EDITION
19

Clayton's Basic Pharmacology for Nurses

Willihnganz Gurevitz Clayton

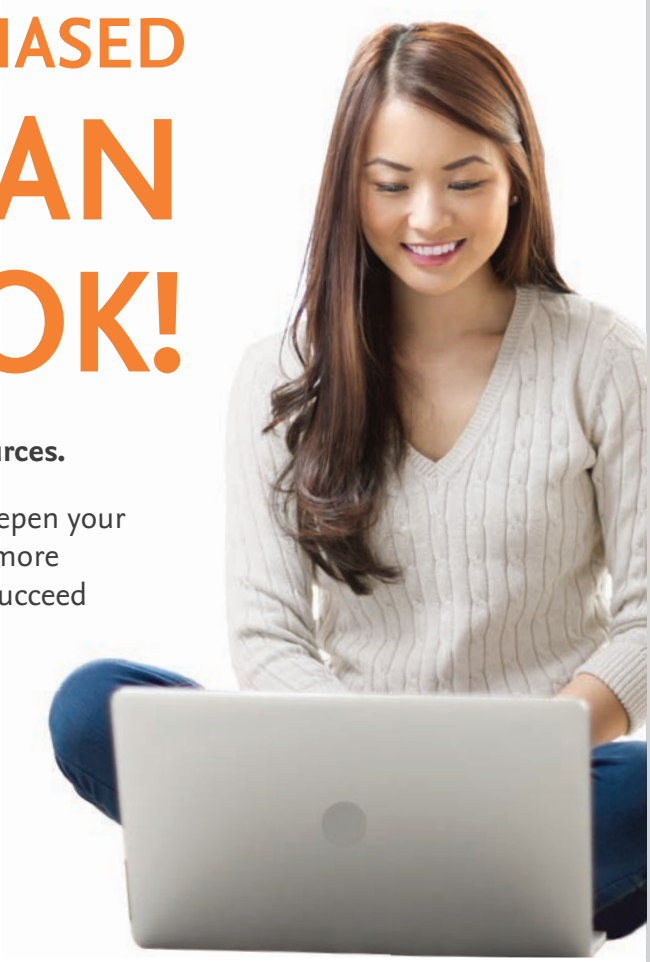
ELSEVIER

Evolve®

Student Resources on Evolve
Access Code Inside

Evolve®

YOU'VE JUST PURCHASED MORE THAN A TEXTBOOK!



Enhance your learning with Evolve Student Resources.

These online study tools and exercises can help deepen your understanding of textbook content so you can be more prepared for class, perform better on exams, and succeed in your course.

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

http://evolve.elsevier.com/Willihnganz/basic/

If your school uses its own Learning Management System, your resources may be delivered on that platform. Consult with your instructor.

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

Place Sticker Here

REGISTER TODAY!

ELSEVIER

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

2019v1.0

Clayton's Basic Pharmacology for Nurses

This page intentionally left blank

EDITION
19

Clayton's Basic Pharmacology for Nurses

Michelle J. Willihnganz, MS, RN, CNE
RCTC Nursing Instructor
Rochester Community and Technical College
Rochester, Minnesota

Samuel L. Gurevitz, PharmD
Associate Professor
College of Pharmacy and Health Sciences
Butler University
Indianapolis, Indiana

Bruce D. Clayton, BS Pharm, PharmD, RPh
Professor Emeritus of Pharmacy Practice
College of Pharmacy and Health Sciences
Butler University
Indianapolis, Indiana

ELSEVIER

ELSEVIER
3251 Riverport Lane
St. Louis, Missouri 63043

CLAYTON'S BASIC PHARMACOLOGY FOR NURSES, NINETEENTH EDITION ISBN: 978-0-323-79630-9

Library of Congress Control Number: 2021939099

Content Strategist: Brandi Graham
Director, Content Development: Laurie Gower
Senior Content Development Specialist: Rebecca Leenhouts
Publishing Services Manager: Deepthi Unni
Project Manager: Janish Ashwin Paul
Design Direction: Renee Duenow

Printed in India

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

To Kevin, the love of my life,
and to my wonderful daughters Katie and Jennifer,
who always stand beside me.

