs on pharmacology. The *FDA.org* website offers a twice-monthly newsletter and e-mail updates on various drug-related topics. Information on medications that have just been approved as well as those on the recall list is also available. Various nursing organizations let their members know about new drugs in their area of expertise. You can have many of these updates sent to you in e-mails; for example, the Oncology Nursing Society sends out e-mail updates on new chemotherapeutic medications to their members.

There are various drug applications and drug handbooks available for your smart phone or tablet that you can use in your nursing program and future practice. Drug information is readily available on most health care institution computer systems as well. It is also a good idea to become familiar with the pharmacy department at your institution. The pharmacist can provide a wealth of knowledge to assist you with any questions you have about drug administration, adverse effects, and patient teaching. All the knowledge you are gaining in nursing pharmacology will assist you in providing safe, quality nursing care, and this is only the beginning; you will continue to broaden your horizons in nursing pharmacology with increased understanding and application of your knowledge.

1

The Nursing Process and Drug Therapy

http://evolve.elsevier.com/Lilley

OBJECTIVES

When you reach the end of this chapter, you will be able to do the following:

1. List the five phases of the nursing process.
2. Identify the components of the assessment process for patients receiving medications, including collection and analysis of subjective and objective data.
3. Discuss the process of formulating human need statements (previous editions identified nursing diagnoses) for patients receiving medications.
4. Identify the planning phase of the nursing process with outcome identification as related to patients receiving medications.
5. Discuss the evaluation process associated with the administration of medications and as reflected by outcome identification.
6. Develop a nursing care plan that is based on the nursing process and medication administration.
7. Briefly discuss the "Nine Rights" and other "Rights" associated with safe medication administration.
8. Discuss the connection between Quality and Safety Education for Nurses (QSEN) and interprofessional education (IPE) to the improvement of patient outcomes.
9. Discuss the professional responsibility and standards of practice for the professional nurse as related to the medication administration process.

KEY TERMS

Compliance Implementation or fulfillment of a prescriber's/caregiver's prescribed course of treatment or therapeutic plan by a patient. Use of *compliance* versus the term *adherence* acknowledges the consideration/acceptance of patient/family/caregiver participation in the use of the nursing process.

Medication error Any preventable adverse drug event involving inappropriate medication use by a patient or health care professional; it may or may not cause the patient harm.

Noncompliance An informed decision on the part of the patient not to adhere to or follow a therapeutic plan or suggestion.

Nursing process An organizational framework for the practice of nursing. It encompasses all steps taken by the nurse in caring for a patient: assessment, identification of human needs, planning (with goals and outcome criteria), implementation of the plan (with patient teaching), and evaluation.

Outcomes Descriptions of specific patient behaviors or responses that demonstrate meeting of or achievement of behaviors related to each patient's human needs. These statements are specific while framed in behavioral terms and are measurable.

Prescriber Any health care professional licensed by the appropriate regulatory board to prescribe medications.

OVERVIEW OF THE NURSING PROCESS

The **nursing process** is a well-established, research-supported framework for professional nursing practice. The nursing process begins first with an understanding of underlying concepts associated with the art and science of nursing. It is a flexible, adaptable, and adjustable five-step process consisting of assessment, human need statements, planning with outcome identification, implementation including patient education, and evaluation. As such, the nursing process ensures the delivery of thorough, individualized, and quality nursing care to patients, regardless of age, gender, culture, medical diagnosis, or setting. Through use of the nursing process combined with knowledge and skills, the professional nurse will be able to develop effective

BOX 1.1 Guidelines for Nursing Care Planning

This sample presents useful information for developing a nursing process–focused care plan for patients receiving medications. Brief listings and discussions of what must be contained in each phase of the nursing process are included. This sample may be used as a template for formatting nursing care plans in a variety of patient care situations/settings.

Assessment

Objective Data

Objective data include information available through the senses, such as what is seen, felt, heard, and smelled. Among the sources of data are the medical record, laboratory test results, reports of diagnostic procedures, physical assessment, and examination findings. Examples of specific data are age, height, weight, allergies, medication profile, and health history.

Subjective Data

Subjective data include all spoken information shared by the patient, such as complaints, problems, or stated needs (e.g., patient complains of "dizziness, headache, vomiting, and feeling hot for 10 days").

Human Need Statements

Once the assessment phase has been completed, the nurse analyzes objective and subjective data about the patient and the drug and formulates statements of human need fulfillment/alteration. The following is an example of a human need statement: "Altered safety needs, risk for injury, related to medication-induced sedation as evidenced by decreased sensorium, dizziness, confusion…" This statement of human need can be broken into three parts, as follows:

- Part 1—"Altered safety needs, risk for injury" is the statement of the human response of the patient to illness, injury, medications, or significant change. This can be an actual response, an increased risk, or an opportunity to improve the patient's health status. Part 2—"Related to lack of experience with medication regimen and second-grade reading level as an adult." This portion of the statement identifies factors related to the response; it often includes multiple factors with some degree of connection between them. The human need statement does not necessarily claim that there is a cause-and-effect link between these factors and the response, only that there is a connection.
- Part 3—"As evidenced by inability to perform a return demonstration and inability to state adverse effects to report to the prescriber." This statement lists clues, cues, evidence, and/or data that support the nurse's claim that the human need statement is accurate.

Human need statements are prioritized in order of criticality based on patient needs or problems. The ABCs of care (airway, breathing, and circulation) are often used as a basis for prioritization. Prioritizing always begins with the most important, significant, or critical need of the patient. Human need statements that involve actual responses are always ranked above statements that involve only risks.

Planning: Outcome Identification

The planning phase includes the identification of outcomes that are patient oriented and provide time frames. **Outcomes** are objective, realistic, and measurable patient-centered statements with time frames.

Implementation

In the implementation phase, the nurse intervenes on behalf of the patient to address specific patient problems and needs. This is done through independent nursing actions; collaborative activities such as physical therapy, occupational therapy, and music therapy; and implementation of medical orders. Family, significant others, and caregivers assist in carrying out this phase of the nursing care plan. Specific interventions that relate to particular drugs (e.g., giving a particular cardiac drug only after monitoring the patient's pulse and blood pressure), nonpharmacologic interventions that enhance the therapeutic effects of medications, and patient education are major components of the implementation phase. See the previous text discussion of the nursing process for more information on nursing interventions.

Evaluation

Evaluation is the part of the nursing process that includes monitoring whether patient outcomes, as related to the human need statements, are met. Monitoring includes observing for therapeutic effects of drug treatment, as well as for adverse effects and toxicity. Many indicators are used to monitor these aspects of drug therapy, as well as the results of appropriately related nonpharmacologic interventions. If the outcomes are met, the nursing care plan may or may not be revised to include new human need statements; such changes are made only if appropriate. If outcomes are not met, revisions are made to the entire nursing care plan with further evaluation.

solutions to meet patient's needs. The nursing process is usually discussed in nursing courses and/or textbooks that deal with the fundamentals of nursing practice, nursing theory, physical assessment, adult or pediatric nursing, and other nursing specialty areas. However, because of the importance of the nursing process and its application in the care of patients, the five phases of the nursing process will be described in each chapter as it relates to specific drug groups or classifications.

Critical thinking is a major part of the nursing process and involves the use of thought processes to gather information and then develop conclusions, make decisions, draw inferences, and reflect upon all aspects of patient care. The elements of the nursing process address the physical, emotional, spiritual, sexual, financial, cultural, and cognitive aspects of a patient. Attention to these many aspects allows a more holistic approach to patient care. For example, a cardiologist may focus on cardiac functioning and pathology, a physical therapist on movement, and a chaplain on the spiritual aspects of patient care. However, it is the professional nurse who critically thinks and processes all points of information, incorporates all these data about the patient, and then uses this information to develop and coordinate patient care. Therefore the nursing process remains a central process and framework for nursing care. Box 1.1 provides guidelines for nursing care planning related to drug therapy and the nursing process.

Before further discussion of the phases of the nursing process, it is important to mention two contemporary trends in the educational preparation of nurses and other health care professionals. First is the implementation of Quality and Safety Education for Nurses (QSEN) initiatives within the realm of nursing education. The QSEN project, initiated in 2005, was developed to address the continued challenge of preparing future nurses with the knowledge, skills, and attitudes (called *KSAs*) needed to continuously improve the quality and safety of patient care within the health care system. These KSAs flow out of the QSEN initiatives and are being integrated into nursing education curricula and clinical outcomes. The six major initiatives include the following: patient-centered care, teamwork and collaboration,

evidence-based practice (EBP), quality improvement (QI), safety, and informatics. Because of this growing trend for increasing core competencies of quality and safety within nursing education and practice, QSEN-focused boxes as related to drug therapy and the nursing process will be included in several chapters. Second is the development of the Interprofessional Education Collaborative (IPEC). In 2009 IPEC formed with the intent to develop core competencies for interprofessional collaborative practice building upon the disciplinary competencies for the professions of dentistry, medicine, nursing, osteopathic medicine, pharmacy, and public health. As noted by the World Health Organization (2010), interprofessional education occurs when students from two or more professions learn from and with each other with the objective of effective collaboration to improve health outcomes. As the students learn to work within an interprofessional framework, they become prepared to enter the workplace as an important member of the collaborative practice team. These initiatives and behaviors are important to mention because they have been identified as helping health care systems in moving out of fragmentation and into a position of strength.

ASSESSMENT

During the initial assessment phase of the nursing process, data are collected, reviewed, and analyzed from patient, family, group, and/or community sources. Performing a comprehensive assessment allows you to organize the information collected and then place this information into meaningful categories of knowledge known as *human need statements.* Formulating a human need statement focuses on how the data collected signify a problem, strength, or vulnerability. For the purposes of this textbook, human need statements will be related to drug therapy. Information about the patient may come from a variety of sources, including the patient; the patient's family, caregiver, or significant other; and the patient's medical record. Methods of data collection revolve around interviewing, direct and indirect questioning, observation, medical records review, head-to-toe physical examination, and a nursing assessment. Data are categorized into objective and subjective data. Objective data may be defined as any information gathered through the senses or that which is seen, heard, felt, or smelled. Objective data may also be obtained from a nursing physical assessment; nursing history; past and present medical history; results of laboratory tests, diagnostic studies, or procedures; measurement of vital signs, weight, and height; and medication profile. A medication profile or a medication history review includes, but is not limited to, the following information: allergies of any type; any and all drug use; listing of all prescribed medications; use of home or folk remedies and herbal and/or homeopathic treatments, plant or animal extracts, and dietary supplements; intake of alcohol, tobacco, and caffeine; current or past history of illegal drug use; use of over-the-counter (OTC) medications (e.g., aspirin, acetaminophen, vitamins, laxatives, cold preparations, sinus medications, antacids, acid reducers, antidiarrheals, minerals, elements); use of hormonal drugs (e.g., testosterone, estrogens, progestins, oral contraceptives); past and present health history and associated drug regimen(s); family history and racial, ethnic, and/or cultural attributes, with attention to specific or different responses to medications, as well as any unusual individual responses; growth and developmental stage (e.g., Erikson's developmental tasks) with attention to issues related to the patient's age and medication regimen. A holistic nursing assessment includes the gathering of data about the whole individual, including physical/emotional realms, religious preference, health beliefs, sociocultural characteristics, race, ethnicity, lifestyle, stressors, socioeconomic status, educational level, motor skills, cognitive ability, support systems, and use of any alternative and complementary therapies. Subjective data include information shared through the spoken word by any reliable source, such as the patient, spouse, family member, significant other, and/or caregiver.

Assessment about the specific drug is also important and involves the collection of specific information about prescribed, OTC, and herbal/complementary/alternative therapeutic drug use, with attention to the drug's action; signs and symptoms of allergic reaction; adverse effects; dosages and routes of administration; contraindications; drug incompatibilities; drug-drug, drug-food, and drug–laboratory test interactions; and toxicities and available antidotes. Nursing pharmacology textbooks provide a more nursing-specific knowledge base regarding drug therapy as related to the nursing process. Use of current references or those dated within the past 3 years is highly recommended. Some examples of authoritative textbook sources include the *Physicians' Desk Reference, Mosby's Drug Consult,* drug manufacturers' inserts, drug handbooks, and/or licensed pharmacists. Authoritative journal references include professional journals within the past 3 to 5 years that are refereed. Refereed journals are professional journals or publications in which articles/papers are selected for publication by a panel of readers/referees who are experts in the field. Reliable online resources include, but are not limited to, the US Pharmacopeia (USP) *(www.usp.org),* and the US Food and Drug Administration (FDA) *(www.fda.gov)*. Other online resources are cited throughout this textbook.

Gather additional data about the patient and a given drug by asking these simple questions: What is the patient's oral intake? Tolerance of fluids? Swallowing ability for pills, tablets, capsules, and liquids? If there is difficulty swallowing, what is the degree of difficulty and are there solutions to the problem? Use of thickening agents with fluids or use of other dosage forms because of difficulty swallowing? What are the results of laboratory and other diagnostic tests related to organ functioning and drug therapy? What do renal function studies (e.g., blood urea nitrogen level, serum creatinine level) reveal? What are the results of hepatic function tests (e.g., total protein level, serum levels of bilirubin, alkaline phosphatase, creatinine phosphokinase, other liver enzymes)? What are the patient's white blood cell and red blood cell counts? Hemoglobin and hematocrit levels? Current as well as past health status and presence of illness? What are the patient's experiences with use of any drug regimen? What has been the patient's relationship with health care professionals and/or experiences with previous therapeutic regimens? What are current and past values for blood pressure, pulse rate, temperature, and respiratory rate? What medications is the patient currently taking, and how is the patient taking and tolerating them? Are there issues of **compliance**? Is there any use of folk medicines or folk

remedies? What is the patient's understanding of the medication? Are there any age-related concerns? If patients are not reliable historians, family members, significant others, and/or caregivers may be able to provide answers to these questions.

It is worth mentioning that there is often discussion about the difference between the terms *compliance* and *adherence*. Both of these terms, although not to be used interchangeably, are used to describe the extent to which patients take medications as prescribed. Often the term *adherence* is perceived as implying more collaboration and active role between patients and their providers (see Key Terms definition of *compliance*). Once assessment of the patient and the drug has been completed, the specific prescription or medication order (from any **prescriber**) must be checked for the following seven elements: (1) patient's name, (2) date the drug order was written, (3) name of drug(s), (4) drug dosage amount, (5) drug dosage frequency, (6) route of administration, and (7) prescriber's signature.

It is also important during assessment to consider the traditional, nontraditional, expanded, and collaborative roles of the nurse. Physicians and dentists are no longer the only practitioners legally able to prescribe and write medication orders. Nurse practitioners and physician assistants have gained the professional privilege of legally prescribing medications. Remain current on legal regulations, as well as specific state nurse practice acts and standards of care.

Analysis of Data

After data about the patient and drug have been collected and reviewed, critically analyze and synthesize the information. Clinical reasoning is the foundation of analyzing data and applying that data to the development of human need statements. Verify all information and document appropriately. It is at this point that the sum of the information about the patient and drug are used in the development of these human need statements.

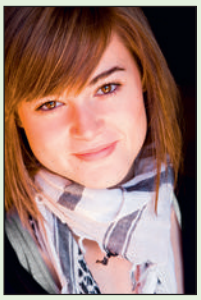
IDENTIFICATION OF HUMAN NEED STATEMENTS

Identification of human needs occurs with the collection of patient data. Human need statements are subsequently developed by professional nurses and are used as a means of communicating and sharing information about the patient and the patient experience. Identification of human needs is the result of clinical judgement about a human response to health conditions and/or life processes, critical thinking, creativity, and accurate collection of data regarding the patient as well as the drug. Human need statements associated with drug therapy develop out of data associated with various disturbances, deficits, excesses, impairments in bodily functions, and/or other problems or concerns as related to drug therapy. See Box 1.2 for a brief listing of human need statements. The development of nursing diagnoses, used in the previous edition, will be replaced with statements consistent with human need theory.

Formulation of human need statements remains a three-step process as follows: Part 1 of the statement is the human need. Part 2 of this statement addresses further attention to the differences in human need fulfillment or alteration occurring in all individuals regardless of age, gender, educational, cultural, setting and socioeconomic situation (Yura & Walsh, 1978). Statement of the nursing human needs (alteration, fulfillment) does not necessarily claim a cause-and-effect link between these factors and the response; it indicates only that there is a connection between them. Part 3 of the statement of human needs (as with the previous use of nursing diagnoses) contains a listing of clues, cues, evidence, signs, symptoms, or other data that support the nurse's claim that this human need statement is accurate. Tips for writing nursing diagnoses include the following: Begin with a "statement" of a human need; connect the first part of the statement or the human response with the second part, the cause, using the phrase "related to"; be sure that the first two parts are not restatements of one another; include several factors in the second part of the statement, such as associated factors, if appropriate; select a cause for the second part of the statement that can be changed by nursing interventions; avoid negative wording or language; and, finally, list clues or cues and/or more defining characteristics that led to the nursing diagnosis in the third part of the statement or "as evidenced by." The suggested format to be utilized when formulating a nursing human need statement may look like this: Altered sensory integrity, decreased, related to medication-induced altered level of consciousness as evidenced by sleepiness, decreased reflexes, decreased orientation

CASE STUDY

Patient-Centered Care: The Nursing Process and Pharmacology



(© Jose AS Reyes.)

Dollie, a 27-year-old social worker, is visiting the clinic today for a physical examination. She states that she and her husband want to "start a family," but she has not had a physical for several years. She was told when she was 22 years of age that she had "anemia" and was given iron tablets, but Dollie states that she has not taken them for years. She said she "felt better" and did not think she needed them. She denies any use of tobacco and illegal drugs; she states that she may have a drink with dinner once or twice a month. She uses tea tree oil on her face twice a day to reduce acne breakouts. She denies using any other drugs.

1. What other questions does the nurse need to ask during this assessment phase?
2. After laboratory work is performed, Dollie is told that she is slightly anemic. The prescriber recommends that she resume taking iron supplements as well as folic acid. She is willing to try again and says that she is "all about doing what's right to stay healthy and become a mother." What human need statements would be appropriate at this time?
3. Dollie is given a prescription that reads as follows: "Ferrous sulfate 325 mg, PO for anemia." When she goes to the pharmacy, the pharmacist tells her that the prescription is incomplete. What is missing? What should be done?
4. After 4 weeks, Dollie's latest laboratory results indicate that she still has anemia. However, Dollie states, "I feel so much better that I'm planning to stop taking the iron tablets. I hate to take pills." How should the nurse handle this?

For answers, see *http://evolve.elsevier.com/Lilley*.

BOX 1.2 A Brief Listing of Human Needs

Autonomous choice
Basic physiologic needs: food, fluids and nutrients; elimination (gastrointestinal and urinary); reproductive function; physical activity
Belongingness and love
Effective perception
Esteem need
Freedom from pain
Interchange of gases
Self-actualization needs
Self-control
Self-determination
Self-esteem
Spiritual integrity

Modified from Petro-Yura, H., & Walsh, M. B. (1983). *Human needs 2 and the nursing process*. Washington DC: Catholic University of America Press.

to place and time. Completing a nursing human need statement is as simple as linking the above three statements! Some of the human needs include the need for nutrition, territoriality, air, to love and to be loved, tenderness, activity, sleep, safety, food, fluids, elimination, and physical safety. See Box 1.2 for a listing of Yura and Walsh's human needs.

PLANNING: OUTCOME IDENTIFICATION

After data are collected and human need statements are formulated, the planning phase begins; this includes identification of outcomes. The major purpose of the planning phase is to prioritize the human needs and specify outcomes including the time frame for their achievement. The planning phase provides time to obtain special equipment for interventions, review the possible procedures or techniques to be used, and gather information for oneself (the nurse) or for the patient. This step leads to the provision of safe care if professional judgment is combined with the acquisition of knowledge about the patient and the medications to be given. In the 1990s the American Nurses Association (ANA) expanded the nursing process to include outcome identification as part of the planning phase.

Outcomes are objective, measurable, and realistic with an established time frame for their achievement. Patient outcomes reflect expected and measurable changes in behavior through nursing care and are developed in collaboration with the patient. Patient outcomes are behavior based and may be categorized into physiologic, psychological, spiritual, sexual, cognitive, motor, and/or other domains. They are patient focused, succinct, and well thought out. Outcomes also include expectations for behavior, indicating something that can be changed and with a specific time frame or deadline. The ultimate aim of outcome identification, pertinent to drug therapy, is the safe and effective administration of medications. Outcomes need to reflect each human need statement and serve as a guide to the implementation phase of the nursing process. Formulation of outcomes begins with the analysis of the judgments made about patient data and subsequent human need(s) statement and ends with the development of a nursing care plan. They also provide a standard for measuring movement toward goals. With regard to medication administration, these outcomes may address special storage and handling techniques, administration procedures, equipment needed, drug interactions, adverse effects, and contraindications. In this textbook, specific time frames are *not* provided in each chapter's nursing process section because patient care is individualized in each patient care situation.

IMPLEMENTATION

Implementation is guided by the preceding phases of the nursing process (i.e., assessment, statement of human needs, and planning). Implementation requires constant communication and collaboration with the patient and with members of the health care team involved in the patient's care, as well as with any family members, significant others, or other caregivers. Implementation consists of initiation and completion of specific nursing actions as defined by the statement of human needs and outcome identification. Implementation of nursing actions may be independent, collaborative, or dependent upon a prescriber's order. Interventions are defined as any treatment based on clinical judgment and knowledge and performed by a nurse to enhance outcomes. Statements of interventions include frequency, specific instructions, and any other relevant information. With medication administration, you need to know and understand all of the information about the patient and about each medication prescribed. In years past, nurses adhered to the "Five Rights" of medication administration: right drug, right dose, right time, right route, and right patient. However, this edition strongly encourages the use of the "Nine Rights" of medication administration inclusive of the basic "Six Rights." The Nine Rights are discussed in the following section. These "rights" of medication administration have been identified as additional standards of care as related to drug therapy. Even implementation of these "rights" does not reflect the complexity of the role of the professional nurse because they focus more on the individual/patient than on the system as a whole or the entire medication administration process beginning with the prescriber's order.

Nine Rights of Medication Administration

Right Drug

The "right drug" begins with the registered nurse's valid license to practice. Most states allow currently licensed practical nurses to administer medications with specific guidelines. The registered nurse is responsible for checking all medication orders and/or prescriptions. To ensure that the correct drug is given, the specific medication order must be checked against the medication label or profile three times before giving the medication. Conduct the first check of the right drug/drug name during your initial preparation of the medication for administration. At this time, consider whether the drug is appropriate for the patient and, if doubt exists or an error is deemed possible, contact the prescriber immediately to verify the drug order. It is also appropriate at this time to note the drug's indication and be aware that a drug may have multiple indications, including off-label use and non–FDA-approved indications. In this textbook, each particular drug is

discussed in a specific chapter that deals with its main indication, but the drug may also be cross-referenced in other chapters if it has multiple uses.

All medication orders or prescriptions are required by law to be signed by the prescriber involved in the patient's care. If a verbal order is given, the prescriber must sign the order within 24 hours or as per guidelines within a health care setting. Verbal and/or telephone orders are often used in emergencies and time-sensitive patient care situations. To be sure that the right drug is given, information about the patient and drug (see previous discussion of the assessment phase) must be obtained to make certain that all variables and data have been considered. See previous discussion about authoritative sources/references.

Avoid relying upon the knowledge of peers because this is unsafe nursing practice. Remain current in your knowledge of generic (nonproprietary) drug names, as well as trade names (proprietary name that is registered by a specific drug manufacturer); however, use of the drug's generic name is now preferred in clinical practice to reduce the risk for medication errors. A single drug often has numerous trade names, and drugs in different classes may have similarly spelled names, increasing the possibility of medication errors. Therefore, when it comes to the "right drug" phase of the medication administration process, use of a drug's generic name is recommended to help avoid a medication error and enhance patient safety. (See Chapter 2 for more information on the naming of drugs.)

If there are questions about the medication order at any time during the medication administration process, contact the prescriber for clarification. Never make any assumptions when it comes to drug administration, and, as previously emphasized in this chapter, confirm at least three times the right drug, right dose, right time, right route, right patient, and right documentation before giving the medication.

QSEN

EVIDENCE-BASED PRACTICE

Nurses' Clinical Reasoning: Processes and Practices of Medication Safety

Review

In one of the first quality reports about medication safety in the series *To Err Is Human* (2000), Kohn, Corrigan, and Donaldson identified medication errors as the most common of errors occurring in health care. In 2007 in another quality series, Aspden and colleagues reported that a patient in a hospital could expect at least one medication error per hospital day. They also reported that as many as 7000 deaths might occur in hospitals each year because of medication errors, with a great variation among hospitals as to the number of events reported. It is important to note that in 1994 (Leape), research on medication errors changed from one of individual focus to one of a series of failures or breakdowns in the complexity of health care systems. Lacking in most of the medication error research is the critical role that professional nurses play in preventing medication errors from reaching the patient. Not only did a process need to be researched but especially the phenomenon behind the process of prevention of errors, which led to this particular qualitative research study. This study was designed to look at the nurse's clinical reasoning and actions preventing the medication error prior to even reaching the patient.

Methodology

Grounded theory was used to identify the essence of medication safety. This qualitative method research design was used in an attempt to understand the world of preventing medication errors by the nurse and to gain an understanding of their knowledge. Qualitative research is a method of inquiry used in social and natural sciences as well as in nonacademic contexts such as market research. It is a broad methodology used to often examine the how and why of decision making and not just the who, what, where, and when. This type of research is important to use in the context of exploring study participants within their environment … looking at understanding human behavior and reasons for that behavior … the why and how of decision-making versus the empirical investigation through statistical analysis. Nurses were interviewed face-to-face about what they thought and did to prevent errors. In addition, they were asked to identify factors that they thought increased the likelihood of a medication error occurring and how they made a difference in the interception of errors. A purposive sample of 50 medical-surgical nurses from 10 mid-Atlantic hospitals was used. Interviews, conducted in private settings on hospital units, included open-ended questions regarding their processes, and taped recordings were approximately 60 minutes in length.

Findings

The analysis of data was one of the discovery (of grounded theory) beginning with a line-by-line analysis of the narratives, with coding of data reflecting the nurses' thoughts and actions when they recognized something was wrong with the medication and/or patient. An iterative (repetitive) process was used until all categories appeared to be saturated and theoretically sound. Emerging ideas were also categorized during the interviews, and the nurses' dialogues, researcher observations, and analytic memos provided the data for analysis. The analysis of data revealed that nurses, to ensure patient safety, needed to interact with others. A majority of the nurses clearly acknowledged their role in the process of "Five Rights" of medication administration, as well as the need to extend safe practice beyond these five tasks. Two safety processes were found within the clinical reasoning: The first process was maintaining medication safety with various medication practices, including advocacy with pharmacy, educating patients, and conducting medication reconciliation. The second process was managing the clinical environment with four environmentally focused safety categories, including coping with interruptions and documenting "near misses." These processes and practices demonstrated nurses' clinical reasoning that served as a foundation of the "safety net" protecting patients from medication errors. Out of all these narratives, there also emerged a model for the processes and practices of safe medication administration.

Application to Nursing Practice

Nurses in this study clearly demonstrated how clinical reasoning was used to prevent potential medication errors from reaching the patient. This evidence is critical to further development of medication safety practices for implementation by professional nurses. All processes, practices, and reasoning related to safe medication administration demonstrated by nurses need to be acknowledged, valued, and respected by nurse/health care managers/leaders within the various health care settings. In addition, more research is needed on development of models for safe medication practice that reaches further than just the "Five Rights" and emphasis on astute clinical reasoning. Systemic policies for safer medication administration may be developed out of these practice models. Results of this study may also be helpful in development of nursing curricula focused on patient safety as the very basis of quality patient care.

From Dickson, G. L., & Flynn, L. (2012). Nurses' clinical reasoning: processes and practices of medication safety. *Qualitative Health Research, 22*(1), 3–16.

Right Dose

Whenever a medication is ordered, a dosage is identified from the prescriber's order. Always confirm that the dosage amount is appropriate for the patient's age and size. Use of a current, authoritative drug reference is encouraged. In addition, check the prescribed dose against the available drug stocks and against the normal dosage range. Recheck all mathematical calculations, and pay careful attention to decimal points, the misplacement of which could lead to a tenfold or even greater overdose. Leading zeros, or zeros placed before a decimal point, are allowed, but trailing zeros, or zeros following the decimal point, are to be avoided. For example, 0.2 mg is allowed, but 2.0 mg is not acceptable, because it could easily be mistaken for 20 mg, especially with unclear penmanship. Patient variables (e.g., vital signs, age, gender, weight, height) require careful assessment because of the need for dosage adjustments in response to specific parameters. Pediatric and elderly patients are more sensitive to medications than are younger and middle-age adult patients; thus use extra caution with drug dosage amounts for these patients.

QSEN

SAFETY AND QUALITY IMPROVEMENT: PREVENTING MEDICATION ERRORS

Right Dose?

The nurse is reviewing the orders for a newly admitted patient. One order reads: "Tylenol, 2 tablets PO, every 4 hours as needed for pain or fever."

The pharmacist calls to clarify this order, saying, "The dose is not clear." What does the pharmacist mean by this? The order says "2 tablets." Isn't that the dose?

NO! If you look up the dosage information for Tylenol (acetaminophen), you will see that Tylenol tablets are available in strengths of both 325 mg and 500 mg. The order is missing the "right dose" and needs to be clarified. *Never* assume the dose of a medication order!

Right Time

Each health care setting or institution has a policy regarding routine medication administration times. These policies need to be checked and committed to memory! Include in your three checks the frequency of the ordered medication, the time to be administered, and when the last dose of medication was given. However, when giving a medication at the prescribed time, you may be confronted with a conflict between the timing suggested by the prescriber and specific pharmacokinetic or pharmacodynamic drug properties, concurrent drug therapy, dietary influences, laboratory and/or diagnostic testing, and specific patient variables. For example, the prescribed right time for administration of antihypertensive drugs may be four times a day, but for an active, professional 42-year-old male patient working 14 hours a day, taking a medication four times daily may not be feasible, and this regimen may lead to **noncompliance** and subsequent complications. For patient safety, your appropriate actions would include contacting the prescriber and inquiring about the possibility of prescribing another drug with a different dosing frequency (e.g., once or twice daily).

For routine medication orders, the standard of care is to give the medications no more than ½ hour before or after the actual time specified in the prescriber's order (e.g., if a medication is ordered to be given at 0900 every morning, you may give it at any time between 0830 and 0930); the exception includes medications designated to be given stat (immediately) that must be administered within ½ hour of the time the order is written. Assess and follow the health care institution policy and procedure for any other specific information concerning the "½ hour before or after" rule. For medication orders with the annotation "prn" (*pro re nata,* or "as required"), the medication must be given at special times and under certain circumstances. For example, an analgesic is ordered every 4 to 6 hours *prn* for pain; after one dose of the medication, the patient complains of pain. After assessment, intervention with another dose of analgesic would occur, but only 4 to 6 hours after the previous dose. In addition, because of the increasing incidence of medication errors related to the use of abbreviations, many prescribers are using the wording "as required" or "as needed" instead of the abbreviation "prn." Military time is used when medication and other orders are written into a patient's medical record (Table 1.1).

Nursing judgment may lead to some variations in timing; however, any change with the rationale for change must be documented and the prescriber contacted. If medications are ordered to be given once every day, twice daily, three times daily, or even four times daily, the times of administration may be

TABLE 1.1 Conversion of Standard Time to Military Time

Standard Time	Military Time
1 AM	0100
2 AM	0200
3 AM	0300
4 AM	0400
5 AM	0500
6 AM	0600
7 AM	0700
8 AM	0800
9 AM	0900
10 AM	1000
11 AM	1100
12 PM (noon)	1200
1 PM	1300
2 PM	1400
3 PM	1500
4 PM	1600
5 PM	1700
6 PM	1800
7 PM	1900
8 PM	2000
9 PM	2100
10 PM	2200
11 PM	2300
12 AM (midnight)	2400

changed if it is not harmful to the patient or if the medication or the patient's condition does not require adherence to an exact schedule. For example, suppose that an antacid is ordered to be given three times daily at 0900, 1300, and 1700 but the nurse has misread the order and gives the first dose at 1100. Depending on the specific policy of a hospital or other health care setting, the medication, and the patient's condition, such an occurrence may not be considered an error, because the dosing may be changed once the prescriber is contacted, so that the drug is given at 1100, 1500, and 1900 without harm to the patient and without incident to the nurse. If this were an antihypertensive medication, the patient's condition and physical well-being could be greatly compromised by one missed or late dose. Thus falling behind in dosing times is not to be taken lightly or ignored. Never underestimate the effect of a change in the dosing or timing of medication, because one missed dose of certain medications can be life threatening.

Other factors must be considered in determining the right time, such as multiple-drug therapy, drug-drug or drug-food compatibility, scheduling of diagnostic studies, bioavailability of the drug (e.g., the need for consistent timing of doses around the clock to maintain blood levels), drug actions, and any biorhythm effects such as occur with steroids. It is also critical to patient safety to avoid using abbreviations for *any* component of a drug order (i.e., dose, time, route). Spell out *all* terms (e.g., *three times daily* instead of *tid*) in their entirety. Be careful to write out all words and abbreviations, because the possibility of miscommunication or misinterpretation poses a risk to the patient. The Joint Commission created a "do not use" list of abbreviations in 2010 and integrated the list into their Information Management standards. For accredited facilities, abbreviations are not to be used in internal communications, telephone/verbal prescriptions, computer-generated labels, labels for drug storage bins, medication administration records, and pharmacy and prescriber computer entry screens. Further discussion is included in Chapter 5.

Right Route and Form

As previously stated, you must know the particulars about each medication before administering it to ensure that the right drug, dose, route, and dosage form are being used. A complete medication order includes the route of administration. Confirm the appropriateness of the prescribed route while also making sure the patient can take/receive the medication by the prescribed route. If a medication order does not include the route, be sure to ask the prescriber to clarify it. Never *assume* the route of administration. In addition, it is critical to patient safety to be aware of the right form of medication. For example, there are various dosage forms of a commonly used medication, acetaminophen. It is available in oral suspension, tablet, capsule, gelcap, and pediatric drops, as well as rectal suppository dosage forms. Nurses need to give the right drug via the right route with use of the correct dosage form. Another example is the administration of a controlled-release dosage form of a medication. This dosage form is not to be crushed or altered due to the subsequent and immediate release of the drug (versus the controlled release) which, in some cases, may be life threatening.

Right Patient

Checking the patient's identity before giving each medication dose is critical to the patient's safety. Confirm the name on the order and the patient, and be sure to use several identifiers. Ask the patient to state his or her name, and then check the patient's identification band to confirm the patient's name, identification number, age, and allergies. With pediatric patients, the parents and/or legal guardians are often the ones who identify the patient for the purpose of administration of prescribed medications. With newborns and in labor and delivery situations, the mother and baby have identification bracelets with matching numbers, which must be thoroughly and repetitively checked before giving medications. In older adult patients or those with altered sensorium or level of consciousness, asking the patient his or her name or having the patient state his or her name is neither realistic nor safe. Therefore checking the identification band against the medication profile, medication order, or other treatment or service orders is crucial to avoid errors. When available, use technology such as scanning a bar code on the patient's identification band. In 2016, the Joint Commission published an update to the 2008 National Patient Safety Goals for patient care. These goals emphasize the use of two identifiers when providing care, treatment, or services to patients. To meet these goals, The Joint Commission recommends that the patient be identified "reliably" and also that the service or treatment (e.g., medication administration) be matched to that individual. The Joint Commission's statement of National Patient Safety Goals indicates that the two identifiers may be in the same location, such as on a wristband. In fact, it is patient-specific information that is the identifier. Acceptable identifiers include the patient's name, date of birth, home address, Social Security number, or a hospital/health care facility-assigned identification number.

Right Documentation

Documentation of information related to medication administration is crucial to patient safety. Recording patient observations and nursing actions has always been an important ethical responsibility, but now it is becoming a major medical-legal consideration as well. Because of its significance in professional nursing practice, correct documentation became known as the "sixth right" of medication administration, adding to the previous use of "Five Rights." Always assess the prescribed order in the patient's medical record for the presence of the following information: date and time of medication administration, name of medication, dose, route, and site of administration. Document administration only after the medication has been given including the time, route, and any laboratory values or vital signs (as appropriate). Documentation of drug action may also be made in the regularly scheduled assessments for changes in symptoms the patient is experiencing, adverse effects, toxicity, and any other drug-related physical and/or psychological symptoms. Documentation must also reflect any improvement in the patient's condition, symptoms, or disease process, as well as no change or a lack of improvement. You must not only document these observations, but also report them to the prescriber promptly in keeping with your critical thinking and judgment. Document

any teaching, as well as an assessment of the degree of understanding exhibited by the patient. Other areas of information that need to be documented include the following: (1) if a drug is *not* administered, with the reason why and any actions taken (e.g., contacting the prescriber and monitoring the patient), (2) actual time of drug administration, and (3) data regarding clinical observations and treatment of the patient if a medication error has occurred. If there is a medication error, complete an incident report with the entire event, surrounding circumstances, therapeutic response, adverse effects, and notification of the prescriber described in detail. However, do not record completion of an incident report in the medical record.

Right Reason or Indication

Right reason or indication addresses the appropriateness in use of the medication to the patient. Confirm the rationale for use through researching the patient's history while also asking the patient the reason he or she is taking the drug. Always revisit the rationale for long-term medication use. Knowledge of the drug's indication allows the nurse, prescriber, members of the health care team, patient and/or family members to understand what is being treated. Understanding the indication helps pharmacists and nurses to catch potential errors, provide thorough explanations to the patient/family, and decrease challenges to medication reconciliation.

Right Response

Right response refers to the drug and its desired response in the patient. Continually assess and evaluate the achievement of the desired response, as well as any undesired response. Examples of data gathering include, but are not limited to, monitoring vital signs, weight, edema, intake and output, nutritional intake, laboratory values, results of diagnostic testing, and auscultating heart and lung sounds. Document any assessment, intervention, and monitoring as deemed appropriate.

Right to Refuse

The ninth right is that of the right of the patient to refuse. Patients refuse medications for a variety of reasons. If refusal of a medication occurs, always respect the patient's right (to refuse), determine the reason, and take appropriate action, including notifying the prescriber. Do not force! Document the refusal and a concise description of the reason for refusal. Document any further actions you take at this time, such as vital signs and/or system assessment. If a consequence to the patient's condition and/or as hospital policy dictates, the prescriber is to be contacted immediately. Never return unwrapped medication to a container, and discard medication dose according to agency policy. If the wrapper remains intact, return the medication to the automated medication-dispensing system. Revise the nursing care plan as needed.

This list is never ending and ever changing, and additional rights to be considered when administering medications include the following:

- Patient safety, ensured by use of the correct procedures, equipment, and techniques of medication administration and documentation
- Individualized, holistic, accurate, and complete patient education with appropriate instructions
- Double-checking and constant analysis of the system (i.e., the process of drug administration including all personnel involved, such as the prescriber, the nurse, the nursing unit, and the pharmacy department, as well as patient education)
- Proper drug storage
- Accurate calculation and preparation of the dose of medication and proper use of all types of medication delivery systems
- Careful checking of the transcription of medication orders
- Accurate use of the various routes of administration and awareness of the specific implications of their use
- Close consideration of special situations (e.g., patient difficulty in swallowing, use of a nasogastric tube, unconsciousness of the patient, advanced patient age)
- Implementation of all appropriate measures to prevent and report medication errors, and the use of nonexpired medications

Medication Errors

When the Nine Rights (and other rights) of drug administration are discussed, medication errors must be considered. Medication errors are a major problem for all of health care, regardless of the setting. The National Coordinating Council for Medication Error Reporting and Prevention defines a **medication error** as any *preventable* event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, or systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use *(www.nccmerp.org/about-medication-errors)*. Both patient-related and system-related factors must always be considered when examining the medication administration process and the prevention of medication errors. See Chapter 5 for further discussion of medication errors and their prevention.

EVALUATION

Evaluation occurs after the nursing care plan has been implemented but also needs to occur at each phase of the nursing process. It is systematic, ongoing, and a dynamic phase of the nursing process as related to drug therapy. It includes monitoring the fulfillment of outcomes, as well as monitoring the patient's therapeutic response to the drug and its adverse effects and toxic effects. Documentation is also a very important component of evaluation and consists of clear, concise, abbreviation-free documentation that records information related to goals and outcome criteria, as well as information related to any aspect of the medication administration process, including therapeutic effects versus adverse effects or toxic effects of medications (see Teamwork and Collaboration: Legal and Ethical Principles box).

Evaluation also includes monitoring the implementation of standards of care. Several standards are in place to help in the

QSEN

TEAMWORK AND COLLABORATION: LEGAL AND ETHICAL PRINCIPLES

Do's and Don'ts of Documentation

Do's

- Do check to be sure you have the correct medical record before documenting.
- Do include the time you gave a medication, the route of administration, and the patient's response.
- Do document:
  - Only the facts
  - Patient teaching
  - Any precautions and/or preventative measures
  - The exact time, message, response when communicating with a physician and/or health care provider
  - A patient's refusal to take a medication or allow a treatment and appropriate nursing interventions and report to the patient's physician and the charge nurse.
- Do record each phone call to a physician with exact time, message, and response.
- Do give precise descriptions.
- Do document patient care at the time you provide it.

Don'ts

- Don't document a symptom, such as "c/o pain," without noting what you did to intervene on the patient's behalf.
- Don't alter a patient's medical record and/or nursing notes.
- Don't give excuses, such as "medication not given because not available."
- Don't document ahead of time.
- Don't mention the term *incident report* in documentation. Incident reports are confidential and filed separately. Document only the facts of the medication error or incident and appropriate actions taken.
- Don't use the following terms: *by mistake, by accident, accidentally, unintentional,* or *miscalculated.*
- Don't record casual conversations with peers, prescribers, or other members of the health care team.
- Don't use abbreviations. Some agencies or facilities may still keep a list of approved abbreviations, but overall their use is discouraged.
- Don't use negative language.

Modified from *Do's and don'ts of documentation.* (2013). Nurses Service Organization. Available at www.nso.com. Accessed March 27, 2015.

evaluation of outcomes of care, such as those established by state nurse practice acts and by The Joint Commission. Guidelines for nursing services policies and procedures are established by The Joint Commission. There are even specific standards regarding medication administration to protect both the patient and the nurse. The ANA *Code of Ethics* and Patient Rights statement are also used in establishing and evaluating standards of care.

Guidelines for nursing services policies and procedures are established by The Joint Commission. There are even specific standards regarding medication administration to protect both the patient and the nurse. The ANA *Code of Ethics* and Patient Rights statement are also used in establishing and evaluating standards of care.

In summary, the nursing process is an ongoing and constantly evolving process (see Box 1.1). The nursing process, as it relates to drug therapy, involves the way in which a nurse gathers, analyzes, organizes, provides, and acts upon data about the patient within the context of prudent nursing care and standards of care. The nurse's ability to make astute assessments, formulate human need statements, identify outcomes, implement safe and accurate drug administration, and continually evaluate patients' responses to drugs increases with additional experience and knowledge.

KEY POINTS

- The nursing process is an ongoing, constantly changing, and evolving framework for professional nursing practice. It may be applied to all facets of nursing care, including medication administration.
- The five phases of the nursing process include assessment; development of human need statements; planning with outcome identification; implementation, including patient education; and evaluation.
- Human need statements are formulated based on objective and subjective data and help to drive the nursing care plan. Statements of human needs are then developed and constantly updated and revised. Safe, therapeutic, and effective medication administration is a major responsibility of professional nurses as they apply the nursing process to the care of their patients.
- Two contemporary trends in the educational preparation of nurses and other health care professionals include the implementation of Quality and Safety Education for Nurses (QSEN) initiatives in nursing education and the development of Interprofessional Education Collaborative (IPEC). Both trends are aimed at improving the education of nurses and of health care professionals, with the common goal of improving patient care outcomes.
- Nurses are responsible for safe and prudent decision-making in the nursing care of their patients, including the provision of drug therapy; in accomplishing this task, they attend to the Nine Rights and adhere to legal and ethical standards related to medication administration and documentation. There are additional rights related to drug administration. These rights deserve worthy consideration before initiation of the medication administration process. Observance of all of these rights enhances patient safety and helps avoid medication errors.

CRITICAL THINKING EXERCISES

1. When medications were administered during the night shift, a patient refused to take his 0200 dose of an antibiotic, claiming that he had just taken it. What is the best action by the nurse to maintain patient safety?
2. During a busy shift, the nurse notes that the medical record of a newly admitted patient has a few orders for various medications and diagnostic tests that were taken by telephone by another nurse. The nurse is on the way to the patient's room to do an assessment when the unit secretary tells the nurse that one of the orders reads as follows: "Lasix, 20 mg, stat." What is the priority action by the nurse? How does the nurse go about giving this drug? Explain the best action to take in this situation.

For answers, see *http://evolve.elsevier.com/Lilley*.

REVIEW QUESTIONS

1. An 86-year-old patient is being discharged to home on drug therapy for hyperthyroidism and has very little information regarding the medication. Which statement best reflects a realistic outcome of patient teaching activities?
   - **a.** The patient and patient's daughter will state the proper way to take the drug.
   - **b.** The nurse will provide teaching about the drug's adverse effects.
   - **c.** The patient will state all the symptoms of toxicity of the drug.
   - **d.** The patient will call the prescriber if adverse effects occur.
2. A patient has a new prescription for a blood pressure medication that may cause him to feel dizzy during the first few days of therapy. Which is the best human needs statement for this situation?
   - **a.** Physical activity
   - **b.** Physical safety
   - **c.** Freedom pain
   - **d.** Interchange of gases
3. A patient's medical record includes an order that reads as follows: "Atenolol 25 mg once daily at 0900." Which action by the nurse is correct?
   - **a.** The nurse does not give the drug.
   - **b.** The nurse gives the drug orally.
   - **c.** The nurse gives the drug intravenously.
   - **d.** The nurse contacts the prescriber to clarify the dosage route.
4. The nurse is compiling a drug history for a patient. Which questions from the nurse will obtain the most information from the patient? *(Select all that apply.)*
   - **a.** "Do you use sleeping pills to get to sleep?"
   - **b.** "Do you have a family history of heart disease?"
   - **c.** "When you have pain, what do you do to relieve it?"
   - **d.** "Did you have the mumps as a child?"
   - **e.** "Tell me about what happened when you had the allergic reaction to penicillin."
   - **f.** "What herbal products or over-the-counter medications do you use?"
5. A 77-year-old man who has been diagnosed with an upper respiratory tract infection tells the nurse that he is allergic to penicillin. Which is the most appropriate response by the nurse?
   - **a.** "Many people are allergic to penicillin."
   - **b.** "This allergy is not of major concern because the drug is given so often."
   - **c.** "What type of reaction did you have when you took penicillin?"
   - **d.** "Drug allergies don't usually occur in older individuals due to built-up resistance to allergic reactions."
6. The nurse is preparing a care plan for a patient who has been newly diagnosed with type 2 diabetes mellitus. Which of these reflect the correct order of the steps of the nursing process?
   - **a.** Assessment, planning, human needs statement, implementation, evaluation
   - **b.** Evaluation, assessment, human needs statement, planning, implementation
   - **c.** Human needs statement, assessment, planning, implementation, evaluation
   - **d.** Assessment, human needs statement, planning, implementation, evaluation
7. The nurse is reviewing new medication orders that have been written for a newly admitted patient. The nurse will need to clarify which orders? *(Select all that apply.)*
   - **a.** metformin (Glucophage) 1000 mg PO twice a day
   - **b.** sitagliptin (Januvia) 50 mg daily
   - **c.** simvastatin (Zocor) 20 mg PO every evening
   - **d.** irbesartan (Avapro) 300 mg PO once a day
   - **e.** docusate (Colace) as needed for constipation
8. The nurse is reviewing data collected from a medication history. Which of these data are considered objective data? *(Select all that apply.)*
   - **a.** White blood cell count 22,000 mm^3
   - **b.** Blood pressure 150/94 mm Hg
   - **c.** Patient rates pain as an "8" on a 10-point scale
   - **d.** Patient's wife reports that the patient has been very sleepy during the day
   - **e.** Patient's weight is 68 kg

For answers, see p. 908.

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2

Pharmacologic Principles

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OBJECTIVES

When you reach the end of this chapter, you will be able to do the following:

1. Define the common terms used in pharmacology (see Key Terms).
2. Understand the general concepts such as pharmaceutics, pharmacokinetics, and pharmacodynamics, and their application in drug therapy and the nursing process.
3. Demonstrate an understanding of the various drug dosage forms as related to drug therapy and the nursing process.
4. Discuss the relevance of the four aspects of pharmacokinetics (absorption, distribution, metabolism, excretion) to professional nursing practice as related to drug therapy for a variety of patients and health care settings.
5. Discuss the use of natural drug sources in the development of new drugs.
6. Develop a nursing care plan that takes into account general pharmacologic principles, specifically pharmacokinetic principles, as they relate to the nursing process.

KEY TERMS

Additive effects Drug interactions in which the effect of a combination of two or more drugs with similar actions is equivalent to the sum of the individual effects of the same drugs given alone. For example, 1 + 1 = 2 (compare with synergistic effects).

Adverse drug event Any undesirable occurrence related to administering or failing to administer a prescribed medication.

Adverse drug reaction Any unexpected, unintended, undesired, or excessive response to a medication given at therapeutic dosages (as opposed to overdose).

Adverse effects A general term for any undesirable effects that are a direct response to one or more drugs.

Agonist A drug that binds to and stimulates the activity of one or more receptors in the body.

Allergic reaction An immunologic hypersensitivity reaction resulting from the unusual sensitivity of a patient to a particular medication; a type of adverse drug event.

Antagonist A drug that binds to and inhibits the activity of one or more receptors in the body. Antagonists are also called inhibitors.

Antagonistic effects Drug interactions in which the effect of a combination of two or more drugs is less than the sum of the individual effects of the same drugs given alone (1 + 1 equals less than 2); it is usually caused by an antagonizing (blocking or reducing) effect of one drug on another.

Bioavailability A measure of the extent of drug absorption for a given drug and route (from 0% to 100%).

Biotransformation One or more biochemical reactions involving a parent drug; occurs mainly in the liver and produces a metabolite that is either inactive or active. Also known as metabolism.

Blood-brain barrier The barrier system that restricts the passage of various chemicals and microscopic entities (e.g., bacteria, viruses) between the bloodstream and the central nervous system. It still allows for the passage of essential substances such as oxygen.

Chemical name The name that describes the chemical composition and molecular structure of a drug.

Contraindication Any condition, especially one related to a disease state or patient characteristic, including current or recent drug therapy, which renders a particular form of treatment improper or undesirable.

Cytochrome P-450 The general name for a large class of enzymes that plays a significant role in drug metabolism and drug interactions.

Dependence A state in which there is a compulsive or chronic need, as for a drug.

Dissolution The process by which solid forms of drugs disintegrate in the gastrointestinal tract and become soluble before being absorbed into the circulation.

Drug Any chemical that affects the physiologic processes of a living organism.

Drug actions The processes involved in the interaction between a drug and body cells (e.g., the action of a drug on a receptor protein); also called mechanism of action.

Drug classification A method of grouping drugs; may be based on structure or therapeutic use.

Drug effects The physiologic reactions of the body to a drug. They can be therapeutic or toxic and describe how the body is affected as a whole by the drug.

Drug-induced teratogenesis The development of congenital anomalies or defects in the developing fetus caused by the toxic effects of drugs.

Drug interaction Alteration in the pharmacologic or pharmacokinetic activity of a given drug caused by the presence of one or more additional drugs; it is usually related to effects on the enzymes required for metabolism of the involved drugs.

Duration of action The length of time the concentration of a drug in the blood or tissues is sufficient to elicit a response.

Enzymes Protein molecules that catalyze one or more of a variety of biochemical reactions, including those related to the body's physiologic processes, as well as those related to drug metabolism.

First-pass effect The initial metabolism in the liver of a drug absorbed from the gastrointestinal tract before the drug reaches systemic circulation through the bloodstream.

Generic name The name given to a drug by the United States Adopted Names Council. Also called the nonproprietary name. The generic name is much shorter and simpler than the chemical name and is not protected by trademark.

Glucose-6-phosphate dehydrogenase (G6PD) deficiency A hereditary condition in which red blood cells break down when the body is exposed to certain drugs.

Half-life In pharmacokinetics, the time required for half of an administered dose of drug to be eliminated by the body, or the time it takes for the blood level of a drug to be reduced by 50% (also called elimination half-life).

Idiosyncratic reaction An abnormal and unexpected response to a medication, other than an allergic reaction, that is peculiar to an individual patient.

Incompatibility The characteristic that causes two parenteral drugs or solutions to undergo a reaction when mixed or given together that results in the chemical deterioration of at least one of the drugs.

Intraarterial Within an artery (e.g., intraarterial injection).

Intraarticular Within a joint (e.g., intraarticular injection).

Intrathecal Within a sheath (e.g., the theca of the spinal cord, as in an intrathecal injection into the subarachnoid space).

Medication error Any preventable adverse drug event (see above) involving inappropriate medication use by a patient or health care professional; it may or may not cause patient harm.

Medication use process The prescribing, dispensing, and administering of medications, and the monitoring of their effects.

Metabolite A chemical form of a drug that is the product of one or more biochemical (metabolic) reactions involving the parent drug (see later). Active metabolites are those that have pharmacologic activity of their own, even if the parent drug is inactive (see prodrug). Inactive metabolites lack pharmacologic activity and are simply drug waste products awaiting excretion from the body (e.g., via the urinary, gastrointestinal, or respiratory tract).

Onset of action The time required for a drug to elicit a therapeutic response after dosing.

P-glycoprotein A transporter protein that moves drugs out of cells and into the gut, urine, or bile.

Parent drug The chemical form of a drug that is administered before it is metabolized by the body into its active or inactive metabolites (see metabolite). A parent drug that is not pharmacologically active itself is called a prodrug. A prodrug is then metabolized to pharmacologically active metabolites.

Peak effect The time required for a drug to reach its maximum therapeutic response in the body.

Peak level The maximum concentration of a drug in the body after administration, usually measured in a blood sample for therapeutic drug monitoring.

Pharmaceutics The science of preparing and dispensing drugs, including dosage form design.

Pharmacodynamics The study of the biochemical and physiologic interactions of drugs at their sites of activity. It examines the effect of the drug on the body.

Pharmacoeconomics The study of economic factors impacting the cost of drug therapy.

Pharmacogenomics The study of the influence of genetic factors on drug response that result in the absence, overabundance, or insufficiency of drug-metabolizing enzymes (also called pharmacogenomics; see Chapter 8).

Pharmacognosy The study of drugs that are obtained from natural plant and animal sources.

Pharmacokinetics The study of what happens to a drug from the time it is put into the body until the parent drug and all metabolites have left the body. Pharmacokinetics represent the drug absorption into, distribution and metabolism within, and excretion from the body.

Pharmacology The broadest term for the study or science of drugs.

Pharmacotherapeutics The treatment of pathologic conditions through the use of drugs.

Prodrug An inactive drug dosage form that is converted to an active metabolite by various biochemical reactions once it is inside the body.

Prototypical drug The first form of a drug, or first in a class of drugs. Throughout this book, prototypical drugs will be denoted as a "key drug."

Receptor A molecular structure within or on the outer surface of a cell. Receptors bind specific substances (e.g., drug molecules), and one or more corresponding cellular effects (drug actions) occur as a result of this drug-receptor interaction.

Steady state The physiologic state in which the amount of drug removed via elimination is equal to the amount of drug absorbed with each dose.

Substrates Substances (e.g., drugs or natural biochemicals in the body) on which an enzyme acts.

Synergistic effects Drug interactions in which the effect of a combination of two or more drugs with similar actions is

greater than the sum of the individual effects of the same drugs given alone. For example, 1 + 1 is greater than 2 (compare with additive effects).

Therapeutic drug monitoring The process of measuring drug levels to identify a patient's drug exposure and to allow adjustment of dosages with the goals of maximizing therapeutic effects and minimizing toxicity.

Therapeutic effect The desired or intended effect of a particular medication.

Therapeutic index The ratio between the toxic and therapeutic concentrations of a drug.

Tolerance Reduced response to a drug after prolonged use.

Toxic The quality of being poisonous (i.e., injurious to health or dangerous to life).

Toxicity The condition of producing adverse bodily effects due to poisonous qualities.

Toxicology The study of poisons, including toxic drug effects, and applicable treatments.

Trade name The commercial name given to a drug product by its manufacturer; also called the proprietary name.

Trough level The lowest concentration of drug reached in the body after it falls from its peak level, usually measured in a blood sample for therapeutic drug monitoring.

OVERVIEW

Any chemical that affects the physiologic processes of a living organism can be defined as a **drug**. The study or science of drugs is known as **pharmacology**. Pharmacology encompasses a variety of topics, including the following:

- Absorption
- Biochemical effects
- Biotransformation (metabolism)
- Distribution
- Drug history
- Drug origin
- Excretion
- Mechanisms of action
- Physical and chemical properties
- Physical effects
- Drug receptor mechanisms
- Therapeutic (beneficial) effects
- Toxic (harmful) effects

Pharmacology includes the following several subspecialty areas: *pharmaceutics, pharmacokinetics, pharmacodynamics, pharmacogenomics (pharmacogenetics), pharmacoeconomics, pharmacotherapeutics, pharmacognosy,* and *toxicology.* Knowledge of pharmacology enables the nurse to better understand how drugs affect humans. Without understanding basic pharmacologic principles, the nurse cannot fully appreciate the therapeutic benefits and potential toxicity of drugs.

Throughout the process of its development, a drug will acquire at least three different names. The **chemical name** describes the drug's chemical composition and molecular structure. The generic name, or nonproprietary name, is often much shorter and simpler than the chemical name. The **generic name** is used in most official drug compendiums to list drugs. The **trade name**, or proprietary name, is the drug's registered trademark, and indicates that its commercial use is restricted to the owner of the patent for the drug (Fig. 2.1). The patent owner is usually the manufacturer of the drug. Trade names are generally created by the manufacturer with marketability in mind. For this reason, they are usually shorter and easier to pronounce and remember than generic drug names. The *patent life* (the length of time from patent approval until patent expiration) of a newly discovered drug molecule is normally 17 years. The research processes for new drug development normally require about 10 years, and the manufacturer generally has the remaining 7 years for sales profits before patent expiration. A significant amount of these profits serves to offset the multimillion-dollar costs for research and development of the drug. A new category of the generic drug market is called *biosimilars*. Biosimilar, by definition, is a copy version of an already authorized biological product.

After the patent expires, other manufacturers may legally begin to manufacture *generic* drugs with the same active ingredient. At this point, the drug price usually decreases substantially. Due to the high cost of drugs, many institutions have implemented programs in which one drug in a class of several drugs is chosen as the preferred agent, even though the drugs do not have the same active ingredients. This is called *therapeutic equivalence.* Before one drug can be therapeutically substituted for another, the drugs must have been proven to have the same therapeutic effect on the body.

Chemical name
(+/−)-2-(p-isobutylphenyl) propionic acid
Generic name
ibuprofen
Trade name
Motrin, others

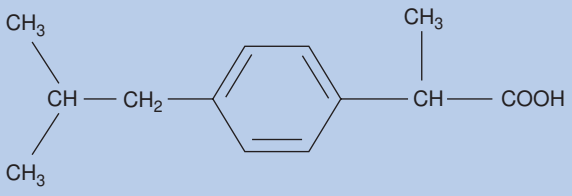

Fig. 2.1 Chemical structure of the common analgesic ibuprofen and the chemical, generic, and trade names for the drug.

Drugs are grouped together based on their similar properties. This is known as a **drug classification**. Drugs can be classified by their structure (e.g., beta-adrenergic blockers) or by their therapeutic use (e.g., antibiotics, antihypertensives, antidepressants). Within the broad classification, each class may have subclasses; for example, penicillins are a subclass within the group of antibiotics, and beta-adrenergic blockers are a subclass within the group of antihypertensives. **Prototypical drugs** are the first drug in a class of drugs and are noted as key drugs throughout this textbook.

Three basic areas of pharmacology—*pharmaceutics, pharmacokinetics,* and *pharmacodynamics*—describe the relationship between the dose of a drug and the activity of that drug in treating the disorder. **Pharmaceutics** is the study of how various dosage forms influence the way in which the drug affects the body. **Pharmacokinetics** is the study of what the body does to the drug. Pharmacokinetics involves the processes of absorption, distribution, metabolism, and excretion. **Pharmacodynamics** is the study of what the drug does to the body. Pharmacodynamics involves drug-receptor relationships. Fig. 2.2 illustrates the three phases of drug activity, starting with the pharmaceutical phase, proceeding to the pharmacokinetic phase, and finishing with the pharmacodynamic phase.

Pharmacotherapeutics (also called *therapeutics*) focuses on the clinical use of drugs to prevent and treat diseases. It defines the principles of **drug actions**. Some drug mechanisms of action are more clearly understood than others. Drugs are also categorized into pharmacologic classes according to their physiologic functions (e.g., beta-adrenergic blockers) and primary disease states treated (e.g., anticonvulsants, antiinfectives). The US Food and Drug Administration (FDA) regulates the approval and clinical use of all drugs in the United States, including the requirement of an expiration date on all drugs. This textbook focuses almost exclusively on current FDA-approved indications for the drugs discussed in each chapter and on drugs that are currently available in the United States at the time of this writing. Only FDA-approved indications are permitted to be described in the manufacturer's written information, or labeling, for a given drug product. At times, prescribers may choose to use drugs for non–FDA-approved indications. This is known as *off-label prescribing.* Evolving over time in clinical practice, previously off-label indications often become FDA-approved indications for a given drug.

The study of the adverse effects of drugs and other chemicals on living systems is known as **toxicology**. **Toxic** effects are often an extension of a drug's therapeutic action. Therefore toxicology frequently involves overlapping principles of both pharmacotherapy and toxicology. The study of natural (versus synthetic) drug sources (i.e., plants, animals, minerals) is called **pharmacognosy**. **Pharmacoeconomics** focuses on the economic aspects of drug therapy.

In summary, pharmacology is a very dynamic science that incorporates several different disciplines, including chemistry, physiology, and biology.

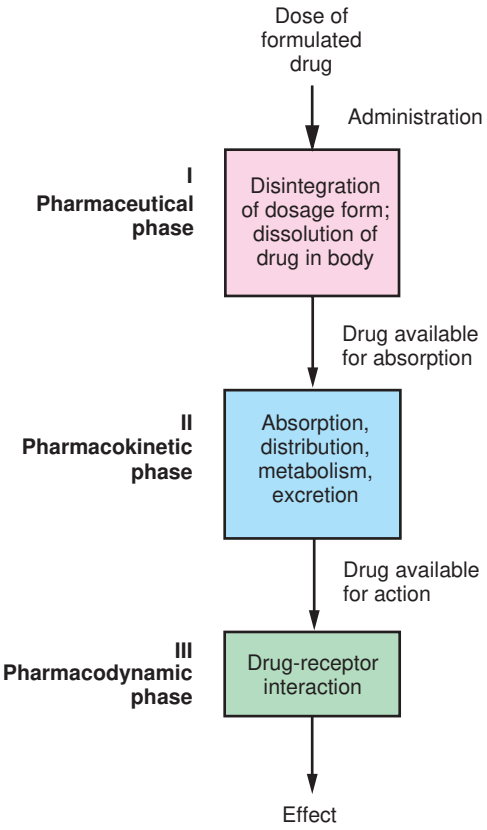

Fig. 2.2 Phases of drug activity. (From McKenry, L. M., Tessier, E., & Hogan, M. (2006). *Mosby's pharmacology in nursing* (22nd ed.). St Louis: Mosby.)

PHARMACEUTICS

Different drug dosage forms have different pharmaceutical properties. Dosage form determines the rate at which drug **dissolution** (dissolving of solid dosage forms and their absorption, e.g., from the gastrointestinal [GI] tract) occurs. A drug to be ingested orally may be in either a solid form (tablet, capsule, or powder) or a liquid form (solution or suspension). Table 2.1 lists various oral drug preparations and the relative rate at which they are absorbed. Oral drugs that are liquids (e.g., elixirs, syrups) are already dissolved and are usually absorbed more quickly than solid dosage forms. Enteric-coated tablets, on the other hand, have a coating that prevents them from being broken down in the acidic pH environment of the stomach and are not absorbed until they reach the higher (more alkaline) pH of the

TABLE 2.1 Drug Absorption of Various Oral Preparations

Oral disintegration, buccal tablets, and oral soluble wafers	Fastest
Liquids, elixirs, and syrups	
Suspension solutions	
Powders	
Capsules	
Tablets	
Coated tablets	
Enteric-coated tablets	Slowest

TABLE 2.2 Dosage Forms

Route	Forms
Enteral	Tablets, capsules, oral soluble wafers, pills, timed-release capsules, timed-release tablets, elixirs, suspensions, syrups, emulsions, solutions, lozenges or troches, rectal suppositories, sublingual or buccal tablets
Parenteral	Injectable forms, solutions, suspensions, emulsions, powders for reconstitution
Topical	Aerosols, ointments, creams, pastes, powders, solutions, foams, gels, transdermal patches, inhalers, rectal and vaginal suppositories

intestines. This pharmaceutical property results in slower dissolution and therefore slower absorption.

Particle size within a tablet or capsule can make different dosage forms of the same drug dissolve at different rates, become absorbed at different rates, and thus have different times to onset of action. An example is the difference between micronized glyburide and nonmicronized glyburide. Micronized glyburide reaches a maximum concentration peak faster than does the nonmicronized formulation.

Combination dosage forms contain multiple drugs in one dose—for example, the cholesterol and antihypertensive medications atorvastatin/amlodipine tablets called Caduet. There are large numbers of such combinations; examples are cited in the various chapters of this textbook.

A variety of dosage forms exist to provide both accurate and convenient drug delivery systems (Table 2.2). These delivery systems are designed to achieve a desired therapeutic response with minimal adverse effects. Many dosage forms have been developed to encourage patient adherence with the medication regimen. Extended-release tablets and capsules release drug molecules in the patient's GI tract over a prolonged period. This ultimately prolongs drug absorption as well as duration of action. This is the opposite of immediate-release dosage forms, which release all of the active ingredient immediately upon dissolution in the GI tract. Extended-release dosage forms are normally easily identified by various capital letter abbreviations attached to their names. Examples of this nomenclature are SR (slow release or sustained release), SA (sustained action), CR (controlled release), XL (extended length), and XT (extended time). Convenience of administration correlates strongly with patient adherence, because these forms often require fewer daily doses. Extended-release oral dosage forms must not be crushed, as this could cause accelerated release of drug from the dosage form and possible toxicity. Enteric-coated tablets also are not recommended for crushing. This would cause disruption of the tablet coating designed to protect the stomach lining from the local effects of the drug and/or protect the drug from being prematurely disrupted by stomach acid. The ability to crush a tablet or open a capsule can facilitate drug administration when patients are unable or unwilling to swallow a tablet or capsule, and also when medications need to be given through an enteral feeding tube. Capsules, powder, or liquid contents can often be added to soft foods such as applesauce or pudding, or dissolved in a beverage. Granules contained in capsules are usually for extended drug release and normally should not be crushed or chewed by the patient. However, they can often be swallowed when sprinkled on one of the soft foods. Consultation with a pharmacist or use of other suitable source is necessary if any question exists as to whether a drug can be crushed or mixed with a specific food or beverage.

An increasingly popular dosage form is one that dissolves in the mouth and is absorbed through the oral mucosa. These include orally disintegrating tablets as well as thin wafers. Depending on the specific drug product, the dosage form may dissolve on the tongue, under the tongue, or in the buccal (cheek) pocket.

The specific characteristics of the dosage form have a large impact on how and to what extent the drug is absorbed. For a drug to work at a specific site in the body, either it must be applied directly at the site in an active form or it must have a way of getting to that site. Oral dosage forms rely on gastric and intestinal enzymes and pH environments to break the medication down into particles that are small enough to be absorbed into the circulation. Once absorbed through the mucosa of the stomach or intestines, the drug is then transported to the site of action by blood or lymph.

Many topically applied dosage forms work directly on the surface of the skin. Once the drug is applied, it is in a form that allows it to act immediately. With other topical dosage forms, the skin acts as a barrier through which the drug must pass to get into the circulation; once there, the drug is then carried to its site of action (e.g., fentanyl transdermal patch for pain).

Dosage forms that are administered via injection are called *parenteral* forms. They must have certain characteristics to be safe and effective. The arteries and veins that carry drugs throughout the body can easily be damaged if the drug is too concentrated or corrosive. The pH of injections must be very similar to that of the blood for these drugs to be administered safely. Parenteral dosage forms that are injected intravenously are immediately placed into solution in the bloodstream and do not have to be dissolved in the body. Therefore 100% absorption is assumed to occur immediately upon intravenous injection.

PHARMACOKINETICS

Pharmacokinetics is the study of what happens to a drug from the time it is put into the body until the **parent drug** and all metabolites have left the body. Specifically, the combined processes of pharmacokinetics include drug absorption into, distribution and metabolism within, and excretion from the body represent.

Absorption

Absorption is the movement of a drug from its site of administration into the bloodstream for distribution to the tissues. **Bioavailability** is the term used to express the extent of drug absorption. A drug that is absorbed from the intestine must first pass through the liver before it reaches the systemic circulation. If a large proportion of a drug is chemically changed into inactive metabolites in the liver, then a much smaller amount of drug will pass into the circulation (i.e., will be bioavailable). Such a drug

is said to have a high **first-pass effect**. First-pass effect reduces the bioavailability of the drug to less than 100%. Many drugs administered by mouth have a bioavailability of less than 100%, whereas drugs administered by the intravenous route are 100% bioavailable. If two drug products have the same bioavailability and same concentration of active ingredient, they are said to be bioequivalent (e.g., a brand-name drug and the same generic drug).

Various factors affect the rate of drug absorption. How a drug is administered, or its route of administration, affects the rate and extent of absorption of that drug. Although a number of dosage formulations are available for delivering medications, they can all be categorized into three basic routes of administration: enteral (GI tract), parenteral, and topical.

CASE STUDY

Patient-Centered Care: Pharmacokinetics

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Four patients with angina are receiving a form of nitroglycerin, as follows:

Mrs. A. takes 6.5 mg (extended release tablets) PO three times a day to prevent angina.

Mr. B. takes a transdermal patch that delivers 0.2 mg/hr, also to prevent angina.

Mrs. C. takes 0.4 mg sublingually, only if needed for chest pain.

Mr. D. is in the hospital with severe heart failure after a myocardial infarction, and is receiving 15 mcg/min via an intravenous infusion.

You may refer to the section on nitroglycerin in Chapter 23 or to a nursing drug handbook to answer these questions.

1. For each patient, state the rationale for the route or form of drug that was chosen. Which forms have immediate action? Why would this be important?
2. Which form or forms are most affected by the first-pass effect? Explain your answer.
3. What would happen if Mrs. A. chewed her nitroglycerin dose? If Mrs. C. chewed her nitroglycerin dose?

For answers, see *http://evolve.elsevier.com/Lilley*.

Enteral Route

In enteral drug administration, the drug is absorbed into the systemic circulation through the mucosa of the stomach and/or small or large intestine. Orally administered drugs are absorbed from the intestinal lumen into the blood system and transported to the liver. Once the drug is in the liver, hepatic enzyme systems metabolize it, and the remaining active ingredients are passed into the general circulation. Many factors can alter the absorption of drugs, including acid changes within the stomach, absorption changes in the intestines, and the presence or absence of food and fluid. Various factors that affect the acidity of the stomach include the time of day; the age of the patient; and the presence and types of medications, foods, or beverages. Enteric coating is designed to protect the stomach by having drug dissolution and absorption occur in the intestines. Taking an enteric-coated medication with a large amount of food may cause it to be dissolved by acidic stomach contents and thus reduce intestinal drug absorption and negate the coating's stomach-protective properties. Anticholinergic drugs slow GI transit time (or the time it takes for substances in the stomach to be dissolved for transport to and absorption from the intestines). This may reduce the amount of drug absorption for acid-susceptible drugs that become broken down by stomach acids. The presence of food may enhance the absorption of some fat-soluble drugs or of drugs that are more easily broken down in an acidic environment.

Drug absorption may be altered in patients who have had portions of the small intestine removed because of disease. This is known as *short bowel syndrome.* Similarly, bariatric weight-loss surgery reduces the size of the stomach. As a result, medication absorption can be altered, because stomach contents are delivered to the intestines more rapidly than usual. This is called *gastric dumping.* Examples of drugs to be taken on an empty stomach and those to be taken with food are provided in Box 2.1. The stomach and small intestine are highly vascularized. When blood flow to this area is decreased, absorption may also be decreased. Sepsis and exercise are examples of circumstances under which blood flow to the GI tract is often reduced. In both cases, blood tends to be routed to the heart and other vital organs. In the case of exercise, it is also routed to the skeletal muscles.

Rectally administered drugs are often given for systemic effects (e.g., antinausea, analgesia, antipyretic effects), but they are also used to treat disease within the rectum or adjacent bowel (e.g., antiinflammatory ointment for hemorrhoids). In this case, rectal administration may also be thought of as a *topical* route of drug administration.

Sublingual and buccal routes. Drugs administered by the *sublingual* route are absorbed into the highly vascularized tissue under the tongue—the oral mucosa. Sublingual nitroglycerin is an example. Sublingually administered drugs are absorbed rapidly because the area under the tongue has a large blood supply. These drugs bypass the liver and yet are systemically bioavailable. The same applies for drugs administered by the *buccal route* (the oral mucosa between the cheek and the gum). Through these routes, drugs such as nitroglycerin are absorbed rapidly into the bloodstream and delivered to their site of action (e.g., coronary arteries).

Parenteral Route

The parenteral route is the fastest route by which a drug can be absorbed, followed by the enteral and topical routes. *Parenteral*

BOX 2.1 Drugs to Be Taken on an Empty Stomach and Drugs to Be Taken With Food

Many medications are taken on an empty stomach with at least 6 ounces of water. The nurse must give patients specific instructions regarding those medications that are not to be taken with food. Examples include alendronate sodium and risedronate sodium.

Medications that are generally taken with food include carbamazepine, iron and iron-containing products, hydralazine, lithium, propranolol, spironolactone, nonsteroidal antiinflammatory drugs, and theophylline.

Macrolides and oral opioids are often taken with food (even though they are specified to be taken with a full glass of water and on an empty stomach) to minimize the gastrointestinal irritation associated with these drugs. If doubt exists, consult a licensed pharmacist or a current authoritative drug resource. An Internet source to use is *www.usp.org*.

is a general term meaning any route of administration other than the GI tract. It most commonly refers to injection. Intravenous injection delivers the drug directly into the circulation, where it is distributed with the blood throughout the body. Drugs given by intramuscular injection and subcutaneous injection are absorbed more slowly than those given intravenously. These drug formulations are usually absorbed over a period of several hours; however, some are specially formulated to be released over days, weeks, or months.

Drugs can be injected intradermally, subcutaneously, *intraarterially,* intramuscularly, *intrathecally,* intraarticularly, or intravenously. **Intraarterial**, **intrathecal**, or **intraarticular** injections are usually given by physicians. Medications given by the parenteral route have the advantage of bypassing the first-pass effect of the liver. Parenteral administration offers an alternative route of delivery for medications that cannot be given orally. However, drugs that are administered by the parenteral route must still be absorbed into cells and tissues before they can exert their pharmacologic effect (Table 2.3).

Subcutaneous, intradermal, and intramuscular routes. Injections into the fatty subcutaneous tissues under the dermal layer of skin are referred to as *subcutaneous* injections. Injections under

TABLE 2.3 Routes of Administration and Related Nursing Considerations

Route	Advantages	Disadvantages	Nursing Considerations
Intravenous (IV)	Provides rapid onset (drug delivered immediately to bloodstream); allows more direct control of drug level in blood; gives option of larger fluid volume, therefore diluting irritating drugs; avoids first-pass metabolism	Often of higher cost; requires intravenous access and not self-administered; irreversibility of drug action in most cases and inability to retrieve medication; risk of fluid overload; greater likelihood of infection; possibility of embolism	Thorough handwashing and use of gloves. Continuous intravenous infusions require frequent monitoring to be sure that the correct volume and amount are administered and that the drug reaches safe, therapeutic blood levels. Intravenous drugs and solutions must be checked for compatibilities. Intravenous sites are to be monitored for redness, swelling, heat, and drainage—all indicative of complications, such as thrombophlebitis, infiltration, and infection. If intermittent intravenous infusions are used, clearing or flushing of the line with normal saline before and after is generally indicated to keep the intravenous site patent and minimize incompatibilities. Always check facility protocol on the length of time that an IV catheter may be left in the same site. Use a filter needle when withdrawing from an ampule or vial and replace with regular needle prior to use (for all parenterally administered drugs).
Intramuscular (IM); subcutaneous (subQ)	Intramuscular injections are indicated/used with drugs that are poorly soluble which are often given in "depot" preparation form and are then absorbed over a prolonged period; several drugs may be administered simultaneously if compatible in syringe and/or without contraindication; IM and subcutaneous routes result in more rapid absorption as compared with oral route	Discomfort of injection; if inaccurate technique or improper landmarking occurs, risks of damage to blood vessels, nerves, and surrounding tissue; IM and subcutaneous routes have slower onset of action as compared with intravenous; only small amounts of drugs may be given intramuscularly (up to 3 mL) and subcutaneously (up to 1 mL)	Thorough handwashing and use of gloves. Use anatomical landmarks to identify correct intramuscular and subcutaneous sites is always required and recommended as a nursing standard of care (see Photo Atlas). For adults, potential intramuscular sites include the ventrogluteal, vastus lateralis, and deltoid. The dorsogluteal site is not recommended because of potential damage to nearby nerves and blood vessels. Use of a 1½ inch, 20 or 25 gauge needle; ½ to 1 inch needle may be indicated in patients who are very thin or emaciated); a larger gauge needle (18–20) may be indicated with use of viscous or oil-based solutions. Subcutaneous injections may be given in the abdomen, thigh and upper arm and recommended to be given at a 90-degree angle with a proper size syringe and needle (⅝ inch, 25-to 27-gauge); in emaciated or very thin patients, the subcutaneous angle is at 45 degrees. Subcutaneous route is selected for only a few drugs (i.e., insulin, heparin) due to irritability of drugs. Insulin syringes are marked in units and hold only 1 mL of medication and to be used only with insulin. Tuberculin syringes hold up to 1 mL of medicine. Selection of correct size of syringe and needle is key to safe administration by these routes and is based on thorough assessment of the patient as well as the characteristics of the drug.
Oral (PO)	Usually easier, more convenient, and less expensive; safer than injection, dosing more likely to be reversible in cases of accidental ingestion (e.g., administration of activated charcoal). Does not require complex equipment.	Variable absorption and slow onset of action; inactivation of some drugs by stomach acid and/or pH; problems with first-pass effect or presystemic metabolism; greater dependence of drug action on patient variables; some drugs irritate GI mucosa	Enteral routes include oral administration and involve a variety of dosage forms (e.g., liquids, solutions, tablets, and enteric-coated pills or tablets). Some medications are recommended to be taken with food, while others are recommended not to be taken with food; it is also suggested that oral dosage forms of drugs be taken with at least 6–8 ounces of fluid, such as water. Other factors to consider include other medicines being taken at the same time and concurrent use of dairy products or antacids. If oral forms are given via nasogastric tube or gastrostomy tube, tube placement in stomach must be assessed prior to giving the medication, and the patient's head is to remain elevated; flushing the nasogastric tube with at least 30–60 mL of water before and after the drug has been given is recommended to help maintain tube patency and prevent clogging.

Continued

TABLE 2.3 Routes of Administration and Related Nursing Considerations—cont'd

Route	Advantages	Disadvantages	Nursing Considerations
Sublingual, buccal (subtypes of oral, but more parenteral than enteral)	Absorbed more rapidly from oral mucosa and leads to more rapid onset of action; avoids breakdown of drug by stomach acid; avoids first-pass metabolism because gastric absorption is bypassed	Patients may swallow pill instead of keeping under tongue until dissolved; pills often smaller to handle	Drugs given via the sublingual route are to be placed under the tongue; once dissolved, the drug may be swallowed. When using the buccal route, medication is placed between the cheek and gum. Both of these dosage forms are relatively nonirritating; the drug usually is without flavor and water-soluble.
Rectal	Provides relatively rapid absorption; good alternative when oral route not feasible; useful for local or systemic drug delivery; usually leads to mixed first-pass and non–first-pass metabolism	Possible discomfort and embarrassment to patient; often higher cost than oral route	Absorption via this route is erratic and unpredictable, but it provides a safe alternative when nausea or vomiting prevents oral dosing of drugs. The patient must be placed on his or her left side so that the normal anatomy of the colon allows safe and effective insertion of the rectal dosage form. Suppositories are inserted using a gloved hand and/or gloved index finger and water-soluble lubricant. The drug must be administered exactly as ordered.
Topical	Delivers medication directly to affected area; decreases likelihood of systemic drug effects	Sometimes awkward to self-administer (e.g., eye drops); may irritate skin, may be messy; usually higher cost than oral route	Most dermatologic drugs are given via topical route in form of a solution, ointment, spray, or drops. Maximal absorption of topical drugs is enhanced with skin that is clean and free of debris; if measurement of ointment is necessary—such as with topical nitroglycerin—application must be done carefully and per instructions (e.g., apply 1 inch of ointment). Gloves help minimize cross-contamination and prevent absorption of drug into the nurse's own skin. If the patient's skin is not intact, sterile technique must be used.
Transdermal (subtype of topical)	Provides relatively constant rate of drug absorption; one patch can last 1–7 days, depending on drug; avoids first-pass metabolism	Rate of absorption can be affected by excessive perspiration and body temperature; patch may peel off; cost is higher; used patches must be disposed of safely; may irritate skin; if skin is inflamed, abraded, or damaged, drug absorption may be increased leading to systemic side effects	Transdermal drugs are to be placed on alternating sites and on a clean, nonhairy, nonirritated area, and only after the previously applied patch has been removed and that area cleansed and dried. Transdermal drugs generally come in a single-dose, adhesive-backed drug application system.
Inhalational	Provides rapid absorption; drug delivered directly to lung tissues where most of these drugs exert their actions	Rate of absorption can be too rapid, increasing the risk for exaggerated drug effects; requires more patient education for self-administration; some patients may have difficulty with administration technique	Inhaled medications are to be used exactly as prescribed and with clean equipment. Instructions need to be given to the patient/family/caregiver regarding medications to be used as well as the proper use, storage, and safe-keeping of inhalers, spacers, and nebulizers. Chapter 9 describes how medications are inhaled and the various inhaled dosage forms.

NOTE: Refer to Chapter 9 for more specific instructions, diagrams, and pictures of some of the different routes of administration. For more information on avoiding the use of abbreviations associated with dosage routes, dosage amounts, dosage frequency, and drug names, as well as the use of symbols, please visit *www.ismp.org/tools/errorproneabbreviations.pdf*.
GI, Gastrointestinal.

the more superficial skin layers immediately underneath the epidermal layer of skin and into the dermal layer are known as *intradermal* injections. Injections given into the muscle beneath the subcutaneous fatty tissue are referred to as *intramuscular* injections. Muscles have a greater blood supply than does the skin; therefore drugs injected intramuscularly are absorbed faster than drugs injected subcutaneously. Absorption from either of these sites may be increased by applying heat to the injection site or by massaging the site. In contrast, the presence of cold, hypotension, or poor peripheral blood flow compromises the circulation, reducing drug activity by reducing drug delivery to the tissues. Most intramuscularly injected drugs are absorbed

QSEN

SAFETY AND QUALITY IMPROVEMENT: PREVENTING MEDICATION ERRORS

Does IV = PO?

The prescriber writes an order for "Lasix 80 mg IV STAT × 1 dose" for a patient who is short of breath with heart failure. When the nurse goes to give the drug, only the PO form is immediately available. Someone must go to the pharmacy to pick up the IV dose. Another nurse says, "Go ahead and give the pill. He needs it fast. It's all the same!" But is it?

Remember, the oral forms of medications must be processed through the gastrointestinal tract, absorbed through the small intestines, and undergo the first-pass effect in the liver before the drug can reach the intended site of action. However, IV forms are injected directly into the circulation and can act almost immediately because the first-pass effect is bypassed. The time until onset of action for the PO form is 30 to 60 minutes; for the IV form, this time is *5 minutes*. This patient is in respiratory distress, and the immediate effect of the diuretic is desired. In addition, because of the first-pass effect, the available amount of orally administered drug that actually reaches the site of action would be less than the available amount of intravenously administered drug. Therefore IV does NOT equal PO! Never change the route of administration of a medication; if questions come up, always check with the prescriber.

over several hours. However, specially formulated long-acting intramuscular dosage forms called *depot drugs* have been designed for slow absorption over a period of several days to a few months or longer.

Topical Route

The topical route of drug administration involves application of medications to various body surfaces. Several topical drug delivery systems exist. Topically administered drugs can be applied to the skin, eyes, ears, nose, lungs, rectum, or vagina. Topical application delivers a uniform amount of drug over a longer period, but the effects of the drug are usually slower in their onset and more prolonged in their duration of action as compared with oral or parenteral administration. This can be a problem if the patient begins to experience adverse effects from the drug and a considerable amount of drug has already been absorbed. All topical routes of drug administration avoid first-pass effects of the liver, with the exception of rectal administration. Because the rectum is part of the GI tract, some drug will be absorbed into the capillaries that feed the portal vein to the liver. However, some drugs will also be absorbed locally into perirectal tissues. Therefore rectally administered drugs are said to have a mixed first-pass and non–first-pass absorption and metabolism. Box 2.2 lists the various drug routes and indicates whether they are associated with first-pass effects in the liver.

Ointments, gels, and creams are common types of topically administered drugs. Examples include sunscreens, antibiotics, and nitroglycerin ointment. The drawback to their use is that their systemic absorption is often erratic and unreliable. In general, these medications are used for local effects, but some are used for systemic effects (e.g., nitroglycerin ointment for maintenance treatment of angina). Topically applied drugs can also be used in the treatment of various illnesses of the eyes, ears, and sinuses.

BOX 2.2 Drug Routes and First-Pass Effects

First-Pass Routes	Non–First-Pass Routes
Hepatic arterial	Aural (instilled into the ear)
Oral	Buccal
Portal venous	Inhaled
Rectal[a]	Intraarterial
	Intramuscular
	Intranasal
	Intraocular
	Intravaginal
	Intravenous
	Subcutaneous
	Sublingual
	Transdermal

[a]Leads to both first-pass and non–first-pass effects.

Eye, ear, and nose drops are administered primarily for local effects, whereas nasal sprays may be used for both systemic and local effects. Vaginal medications may be given for systemic effects (e.g., progestational hormone therapy with progesterone vaginal suppositories) but are more commonly used for local effects (e.g., treatment of vaginal yeast infection with miconazole [Monistat] vaginal cream).

Transdermal route. Transdermal drug delivery through adhesive patches is an elaborate topical route of drug administration that is commonly used for systemic drug effects. Transdermal patches are usually designed to deliver a constant amount of drug per unit of time for a specified time period. For example, a nitroglycerin patch may deliver 0.1 or 0.2 mg/h over 24 hours, whereas a fentanyl patch may deliver 25 to 100 mcg/h over a 72-hour period. This route is suitable for patients who cannot tolerate oral administration and provides a practical and convenient method for drug delivery.

Inhaled route. Inhalation is another type of topical drug administration. Inhaled drugs are delivered to the lungs as micrometer-sized drug particles. This small drug size is necessary for the drug to be transported to the small air sacs within the lungs (alveoli). Once the small particles of drug are in the alveoli, drug absorption is fairly rapid. Many pulmonary and other types of diseases can be treated with such topically applied (inhaled) drugs.

Distribution

Distribution refers to the transport of a drug by the bloodstream to its site of action (Fig. 2.3). Drugs are distributed first to those areas with extensive blood supply. Areas of rapid distribution include the heart, liver, kidneys, and brain. Areas of slower distribution include muscle, skin, and fat. Once a drug enters the bloodstream (circulation), it is distributed throughout the body. At this point, it is also starting to be eliminated by the organs that metabolize and excrete drugs—primarily the liver and the kidneys. Only drug molecules that are not bound to plasma proteins can freely distribute to *extravascular* tissue (outside the blood vessels) to reach their site of action. If a drug is bound to plasma proteins, the drug-protein complex is generally too large

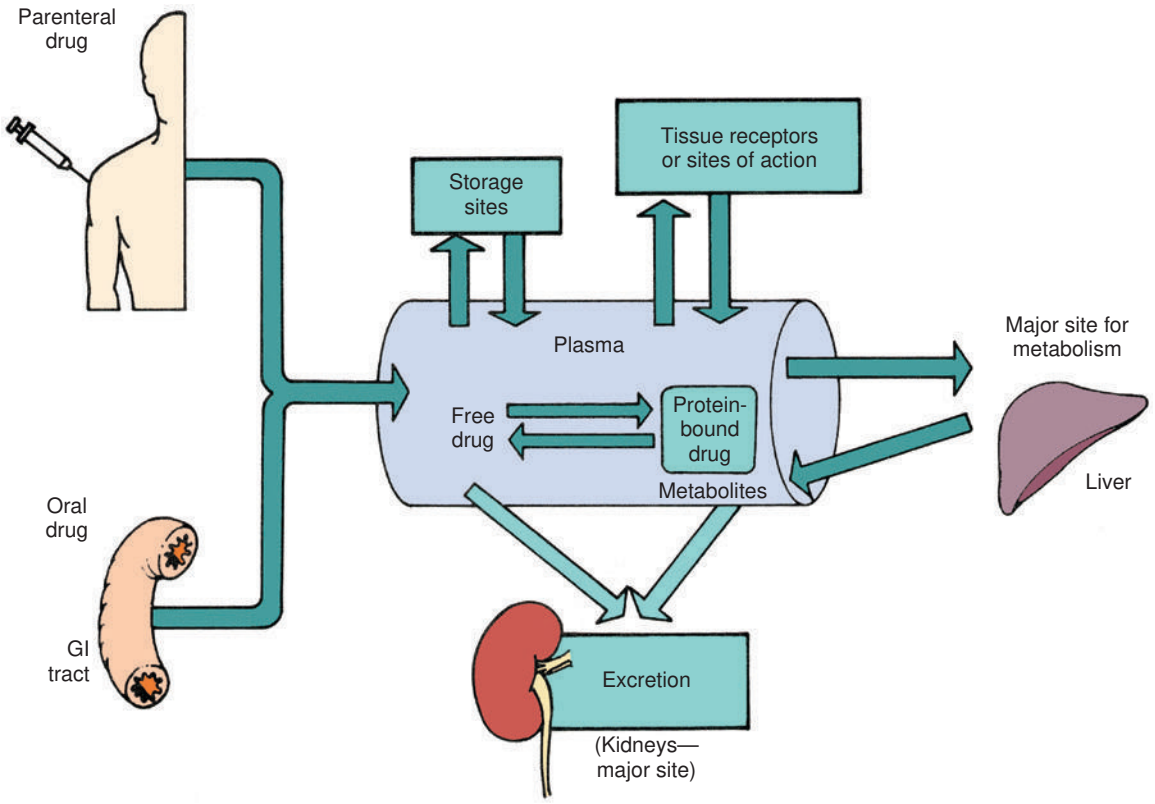

Fig. 2.3 Drug transport in the body. *GI,* Gastrointestinal.

to pass through the walls of blood capillaries into tissues (Fig. 2.4). Albumin is the most common blood protein and carries the majority of protein-bound drug molecules. If a given drug binds to albumin, then there is only a limited amount of drug that is *not* bound. This unbound portion is pharmacologically active and is considered "free" drug, whereas "bound" drug is pharmacologically inactive. Certain conditions that cause low albumin levels, such as extensive burns and malnourished states, result in a larger fraction of free (unbound and active) drug. This can raise the risk for drug toxicity.

When an individual is taking two medications that are highly protein bound, the medications may compete for binding sites on the albumin molecule. Because of this competition, there is more free or unbound drug. Protein binding may lead to an unpredictable drug response called a *drug-drug interaction.* A drug-drug interaction occurs when the presence of one drug decreases or increases the actions of another drug that is administered concurrently (i.e., given at the same time).

A theoretical volume, called the *volume of distribution*, is sometimes used to describe the various areas in which drugs may be distributed. These areas, or *compartments*, may be the blood (*intravascular space*), total body water, body fat, or other body tissues and organs. Typically a drug that is highly water-soluble (hydrophilic) will have a smaller volume of distribution and high blood concentrations. In contrast, fat-soluble drugs

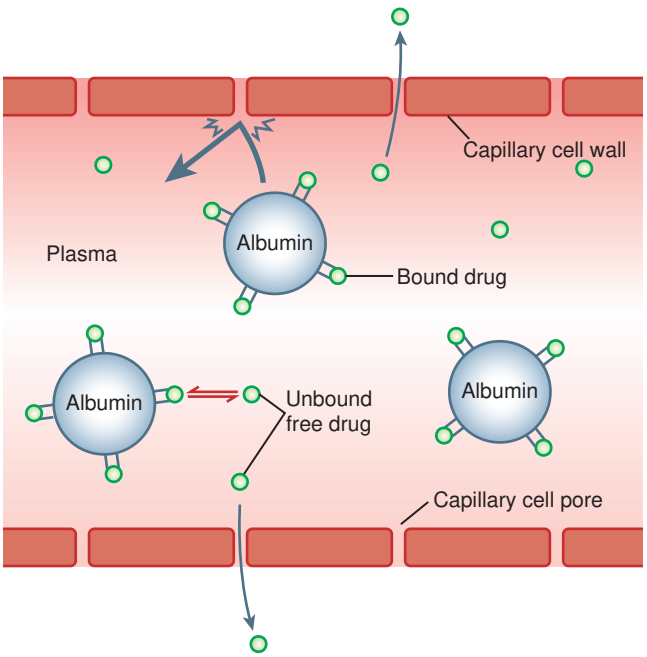

Fig. 2.4 Protein binding of drugs. Albumin is the most prevalent protein in plasma and the most important of the proteins to which drugs bind. Only unbound (free) drug molecules can leave the vascular system. Bound molecules are too large to fit through the pores in the capillary wall.

(lipophilic) have a larger volume of distribution and low blood concentrations. There are some sites in the body into which it may be very difficult to distribute a drug. These sites typically either have a poor blood supply (e.g., bone) or have physiologic barriers that make it difficult for drugs to pass through (e.g., the brain due to the **blood-brain barrier**).

Metabolism

Metabolism is also referred to as **biotransformation**. It involves the biochemical alteration of a drug into an inactive metabolite, a more soluble compound, a more potent active metabolite (as in the conversion of an inactive **prodrug** to its active form), or a less active metabolite. Metabolism is the next pharmacokinetic step after absorption and distribution. The organ most responsible for the metabolism of drugs is the liver. Other metabolic tissues include skeletal muscle, kidneys, lungs, plasma, and intestinal mucosa.

Hepatic metabolism involves the activity of a very large class of enzymes known as **cytochrome P-450** enzymes (or simply P-450 enzymes), also known as *microsomal* enzymes. These enzymes control a variety of reactions that aid in the metabolism of drugs. They target lipid-soluble drugs (also known as *lipophilic* ["fat loving"]) that are typically very difficult to eliminate. The P-450 enzymes are responsible for the metabolism of the majority of medications. Medications with water-soluble (*hydrophilic* ["water loving"]) molecules may be more easily metabolized by simpler chemical reactions such as hydrolysis. Some of the chemical reactions by which the liver can metabolize drugs are listed in Table 2.4. Drug molecules that are the metabolic targets of specific enzymes are said to be **substrates** for those enzymes. Specific P-450 enzymes are identified by standardized number and letter designations. Some of the most common P-450 enzymes and their corresponding drug substrates are listed in Table 2.5. The P-450 system is one of the most important systems that influences drug-drug interactions. The list of drugs that are metabolized by the P-450 enzyme system is constantly changing as new drugs are introduced into the market. For further information, see websites such as *www.medicine.iupui.edu/clinpharm/ddis/* and *www.nursinglink.com/training/articles/320-clinically-significant-drug-interaction-with-the-cytochrome-p450-enzyme-system*. Another common drug **interaction** involves a plasma membrane protein, **P-glycoprotein**, which acts as a drug transport mechanism, transporting drugs out of the cell. Many drugs can be impacted at the P-glycoprotein level. Metabolizing capabilities of the liver can vary considerably from patient to patient. Various factors that alter the biotransformation including genetics, diseases, and the concurrent use of other medications (Table 2.6).

Many drugs can inhibit drug-metabolizing enzymes and are called *enzyme inhibitors*. Decreases in drug metabolism result in the accumulation of the drug and prolongation of the effects of the drug, which can lead to drug toxicity. In contrast, drugs that stimulate drug metabolism are called *enzyme inducers*. This can cause decreased pharmacologic effects. This often occurs with the repeated administration of certain drugs that stimulate the formation of new microsomal enzymes.

TABLE 2.4 Mechanisms of Biotransformation

Type of Biotransformation	Mechanism	Result
Oxidation Reduction Hydrolysis	Chemical reactions	Increase polarity of chemical, making it more water-soluble and more easily excreted. This often results in a loss of pharmacologic activity.
Conjugation (e.g., glucuronidation, glycination, sulfation, methylation, alkylation)	Combination with another substance (e.g., glucuronide, glycine, sulfate, methyl groups, alkyl groups)	Forms a less toxic product with less activity.

TABLE 2.5 Common Liver Cytochrome P-450 Enzymes and Corresponding Drug Substrates

Enzyme	Common Drug Substrates
1A2	acetaminophen, caffeine, theophylline, warfarin
2C9	ibuprofen, phenytoin
2C19	diazepam, naproxen, omeprazole, propranolol
2D6	codeine, fluoxetine, hydrocodone, metoprolol, oxycodone, paroxetine, risperidone, tricyclic antidepressants
2E1	acetaminophen, ethanol
3A4	acetaminophen, amiodarone, cyclosporine, diltiazem, ethinyl estradiol, indinavir, lidocaine, macrolides, progesterone, spironolactone, sulfamethoxazole, testosterone, verapamil

TABLE 2.6 Examples of Conditions and Drugs That Affect Drug Metabolism

		DRUG METABOLISM	
Category	Example	Increased	Decreased
Diseases	Cardiovascular dysfunction		X
	Renal insufficiency		X
Conditions	Starvation		X
	Obstructive jaundice		X
	Genetic constitution		
	Fast acetylator	X	
	Slow acetylator		X
Drugs	Barbiturates	X	
	rifampin (P-450 inducer)	X	
	phenytoin (P-450 inducer)	X	
	ketoconazole (P-450 inhibitor)		X

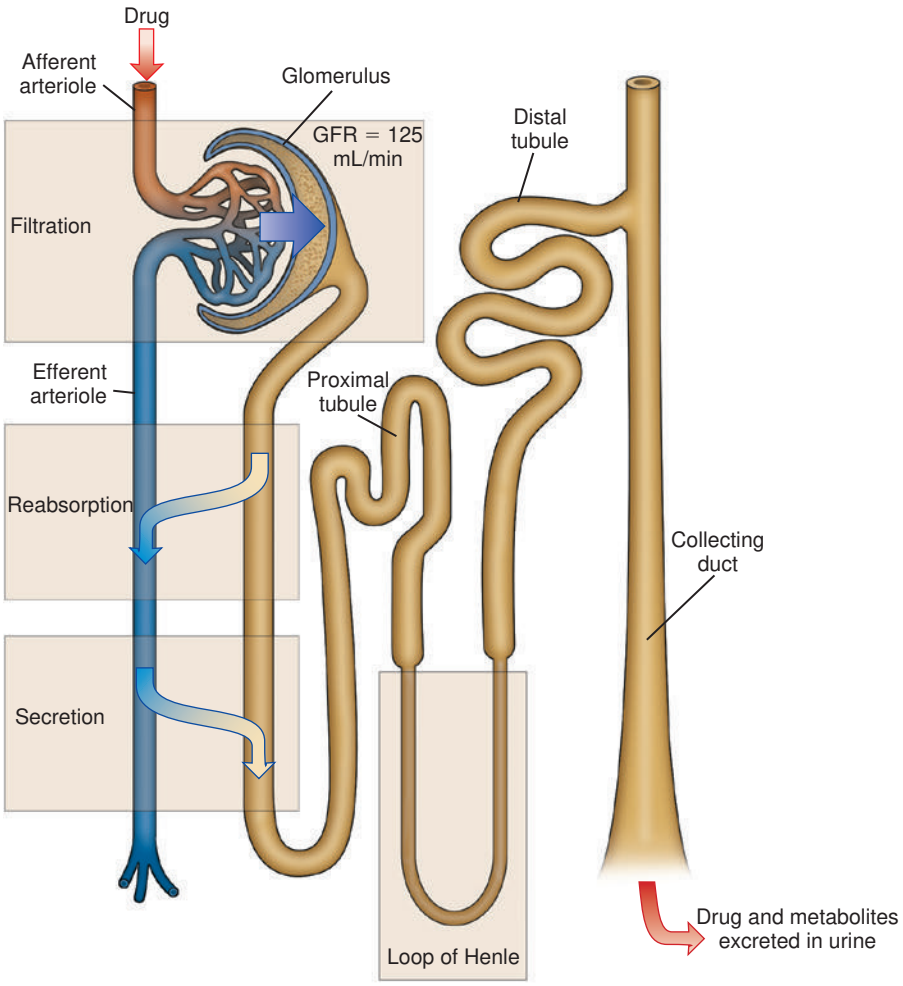

Fig. 2.5 Renal drug excretion. The primary processes involved in drug excretion and the approximate location where these processes take place in the kidney are illustrated. *GFR,* Glomerular filtration rate.

Excretion

Excretion is the elimination of drugs from the body. All drugs, whether they are parent compounds, or active or inactive metabolites, must eventually be removed from the body. The primary organ responsible for this elimination is the kidney. Two other organs that play a role in the excretion of drugs are the liver and the bowel. Most drugs are metabolized in the liver by various mechanisms. Therefore, by the time most drugs reach the kidneys, they have undergone extensive biotransformation, and only a relatively small fraction of the original drug is excreted as the original compound. Other drugs may bypass hepatic metabolism and reach the kidneys in their original form. Drugs that have been metabolized by the liver become more polar and water-soluble. This makes their elimination by the kidneys much easier, because the urinary tract is water-based. The kidneys themselves are also capable of metabolizing various drugs, although usually to a lesser extent than the liver.

The actual act of renal excretion is accomplished through *glomerular filtration*, *active tubular reabsorption*, and *active tubular secretion*. Free (unbound) water-soluble drugs and metabolites go through passive glomerular filtration. Many substances present in the nephrons go through active reabsorption and are taken back up into the systemic circulation and transported away from the kidney. This process is an attempt by the body to retain needed substances. Some substances may also be secreted into the nephron from the vasculature surrounding it. The processes of filtration, reabsorption, and secretion for urinary elimination are shown in Fig. 2.5.

The excretion of drugs by the intestines is another route of elimination. This process is referred to as *biliary excretion*. Drugs that are eliminated by this route are taken up by the liver, released into the bile, and eliminated in the feces. Once certain drugs, such as fat-soluble drugs, are in the bile, they may be reabsorbed into the bloodstream, returned to the liver, and again secreted into the bile. This process is called *enterohepatic recirculation.* Enterohepatically recirculated drugs persist in the body for much longer periods. Less common routes of elimination are the lungs and the sweat, salivary, and mammary glands.

Half-Life

Another pharmacokinetic variable is the **half-life** of the drug. By definition, half-life is the time required for one-half (50%) of a given drug to be removed from the body. It is a measure of the rate at which the drug is eliminated from the body. For

TABLE 2.7 Example of Drug Half-Life Viewed From Different Perspectives

Metric	Changing Values					
Hours after peak concentration	0	8	16	24	32	40
Drug concentration (mg/L)	100 (peak)	50	25	12.5	6.25	3.125 (trough)
Number of half-lives	0	1	2	3	4	5
Percentage of drug removed	0	50	75	88	94	97

instance, if the peak level of a drug is 100 mg/L and the measured drug level in 8 hours is 50 mg/L, then the estimated half-life of that drug is 8 hours. The concept of drug half-life viewed from several different perspectives is shown in Table 2.7.

After about five half-lives, most drugs are considered to be effectively removed from the body. At that time approximately 97% of the drug has been eliminated, and what little amount remains is usually too small to have either therapeutic or toxic effects.

The concept of half-life is clinically useful for determining when steady state will be reached. **Steady state** refers to the physiologic state in which the amount of drug removed via elimination (e.g., renal clearance) is equal to the amount of drug absorbed with each dose. This physiologic plateau phenomenon typically occurs after four to five half-lives of administered drug. Therefore, if a drug has an extremely long half-life, it will take much longer for the drug to reach steady-state blood levels. Once steady-state blood levels have been reached, there are consistent levels of drug in the body that correlate with maximum therapeutic benefits.

Onset, Peak, and Duration

The pharmacokinetic terms *absorption*, *distribution*, *metabolism*, and *excretion* are all used to describe the movement of drugs through the body. Drug actions are the processes involved in the interaction between a drug and a cell (e.g., a drug's action on a receptor). In contrast, **drug effects** are the physiologic reactions of the body to the drug. The terms *onset*, *peak*, *duration*, and *trough* are used to describe drug effects. *Peak* and *trough* are also used to describe drug concentrations, which are usually measured from blood samples.

A drug's **onset of action** is the time required for the drug to elicit a therapeutic response. A drug's **peak effect** is the time required for a drug to reach its maximum therapeutic response. Physiologically this corresponds to increasing drug concentrations at the site of action. The **duration of action** of a drug is the length of time that the drug concentration is sufficient (without more doses) to elicit a therapeutic response. These concepts are illustrated in Fig. 2.6.

The length of time until the onset and peak of action and the duration of action play an important part in determining the **peak level** (highest blood level) and **trough level** (lowest blood level) of a drug. If the peak blood level is too high, then drug **toxicity** may occur. The toxicity may be mild, such as

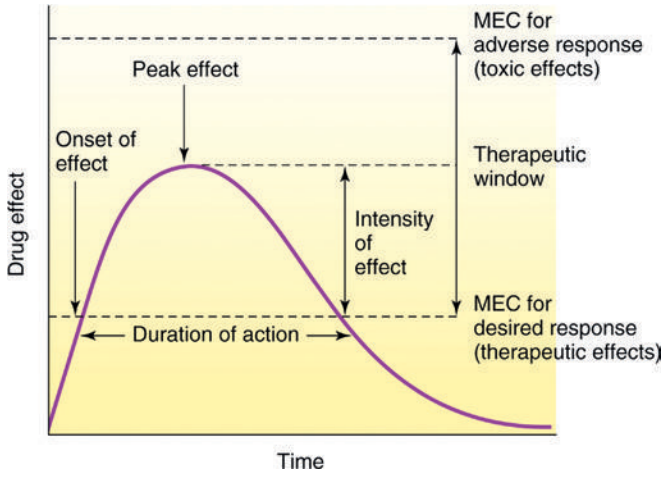

Fig. 2.6 Characteristics of drug effect and relationship to the therapeutic window. *MEC,* Minimal effective concentration.

intensification of the effects of the given drug (e.g., excessive sedation resulting from overdose of a drug with sedative properties). However, it can also be severe (e.g., damage to vital organs due to excessive drug exposure). If the trough blood level is too low, then the drug may not be at therapeutic levels to produce a response. In **therapeutic drug monitoring**, peak (highest) and trough (lowest) values are measured to verify adequate drug exposure, maximize therapeutic effects, and minimize drug toxicity. This monitoring is often carried out by a clinical pharmacist.

PHARMACODYNAMICS

Pharmacodynamics relates to the mechanisms of drug action in living tissues. Drug-induced changes in normal physiologic functions are explained by the principles of pharmacodynamics. A positive change in a faulty physiologic system is called a **therapeutic effect** of a drug. Such an effect is the goal of drug therapy.

Mechanism of Action

Drugs can produce actions (therapeutic effects) in several ways. The effects of a particular drug depend on the characteristics of the cells or tissue targeted by the drug. Once the drug is at the site of action, it can modify (increase or decrease) the rate at which that cell or tissue functions, or it can modify the strength of function of that cell or tissue. A drug cannot, however, cause a cell or tissue to perform a function that is not part of its natural physiology.

Drugs can exert their actions in three basic ways: through receptors, enzymes, and *nonselective interactions*. Not all mechanisms of action have been identified for all drugs. Thus a drug may be said to have an unknown mechanism of action, even though it has observable therapeutic effects in the body.

Receptor Interactions

A **receptor** can be defined as a reactive site on the surface or inside of a cell. If the mechanism of action of a drug involves a

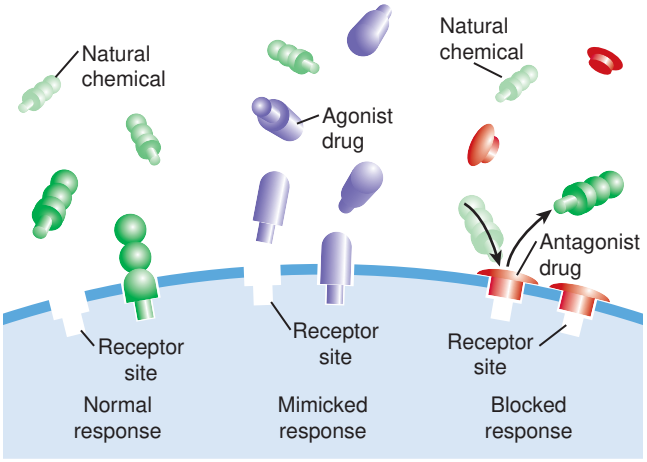

Fig. 2.7 Drugs act by forming a chemical bond with specific receptor sites, similar to a key and lock. The better the "fit," the better the response. Drugs with complete attachment and response are called **agonists**. Drugs that attach but do not elicit a response are called **antagonists**.

TABLE 2.8 Drug-Receptor Interactions

Drug Type	Action
Agonist	Drug binds to the receptor; there is a response.
Partial agonist (agonist-antagonist)	Drug binds to the receptor; the response is diminished compared with that elicited by an agonist.
Antagonist	Drug binds to the receptor; there is no response. Drug prevents binding of agonists.
Competitive antagonist	Drug competes with the agonist for binding to the receptor. If it binds, there is no response.
Noncompetitive antagonist	Drug combines with different parts of the receptor and inactivates it; agonist then has no effect.

receptor interaction, then the molecular structure of the drug is critical. Drug-receptor interaction is the joining of the drug molecule with a reactive site on the surface of a cell or tissue. Most commonly, this site is a protein structure within the cell membrane. Once a drug binds to and interacts with the receptor, a pharmacologic response is produced (Fig. 2.7). The degree to which a drug attaches to and binds with a receptor is called its *affinity.* The drug with the best "fit" and strongest affinity for the receptor will elicit the greatest response. A drug becomes bound to the receptor through the formation of chemical bonds between the receptor on the cell and the active site on the drug molecule. Drugs interact with receptors in different ways either to elicit or to block a physiologic response. Table 2.8 describes the different types of drug-receptor interaction.

Enzyme Interactions

Enzymes are the substances that catalyze nearly every biochemical reaction in a cell. Drugs can produce effects by interacting with these enzyme systems. For a drug to alter a physiologic response in this way, it may either inhibit (more common) or enhance (less common) the action of a specific enzyme. This process is called *selective interaction.* Drug-enzyme interaction occurs when the drug chemically binds to an enzyme molecule in such a way that it alters (inhibits or enhances) the enzyme's interaction with its normal target molecules in the body.

Nonselective Interactions

Drugs with nonspecific mechanisms of action do not interact with receptors or enzymes. Instead, their main targets are cell membranes and various cellular processes such as metabolic activities. These drugs can either physically interfere with or chemically alter cellular structures or processes. Some cancer drugs and antibiotics have this mechanism of action. By incorporating themselves into the normal metabolic process, they cause a defect in the final product or state. This defect may be an improperly formed cell wall that results in cell death through cell lysis, or it may be the lack of a necessary energy substrate, which leads to cell starvation and death.

PHARMACOTHERAPEUTICS

Before drug therapy is initiated, an end point or expected outcome of therapy needs to be established. This desired therapeutic outcome is patient-specific, established in collaboration with the patient, and if appropriate, determined with other members of the health care team. Outcomes need to be clearly defined and must be either measurable or observable by monitoring. Outcome goals must be realistic and prioritized so that drug therapy begins with interventions that are essential to the patient's well-being. Examples include curing a disease, eliminating or reducing a preexisting symptom, arresting or slowing a disease process, preventing a disease or other unwanted condition, or otherwise improving quality of life. These goals and outcomes are not the same as nursing goals and outcomes. See Chapter 1 for a more specific discussion of the nursing process.

Patient therapy assessment is the process by which a practitioner integrates his or her knowledge of medical and drug-related facts with information about a specific patient's medical and social history. Items to be considered in the assessment are drugs currently used (prescription, over-the-counter, herbal, and illicit or street drugs), pregnancy and breastfeeding status, and concurrent illnesses that could contraindicate initiation of a given medication. A **contraindication** for a medication is any patient condition, especially a disease state that makes the use of the given medication dangerous for the patient. Careful attention to this assessment process helps ensure an optimal therapeutic plan. The implementation of a treatment plan can involve several types and combinations of therapies. The type of therapy can be categorized as *acute, maintenance, supplemental* (or *replacement*), *palliative, supportive, prophylactic,* or *empiric.*

Acute Therapy

Acute therapy often involves more intensive drug treatment and is implemented in the acutely ill (those with rapid onset of illness) or the critically ill. It is often needed to sustain life or treat disease. Examples are the administration of vasopressors to maintain blood pressure, the use of volume expanders for a patient who is in shock, and intensive chemotherapy for a patient with newly diagnosed cancer.

Maintenance Therapy

Maintenance therapy does not eradicate preexisting problems the patient may have, but will prevent progression of a disease or condition. It is used for the treatment of chronic illnesses such as hypertension. In this case, maintenance therapy maintains the patient's blood pressure within given limits, which prevents certain end-organ damage. Another example of maintenance therapy is the use of oral contraceptives for birth control.

Supplemental Therapy

Supplemental (or replacement) therapy supplies the body with a substance needed to maintain normal function. This substance may be needed either because it cannot be made by the body or because it is produced in insufficient quantity. Examples are the administration of insulin to diabetic patients and of iron to patients with iron-deficiency anemia.

Palliative Therapy

The goal of palliative therapy is to make the patient as comfortable as possible. Palliative therapy focuses on providing patients with relief from the symptoms, pain, and stress of a serious illness. The goal is to improve quality of life for both the patient and the family. It is typically used in the end stages of an illness when attempts at curative therapy have failed; however, it can be provided along with curative treatment. An example is the use of high-dose opioid analgesics to relieve pain in the final stages of cancer.

Supportive Therapy

Supportive therapy maintains the integrity of body functions while the patient is recovering from illness or trauma. Examples are provision of fluids and electrolytes to prevent dehydration in a patient who is vomiting and has diarrhea, administration of fluids, volume expanders, or blood products to a patient who has lost blood during surgery.

Prophylactic Therapy and Empiric Therapy

Prophylactic therapy is drug therapy provided to *prevent* illness or other undesirable outcome during *planned* events. A common example is the use of preoperative antibiotic therapy for surgical procedures. The antibiotic is given before the incision is made, so that the antibiotic can kill any potential pathogens. Another example is the administration of disease-specific vaccines to individuals traveling to geographic areas where a given disease is known to be endemic.

Empiric therapy is based on clinical probabilities. It involves drug administration when a certain pathologic condition has a high likelihood of occurrence based on the patient's initial presenting symptoms. A common example is use of antibiotics active against the organism most commonly associated with a specific infection before the results of the culture and sensitivity reports are available.

Monitoring

Once the appropriate therapy has been implemented, the effectiveness of the therapy—that is, the clinical response of the patient to the treatment—must be evaluated. Evaluating the clinical response requires familiarity with both the drug's intended therapeutic action (beneficial effects) and its unintended possible **adverse effects** (predictable adverse drug reactions [ADRs]). Examples of monitoring include observing for the therapeutic effect of reduced blood pressure following administration of antihypertensive drugs and observing for the toxic effect of leukopenia after administering antineoplastic (cancer chemotherapy) drugs. Another example is performing a pain assessment after giving pain medication. It should be noted that this textbook highlights only the most common adverse effects of a given drug; however, the drug may have many other less commonly reported adverse effects. Consult comprehensive references or a pharmacist when there is uncertainty regarding adverse effects that a patient may be experiencing.

All drugs are potentially toxic and can have cumulative effects. Recognizing these toxic effects and knowing their manifestations are integral components of the monitoring process. A drug can accumulate when it is absorbed more quickly than it is eliminated or when it is administered before the previous dose has been metabolized or cleared from the body. Knowledge of the organs responsible for metabolizing and eliminating a drug combined with knowledge of how a particular drug is metabolized and excreted enables the nurse to anticipate problems and treat them appropriately if they occur.

Therapeutic Index

The ratio of a drug's toxic level to the level that provides therapeutic benefits is referred to as the drug's **therapeutic index**. The safety of a particular drug therapy is determined by this index. A low therapeutic index means that the difference between a therapeutically active dose and a toxic dose is small. A drug with a low therapeutic index has a greater likelihood than other drugs of causing an adverse reaction, and therefore requires closer monitoring. Examples of such drugs are warfarin and digoxin. In contrast, a drug with a high therapeutic index, such as amoxicillin, is rarely associated with overdose events.

Drug Concentration

All drugs reach a certain concentration in the blood. Drug concentrations can be an important tool for evaluating the clinical response to drug therapy. Certain drug levels are associated with therapeutic responses, whereas other drug levels are associated with toxic effects. Toxic drug levels are typically seen when the body's normal mechanisms for metabolizing and excreting drugs are compromised. This commonly occurs when liver and kidney functions are impaired or when the liver or kidneys are immature (as in neonates). Dosage adjustments should be made in these patients to appropriately accommodate their impaired metabolism and excretion.

Patient's Condition

Another patient-specific factor to be considered is the patient's concurrent diseases or other medical conditions. A patient's response to a drug may vary greatly, depending on physiologic and psychological demands. Disease of any kind, infection, cardiovascular function, and GI function can alter a patient's

therapeutic response. Stress, depression, and anxiety can also be important psychological factors affecting response.

Tolerance and Dependence

To provide optimal drug therapy, it is important to understand and differentiate between tolerance and dependence. **Tolerance** is a decreasing response to repeated drug doses. **Dependence** is a physiologic or psychological need for a drug. *Physical dependence* is the physiologic need for a drug to avoid physical withdrawal symptoms (e.g., tachycardia in an opioid-addicted patient). *Psychological dependence* is also known as *addiction* and is the obsessive desire for the euphoric effects of a drug. Addiction typically involves the recreational use of various drugs such as benzodiazepines, opioids, and amphetamines. See Chapter 17 for further discussion of dependence and addiction.

Interactions

Drugs may interact with other drugs, with foods, or with agents administered as part of laboratory tests. Knowledge of drug interactions is vital for the appropriate monitoring of drug therapy. The more drugs a patient receives, the more likely that a drug interaction will occur. This is especially true in older adults, who typically have an increased sensitivity to drug effects and are receiving several medications. In addition, over-the-counter medications and herbal therapies and food can interact significantly with prescribed medications. See Table 2.9 for common food and drug interactions.

Alteration of the action of one drug by another is referred to as **drug interaction**. A drug interaction can either increase or decrease the actions of one or both of the involved drugs. Drug interactions can be either beneficial or harmful. Numerous drug interactions can occur and have been reported. Only those drug interactions that are considered to be significant with a good probability of occurring and/or those that require dosage/therapy adjustment are discussed in this textbook. An authoritative resource may be used as a means of exploring all possible drug interactions.

Concurrently administered drugs may interact with each other and alter the pharmacokinetics of one another during any of the four phases of pharmacokinetics: absorption, distribution, metabolism, or excretion. Table 2.10 provides examples of drug interactions during each of these phases. Most commonly, drug interactions occur when there is competition between two drugs for metabolizing enzymes, such as the cytochrome P-450 enzymes listed in Table 2.5. As a result, the speed of metabolism of one or both drugs may be enhanced or reduced. This change in metabolism of one or both drugs can lead to subtherapeutic or toxic drug actions.

Many terms are used to categorize drug interactions. When two drugs with similar actions are given together, they can have **additive effects** (1 + 1 = 2). Often drugs are used together for their additive effects so that smaller doses of each drug can be given.

Synergistic effects occur when two drugs administered together interact in such a way that their combined effects are greater than the sum of the effects for each drug given alone (1 + 1 = greater than 2).

Antagonistic effects are said to occur when the combination of two drugs results in drug effects that are less than the sum of the effects for each drug given separately (1 + 1 = less than 2). **Incompatibility** is a term most commonly used to describe parenteral drugs. Drug incompatibility occurs when two parenteral drugs or solutions are mixed together, and the result

TABLE 2.9 Common Food and Drug Interactions

Food	Drug (Category)	Result
Leafy green vegetables	warfarin (anticoagulant)	Decreased anticoagulant effect from warfarin
Dairy products	tetracycline, levofloxacin, ciprofloxacin, moxifloxacin (antibiotics)	Chemical binding of the drug leading to decreased effect and treatment failures
Grapefruit juice	amiodarone (antidysrhythmic), buspirone (antianxiety), carbamazepine (antiseizure), cyclosporine, tacrolimus (immunosuppressants), felodipine, nifedipine, nimodipine, nisoldipine (calcium channel blockers), simvastatin, atorvastatin (anticholesterol drugs)	Decreased metabolism of drugs and increased effects
Aged cheese, wine	Monoamine oxidase inhibitors	Hypertensive crisis

TABLE 2.10 Examples of Drug Interactions and Their Effects on Pharmacokinetics

Pharmacokinetic Phase	Drug Combination	Mechanism	Result
Absorption	antacid with levofloxacin	Antacids bind to the levofloxacin, preventing adequate absorption.	Decreased effectiveness of levofloxacin, resulting from decreased blood levels (harmful)
Distribution	warfarin with amiodarone	Both drugs compete for protein-binding sites.	Higher levels of free (unbound) warfarin and amiodarone, which increases actions of both drugs (harmful)
Metabolism	erythromycin with cyclosporine	Both drugs compete for the same hepatic enzymes.	Decreased metabolism of cyclosporine, possibly resulting in toxic levels of cyclosporine (harmful)
Excretion	amoxicillin with probenecid	Inhibits the secretion of amoxicillin into the kidneys.	Elevation and prolongation of plasma levels of amoxicillin (can be beneficial)

is a chemical deterioration of one or both of the drugs or the formation of a physical precipitate. The combination of two such drugs usually produces a precipitate, haziness, or color change in the solution. Before administering any intravenous medication, the nurse must always inspect the bag for precipitate. If the solution appears cloudy or if visible flecks are seen, the bag must be discarded.

Adverse Drug Events

The recognition of the potential hazards and detrimental effects of medication use is a topic that continues to receive much attention. This focus has contributed to an increasing body of knowledge regarding this topic, as well as the development of new terminology.

Adverse drug event (ADE) is a broad term for any undesirable occurrence involving medications. A similarly broad term also seen in the literature is *drug misadventure.* Patient outcomes associated with ADEs vary from no effects to mild discomfort to life-threatening complications, permanent disability, disfigurement, or death. ADEs can be preventable (see the discussion of medication errors in Chapter 5) or nonpreventable. Fortunately, many ADEs result in no measurable patient harm. ADEs can be both external and internal. The most common causes of ADEs *external* to the patient are errors by caregivers (both professional and nonprofessional) or malfunctioning of equipment (e.g., intravenous infusion pumps). An ADE can be internal, or *patient induced*, such as when a patient fails to take medication as prescribed or drinks alcoholic beverages that he or she was advised not to consume while taking a given medication. An impending ADE that is noticed before it actually occurs is considered a *potential* ADE (and appropriate steps must be taken to avoid such a "near miss" in the future). A less common situation, but one still worth mentioning, is an *adverse drug withdrawal event.* This is an adverse outcome associated with discontinuation of drug therapy, such as hypertension caused by abruptly discontinuing blood pressure medication or return of infection caused by stopping antibiotic therapy too soon.

The two most common broad categories of ADE are medication errors and ADRs. A **medication error** is a preventable situation in which there is a compromise in the "Six Rights" of medication use: *right drug*, *right dose*, *right time*, *right route*, *right patient*, and *right documentation*. Medication errors are more common than ADRs. Medication errors occur during the *prescribing, dispensing, administering,* or *monitoring* of drug therapy. These four phases are collectively known as the **medication use process**. See Chapter 5 for further discussion of medication errors.

An **adverse drug reaction** (ADR) is any reaction to a drug that is unexpected and undesirable and occurs at therapeutic drug dosages. ADRs may or may not be caused by medication errors. ADRs may result in hospital admission, prolongation of hospital stay, change in drug therapy, initiation of supportive treatment, or complication of a patient's disease state. ADRs are caused by processes inside the patient's body. They may or may not be preventable, depending on the situation. Mild ADRs usually do not require a change in the patient's drug therapy or other interventions. More severe ADRs, however, are likely to require changes to a patient's drug regimen. Severe ADRs can be permanently or significantly disabling, life threatening, or fatal. They may require or prolong hospitalization, lead to organ damage (e.g., to the liver, kidneys, bone marrow, skin), cause congenital anomalies, or require specific interventions to prevent permanent impairment or tissue damage.

ADRs that are specific to particular drug groups are discussed in the corresponding drug chapters in this book. Four general categories are discussed here: pharmacologic reaction, hypersensitivity (allergic) reaction, idiosyncratic reaction, and drug interaction.

A pharmacologic reaction is an extension of the drug's normal effects in the body. For example, a drug that is used to lower blood pressure in a patient causes a pharmacologic ADR when it lowers the blood pressure to the point at which the patient becomes unconscious.

Pharmacologic reactions that result in adverse effects are predictable, well known, and result in minor or no changes in patient management. They are related to dose and usually resolve upon discontinuation of drug therapy.

An **allergic reaction** (also known as a *hypersensitivity reaction*) involves the patient's immune system. Immune system proteins known as *immunoglobulins* (see Chapters 47 and 48) recognize the drug molecule, its **metabolite(s)**, or another ingredient in a drug formulation as a dangerous foreign substance. At this point, an *immune response* may occur in which immunoglobulin proteins bind to the drug substance in an attempt to neutralize the drug. Various chemical mediators, such as *histamine*, as well as *cytokines* and other inflammatory substances are released during this process. This response can result in reactions ranging from mild reactions such as skin erythema or mild rash to severe, even life-threatening reactions such as constriction of bronchial airways and tachycardia.

It can be assumed throughout this textbook that the use of any drug is contraindicated if the patient has a known allergy to that specific drug product. Allergy information may be reported by the patient as part of his or her history, or may be observed by health care personnel during a patient encounter. In either case, every effort must be made to document as fully as possible the name of the drug product and the degree and details of the adverse reaction that occurred—for example, "Penicillin; skin rash, pruritus" or "Penicillin; urticaria and anaphylactic shock requiring emergency intervention."

In more extreme cases of disease or injury (e.g., cancer, snakebite), it may be reasonable to administer a given drug *in spite of* a reported allergic or other adverse reaction. In such cases, the patient will likely be premedicated with additional medications as an attempt to control any adverse reactions that may occur.

An **idiosyncratic reaction** is not the result of a known pharmacologic property of a drug or of a patient allergy, but instead occurs unexpectedly in a particular patient. Such a reaction is a genetically determined abnormal response to normal dosages of a drug. The study of such traits, which are solely revealed by drug administration, is called **pharmacogenomics** (see Chapter

8). Idiosyncratic drug reactions are usually caused by a deficiency or excess of drug-metabolizing enzymes. An example is **glucose-6-phosphate dehydrogenase (G6PD) deficiency** (see the Patient-Centered Care: Cultural Implications box).

The final type of ADR is due to drug interactions. A drug interaction occurs when the presence of two (or more) drugs in the body produces an unwanted effect. This unwanted effect can result when one drug either enhances or reduces the effects of another drug. Some drug interactions are intentional and beneficial (see Table 2.10). However, most clinically significant drug interactions are harmful. Drug interactions specific to particular drugs are discussed in detail in the chapters dealing with those drugs.

QSEN

PATIENT-CENTERED CARE: CULTURAL IMPLICATIONS

Glucose-6-Phosphate Dehydrogenase Deficiency

Glucose-6-phosphate dehydrogenase (G6PD) is an enzyme found in abundant amounts in the tissues of most individuals. It reduces the risk for hemolysis of red blood cells when they are exposed to oxidizing drugs such as aspirin. The deficit is sex-linked with the structure of G-6-PD and is carried on the X chromosome. It is transmitted from mother (a healthy carrier) to a son (or daughter who would then also be a healthy carrier). This abnormality is most prevalent in Africa, affecting almost 20% of the population, but is also found in the Mediterranean (4% to 30%) and in Southeast Asia. Approximately 14% of Sardinians and more than 50% of the Kurdish Jewish population also show G6PD deficiencies. When exposed to drugs such as sulfonamides, antimalarials, and aspirin, patients with this deficiency may suffer life-threatening hemolysis of the red blood cells, whereas individuals with adequate quantities of the enzyme have no problems in taking these drugs.

Other Drug Effects

Other drug-related effects that must be considered during drug therapy are teratogenic, mutagenic, and carcinogenic effects. These can result in devastating patient outcomes and may be prevented in many instances by appropriate monitoring.

Teratogenic effects of drugs or other chemicals result in structural defects in the fetus. Compounds that produce such effects are called *teratogens.* Prenatal development involves a delicate program of interrelated embryologic events. Any significant disruption in this process of *embryogenesis* can have a teratogenic effect. Drugs that are capable of crossing the placenta can cause **drug-induced teratogenesis**. Drugs administered during pregnancy can produce different types of congenital anomalies. The period during which the fetus is most vulnerable to teratogenic effects begins with the third week of development and usually ends after the third month. Chapter 3 describes the FDA safety classification for drugs used by pregnant women.

Mutagenic effects are permanent changes in the genetic composition of living organisms and consist of alterations in chromosome structure, the number of chromosomes, or the genetic code of the deoxyribonucleic acid (DNA) molecule. Drugs that are capable of inducing mutations are called *mutagens.* Radiation, viruses, chemicals (e.g., industrial chemicals such as benzene), and drugs can all act as mutagenic agents in humans.

BOX 2.3 Exogenous Causes of Cancer

Dietary customs
Drug abuse
Carcinogenic drugs
Workplace chemicals
Radiation
Environmental pollution
Food-processing procedures
Food-production procedures
Oncogenic viruses
Smoking

Drugs that affect genetic processes are active primarily during cell reproduction (mitosis).

Carcinogenic effects are the cancer-causing effects of drugs, other chemicals, radiation, and viruses. Agents that produce such effects are called *carcinogens.* Some exogenous causes of cancer are listed in Box 2.3.

PHARMACOGNOSY

The source of all early drugs was nature, and the study of these natural drug sources (plants and animals) is called *pharmacognosy*. Although many drugs in current use are synthetically derived, most were first isolated in nature. The four main sources for drugs are plants, animals, minerals, and laboratory synthesis. Plants provide many weak acids and weak bases (alkaloids) that are useful and potent drugs. Animals are the source of many hormone drugs. Conjugated estrogens are derived from the urine of pregnant mares—hence the drug trade name Premarin. *Equine* is the term used for any horse-derived drug. Insulin comes from two sources: pigs (porcine) and humans. Human insulin is now far more commonly used than animal insulins, thanks to the use of recombinant DNA techniques. Heparin is another commonly used drug that is derived from pigs (porcine heparin). Some common mineral sources of currently used drugs are salicylic acid, aluminum hydroxide, and sodium chloride.

PHARMACOECONOMICS

Pharmacoeconomics is the study of the economic factors influencing the cost of drug therapy. One example is performing a *cost-benefit analysis* of one antibiotic versus another when competing drugs are considered for inclusion in a hospital formulary. Such studies typically examine treatment outcomes data (e.g., how many patients recovered and how soon) in relation to the comparative total costs of treatment with the drugs in question.

TOXICOLOGY

The study of poisons and unwanted responses to both drugs and other chemicals is known as *toxicology.* Toxicology is the science of the adverse effects of chemicals on living organisms.

Clinical toxicology deals specifically with the care of the poisoned patient. Poisoning can result from a variety of causes, ranging from drug overdose to ingestion of household cleaning agents to snakebite. Poison control centers are health care institutions equipped with sufficient personnel and information resources to recommend appropriate treatment for the poisoned patient.

Effective treatment of the poisoned patient is based on a system of priorities, the first of which is to preserve the patient's vital functions by maintaining the airway, ventilation, and circulation. The second priority is to prevent absorption of the toxic substance and/or speed its elimination from the body using one or more of the variety of clinical methods available. Several common poisons and their specific antidotes are listed in Table 2.11.

TABLE 2.11 Common Poisons and Their Antidotes

Substance	Antidote
Acetaminophen	Acetylcysteine
Organophosphates (e.g., insecticides)	Atropine
Tricyclic antidepressants, quinidine	Sodium bicarbonate
Calcium channel blockers	Intravenous calcium
Iron salts	Deferoxamine
Digoxin and other cardiac glycosides	Digoxin antibodies
Ethylene glycol (e.g., automotive antifreeze solution), methanol	Ethanol (same as alcohol used for drinking), given intravenously
Benzodiazepines	Flumazenil
Beta blockers	Glucagon
Opiates, opioid drugs	Naloxone
Carbon monoxide (by inhalation)	Oxygen (at high concentration), known as bariatric therapy

These and other antidotes are discussed throughout this textbook where applicable.

SUMMARY

A thorough understanding of the pharmacologic principles of pharmacokinetics, pharmacodynamics, pharmacotherapeutics, and toxicology is essential in drug therapy and to safe, quality nursing practice. Application of pharmacologic principles enables the nurse to provide safe and effective drug therapy while always acting on behalf of the patient and respecting the patient's rights. Nursing considerations associated with various routes of drug administration are summarized in Table 2.3.

KEY POINTS

- The following definitions related to drug therapy are important to remember: *pharmacology*—the study or science of drugs; *pharmacokinetics*—the study of drug distribution among various body compartments after a drug has entered the body, including the phases of absorption, distribution, metabolism, and excretion; *pharmaceutics*—the science of dosage form design.
- The nurse's role in drug therapy and the nursing process is more than just the memorization of the names of drugs, their uses, and associated interventions. It involves a thorough comprehension of all aspects of pharmaceutics, pharmacokinetics, and pharmacodynamics and the sound application of this drug knowledge to a variety of clinical situations. See Chapter 1 for further discussion of drug therapy as it relates to the nursing process.
- Drug actions are related to the pharmacologic, pharmaceutical, pharmacokinetic, and pharmacodynamic properties of a given medication, and each of these has a specific influence on the overall effects produced by the drug in a patient.
- Selection of the route of administration is based on patient variables and the specific characteristics of a drug.
- Nursing considerations vary depending on the drug as well as the route of administration.

CRITICAL THINKING EXERCISES

1. Mr. L. is admitted to the trauma unit with multisystem injuries from an automobile accident. He arrived at the unit with multiple abnormal findings, including shock from blood loss, decreased cardiac output, and urinary output of less than 30 mL/h. Which route of administration would you expect to be the best choice for this patient? Explain your answer.
2. You are administering medications to a patient who had an enteral tube inserted 2 days earlier for continuous feedings. As you review the medication list, you note that one drug is an enteric-coated tablet ordered to be given twice a day. What is the best action regarding giving this drug to this patient?

For answers, see *http://evolve.elsevier.com/Lilley*.

REVIEW QUESTIONS

1. An elderly woman took a prescription medicine to help her to sleep; however, she felt restless all night and did not sleep at all. The nurse recognizes that this woman has experienced which type of reaction or effect?
   - **a.** Allergic reaction
   - **b.** Idiosyncratic reaction
   - **c.** Mutagenic effect
   - **d.** Synergistic effect
2. The nurse is caring for a patient with cirrhosis or hepatitis, and recognizes that abnormalities in which phase of pharmacokinetics may occur in this patient?
   - **a.** Absorption
   - **b.** Distribution
   - **c.** Metabolism
   - **d.** Excretion
3. A patient who has hypertension is now taking a daily beta blocker. Which term best describes this type of therapy?
   - **a.** Palliative therapy
   - **b.** Maintenance therapy
   - **c.** Supportive therapy
   - **d.** Supplemental therapy
4. The nurse is giving medications to a patient in heart failure. The intravenous route is chosen instead of the intramuscular route. What physical function does the nurse recognize as the most influential when deciding to use the intravenous route of drug administration?
   - **a.** Altered biliary function
   - **b.** Increased glomerular filtration
   - **c.** Reduced liver metabolism
   - **d.** Diminished circulation
5. A patient has just received a prescription for an enteric-coated stool softener. When teaching the patient, the nurse should include which statements? *(Select all that apply.)*
   - **a.** "Take the tablet with 2 to 3 ounces of orange juice."
   - **b.** "Be sure to drink 6 to 8 ounces of water with this tablet."
   - **c.** "Avoid taking all other medications with any enteric-coated tablet."
   - **d.** "Crush the tablet before swallowing if you have problems with swallowing."
   - **e.** "Be sure to swallow the tablet whole without chewing it."
6. Each statement describes a phase of pharmacokinetics. Put the statements in order, with 1 indicating the phase that occurs first and 4 indicating the phase that occurs last.
   - **a.** Enzymes in the liver transform the drug into an inactive metabolite.
   - **b.** Drug metabolites are secreted through passive glomerular filtration into the renal tubules.
   - **c.** A drug binds to the plasma protein albumin and circulates through the body.
   - **d.** A drug moves from the intestinal lumen into the mesenteric blood system.
7. A drug that delivers 300 mg has a half-life of 4 hours. How many milligrams of drug will remain in the body after 1 half-life?
8. The nurse is reviewing the various forms of topical medications. Which of these are considered topical medications? *(Select all that apply.)*
   - **a.** Rectal ointment for hemorrhoids
   - **b.** Eye drops for inflammation
   - **c.** Sublingual tablet for chest pain
   - **d.** Inhaled medication for asthma
   - **e.** Intradermal injection for tuberculosis testing

For answers, see p. 908.

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Lifespan Considerations

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OBJECTIVES

When you reach the end of this chapter, you will be able to do the following:

1. Discuss the influences of the patient's age on the effects of drugs and drug responses.
2. Identify drug-related concerns during pregnancy and lactation and provide an explanation of the physiologic basis for these concerns.
3. Summarize the impact of age-related physiologic changes on the pharmacokinetic aspects of drug therapy.
4. Explain how these age-related changes in pharmacokinetics influence various drug effects and drug responses across the lifespan.
5. Provide several examples of how age affects the absorption, distribution, metabolism, and excretion of drugs.
6. Calculate a drug dose for a pediatric patient using the various formulas available.
7. Develop a nursing care plan for drug therapy and the nursing process as related to the various lifespan considerations.

KEY TERMS

Active transport The active (energy-requiring) movement of a substance between different tissues via pumping mechanisms contained within cell membranes.

Diffusion The passive movement of a substance (e.g., a drug) between different tissues from areas of higher concentration to areas of lower concentration. (Compare with active transport.)

Neonate Pertaining to a person younger than 1 month of age; newborn infant.

Older adult Pertaining to a person who is 65 years of age or older. (Note: Some sources consider "older adult" to be 55 years of age or older.)

Pediatric Pertaining to a person who is 12 years of age or younger.

Polypharmacy The use of many different drugs concurrently in treating a patient, who often has several health problems.

OVERVIEW

From the beginning to the end of life, the human body changes in many ways. These changes have dramatic effects on the four phases of pharmacokinetics—drug absorption, distribution, metabolism, and excretion. Newborn, pediatric, and older adult patients each have special needs. Drug therapy at both spectrums of life is more likely to result in adverse effects and toxicity. Fortunately, response to drug therapy changes in a predictable manner in younger and older patients. Knowing the effect that age has on the pharmacokinetic characteristics of drugs helps predict these changes.

Most experience with drugs and pharmacology has been gained from the adult population. The majority of drug studies have focused on the population between 13 and 65 years of age. It has been estimated that 75% of currently approved drugs lack US Food and Drug Administration (FDA) approval for pediatric use and therefore lack specific dosage guidelines for **neonates** and children. Fortunately, many excellent pediatric drug dosage books are available. Most drugs are effective in younger and older patients, but drugs behave very differently in patients at the opposite ends of the age spectrum. It is vitally important from the standpoint of safe and effective drug administration to understand what these differences are and how to adjust for them.

DRUG THERAPY DURING PREGNANCY

A fetus is exposed to many of the same substances as the mother, including any drugs that she takes—prescription, nonprescription, or street drugs. The first trimester of pregnancy is generally the period of greatest danger of drug-induced developmental defects.

Transfer of both drugs and nutrients to the fetus occurs primarily by **diffusion** across the placenta, although not all drugs cross the placenta. Diffusion is a passive process based on differences in concentration between different tissues. **Active transport** requires the expenditure of energy and often involves some sort of cell-surface protein pump. The factors that contribute

TABLE 3.1 Pregnancy, Lactation, and Reproduction

Category	Description
Category A	Studies indicate no risk to the human fetus.
Category B	Studies indicate no risk to the animal fetus; information for humans is not available.
Category C	Adverse effects reported in the animal fetus; information for humans is not available.
Category D	Possible fetal risk in humans has been reported; however, in selected cases consideration of the potential benefit versus risk may warrant use of these drugs in pregnant women.
Category X	Fetal abnormalities have been reported, and positive evidence of fetal risk in humans is available from animal and/or human studies. These drugs are not to be used in pregnant women.
New FDA rules, effective June 2015, for newly approved drugs: Drugs currently on the market are allowed to be phased in. This information will replace the A to X categories. Not all drugs have phased in the new information and this textbook will continue to use the letters. The student is referred to individual drug package inserts for the newest information.	Three detailed subsections on "Pregnancy," "Lactation," and "Females and Males of Reproductive Potential"

FDA, US Food and Drug Administration.

to the safety or potential harm of drug therapy during pregnancy can be broadly broken down into three areas: drug properties, fetal gestational age, and maternal factors.

Drug properties that impact drug transfer to the fetus include the drug's chemistry, dosage, and concurrently administered drugs. Examples of relevant chemical properties include molecular weight, protein binding, lipid solubility, and chemical structure. Important drug dosage variables include dose and duration of therapy.

Fetal gestational age is an important factor in determining the potential for harmful drug effects to the fetus. The fetus is at greatest risk for drug-induced developmental defects during the first trimester of pregnancy. During this period, the fetus undergoes rapid cell proliferation. Skeleton, muscles, limbs, and visceral organs are developing at their most rapid rate. Self-treatment of minor illness is strongly discouraged anytime during pregnancy, but especially during the first trimester. Gestational age is also important in determining when a drug can most easily cross the placenta to the fetus. During the last trimester, the greatest percentage of maternally absorbed drug gets to the fetus.

Maternal factors also play a role in determining drug effects on the fetus. Any change in the mother's physiology can affect the amount of drug to which the fetus may be exposed. Maternal kidney and liver function affect drug metabolism and excretion. Impairment in either kidney or liver function may result in higher drug levels and/or prolonged drug exposure, and thus increased fetal transfer. Maternal genotype may also affect how certain drugs are metabolized (pharmacogenomics). The lack of certain enzyme systems may result in adverse drug effects to the fetus when the mother is exposed to a drug that is normally metabolized by the given enzyme.

Although exposure of the fetus to drugs is most detrimental during the first trimester, drug transfer to the fetus is more likely during the last trimester. This is the result of enhanced blood flow to the fetus, increased fetal surface area, and increased amount of free drug in the mother's circulation.

It is important to use drugs judiciously during pregnancy; however, there are certain situations that require their use. Without drug therapy, maternal conditions such as hypertension, epilepsy, diabetes, and infection could seriously endanger both the mother and the fetus, and the potential for harm far outweighs the risks of appropriate drug therapy.

The FDA classifies drugs according to their safety for use during pregnancy. This system of drug classification is based primarily on animal studies and limited human studies. This is due in part to ethical dilemmas surrounding the study of potential adverse effects on fetuses. Traditionally, the most widely used index of potential fetal risk of drugs has been the FDA's pregnancy safety category system. The five safety categories are described in Table 3.1. The FDA is requiring new pregnancy labeling to be included in their respective package inserts for all newly approved drugs and allowing currently marketed drugs to be phased in gradually. It is anticipated that these new changes will not be fully in effect for several years. The student will likely encounter both the old categories (A to X) as well as the new rules throughout his or her career. The new rule requires the use of three subsections in the prescribing information titled "Pregnancy," "Lactation," and "Females and Males of Reproductive Potential." These subsections will include a summary of the risks of using a drug during pregnancy and breastfeeding, as well as data supporting the summary and information to help health care providers make prescribing decisions. The "Pregnancy" section will include information on dosing and potential risks to the developing fetus. The "Lactation" section will provide information regarding breastfeeding, such as the amount of drug in breast milk and the potential effect on the child. The "Females and Males of Reproductive Potential" section will include information about contraception, pregnancy testing, and infertility. Because not all drugs on the market have the new information, this book will continue to use the letter categories, and the reader is referred to individual drug package inserts for the newest information.

DRUG THERAPY DURING BREASTFEEDING

Breastfed infants are at risk for exposure to drugs consumed by the mother. A wide variety of drugs easily cross from the mother's circulation into the breast milk and subsequently to the breastfeeding infant. Drug properties similar to those discussed in

the previous section influence the exposure of infants to drugs via breastfeeding. The primary drug characteristics that increase the likelihood of drug transfer via breastfeeding include fat solubility, low molecular weight, and high concentration.

Fortunately, breast milk is not the primary route for maternal drug excretion. Drug levels in breast milk are usually lower than those in the maternal circulation. The actual amount of exposure depends largely on the volume of milk consumed. The ultimate decision as to whether a breastfeeding mother takes a particular drug depends on the risk/benefit ratio. The risks of drug transfer to the infant in relation to the benefits of continuing breastfeeding and the therapeutic benefits to the mother must be considered on a case-by-case basis.

CONSIDERATIONS FOR NEONATAL AND PEDIATRIC PATIENTS

Pediatric patients are defined based on age. A *neonate* is defined as between birth and 1 month of age. An *infant* is between 1 and 12 months of age, and a *child* is between 1 and 12 years of age. The age ranges that correspond to the various terms applied to pediatric patients are shown in Table 3.2.

Physiology and Pharmacokinetics

Pediatric patients handle drugs much differently than adult patients, based primarily on the immaturity of vital organs. In both neonates and older pediatric patients, anatomic structures and physiologic systems and functions are still in the process of developing. The Patient-Centered Care: Lifespan Considerations for the Pediatric Patient box on this page lists those physiologic factors that alter the pharmacokinetic properties of drugs in young patients.

Pharmacodynamics

Drug actions (or pharmacodynamics) are altered in young patients, and the maturity of various organs determines how drugs act in the body. Certain drugs may be more toxic, whereas others may be less toxic. The sensitivity of receptor sites may also vary with age; thus higher or lower dosages may be required depending on the drug. In addition, rapidly developing tissues may be more sensitive to certain drugs, and therefore smaller dosages may be required. Certain drugs are contraindicated during the growth years. For instance, tetracycline may permanently discolor a young person's teeth; corticosteroids may suppress growth when given systemically (but not when delivered via asthma inhalers, for example); and quinolone antibiotics may damage cartilage.

TABLE 3.2 Classification of Young Patients

Age Range	Classification
Younger than 38 weeks' gestation	Premature or preterm infant
Younger than 1 month	Neonate or newborn infant
1 month up to 1 year	Infant
1 year up to 12 years	Child

NOTE: The meaning of the term *pediatric* may vary with the individual drug and clinical situation. Often the maximum age for a pediatric patient may be identified as 16 years of age. Consult the manufacturer's guidelines for specific dosing information.

PATIENT-CENTERED CARE: LIFESPAN CONSIDERATIONS FOR THE PEDIATRIC PATIENT

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Pharmacokinetic Changes in the Neonate and Pediatric Patient

Absorption
- Gastric pH is less acidic because acid-producing cells in the stomach are immature until approximately 1 to 2 years of age.
- Gastric emptying is slowed because of slow or irregular peristalsis.
- First-pass elimination by the liver is reduced because of the immaturity of the liver and reduced levels of microsomal enzymes.
- Intramuscular absorption is faster and irregular.

Distribution
- Total body water is 70% to 80% in full-term infants, 85% in premature newborns, and 64% in children 1 to 12 years of age.
- Fat content is lower in young patients because of greater total body water.
- Protein binding is decreased because of decreased production of protein by the immature liver.
- More drugs enter the brain because of an immature blood-brain barrier.

Metabolism
- Levels of microsomal enzymes are decreased because the immature liver has not yet started producing enough.
- Older children may have increased metabolism and require higher dosages once hepatic enzymes are produced.
- Many variables affect metabolism in premature infants, infants, and children, including the status of liver enzyme production, genetic differences, and substances to which the mother was exposed during pregnancy.

Excretion
- Glomerular filtration rate and tubular secretion and resorption are all decreased in young patients because of kidney immaturity.
- Perfusion to the kidneys may be decreased, which results in reduced renal function, concentrating ability, and excretion of drugs.

Dosage Calculations for Pediatric Patients

Most drugs have not been sufficiently investigated to ensure their safety and effectiveness in children. In spite of this, there are numerous excellent pediatric dosage references. Because pediatric patients (especially premature infants and neonates) have small bodies and immature organs, they are very susceptible to drug interactions, toxicity, and unusual drug responses. Pediatric patients require different dosage calculations than do adults. Characteristics of pediatric patients that have a significant effect on dosage include the following:

- Skin is thinner and more permeable.
- Stomach lacks acid to kill bacteria.
- Lungs have weaker mucous barriers.
- Body temperature is less well regulated, and dehydration occurs easily.
- Liver and kidneys are immature, and therefore drug metabolism and excretion are impaired.

Many formulas for pediatric dosage calculation have been used throughout the years. Calculating the dosage according to the body weight is the most commonly used method today. Most