—MJW

To my wonderful wife Eileen
and to our daughter Maire.

—SLG

To Francine,
for her unfailing support and encouragement,
and to
Sarah, Nathaniel, Evelyn, and Grace
and
Beth, Clayton, and Arden,
the lights of our lives!

—BDC

Reviewers and Ancillary Contributors

REVIEWERS

Alice M. Hupp, BS, RN
Lead Instructor
Vocational Nursing
North Central Texas College
Gainesville, Texas

Ashley R. Williams, MSN, RN, CEN
Assistant Professor of Nursing
Capito Department of Nursing
University of Charleston
Charleston, West Virginia
Cabell Huntington Hospital
Huntington, West Virginia

Heather Clark, DNP, RN
Director
Penn State Practical Nursing Program
Penn State Lehigh Valley
Center Valley, Pennsylvania

Darla K. Shar, MSN, RN
Associate Director
Practical Nursing Education
Hannah E. Mullins School of Practical Nursing
Salem, Ohio

Joanna Cain, BSN, BA, RN
President & Founder
Global Academic Consultants
Boulder, Colorado

Lorraine Kelley, RN
Faculty
Department of Nursing and Emergency Medical Services
Pensacola State College
Pensacola, Florida

Molly M. Showalter, MSN Ed., RN
Interim Vocational Nursing Program Director
Department of Health Professions
Texas Southmost College
Brownsville, Texas

Odelia Garcia, MS, MSN, BSN, RN
Vocational Nursing Program Instructor
Nursing
Texas State Technical College
Harlingen, Texas

Grace Frankel BSc. Pharm, PharmD, BCPS
Clinical Pharmacist
Bethesda Regional Health Centre/Southern Health
Steinbach, Manitoba, Canada

James J Mizner Jr, MBA, BS, RPh
Panacea Solutions Consulting-Principal
Reston, VA

ANCILLARY CONTRIBUTOR

Laura Bevlock Kanavy, MSN, BSN, RN
Director, Practical Nursing Program
Career Technology Center of Lackawanna County
Scranton, Pennsylvania
Test Bank, NCLEX Review Questions

LPN/LVN Advisory Board

Preface

The 19th edition of *Clayton's Basic Pharmacology for Nurses*, in the tradition of the book's standards first established in 1957, advocates the administration of medication with safety and precision while focusing on medication safety through medication monitoring and patient education. In the practice setting, the nurse not only must demonstrate knowledge of the underlying disease process but also must be able to perform an accurate assessment. The nurse must also plan and implement care in a manner that involves the patient as an active participant in decisions affecting care. Therefore a primary concern throughout this book is the integration of patient teaching about drug therapy to enable the patient to reach therapeutic goals and attain an optimum level of health. The nurse must also validate patient understanding to ensure that the individual has the ability to provide safe self-care and monitoring of the prescribed treatment plan. User friendly in content, structure, and layout, the text is concise and easy to read. With its emphasis on the seven Rights of Drug Administration (right drug, right time, right indication, right dosage, right patient, right route, and right documentation), *Clayton's Basic Pharmacology for Nurses* provides students with the information needed to provide safe, effective nursing care for patients receiving drug therapy.

ORGANIZATION AND SPECIAL FEATURES

CONTENT THREADS

Clayton's Basic Pharmacology for Nurses, 19th edition, shares some features and design elements with other Elsevier books that you may be using. The purpose of these Content Threads is to make it easier for students and instructors to use the variety of books required by a fast-paced and demanding curriculum.

The shared features in *Clayton's Basic Pharmacology for Nurses*, 19th edition, include the following:

- Cover and internal design similarities; the colorful, student-friendly design encourages reading and learning of this core content
- Numbered lists of Objectives that begin each chapter
- Key Terms with pronunciations at the beginning of each chapter; the Key Terms are in color when they are defined in the chapter
- Bulleted lists of Key Points at the end of each chapter

Next Generation (NG) NCLEX style questions are at the end of each chapter. These questions use single-episode and unfolding cases. They include the six NCSBN Clinical Judgment Measurement Model cognitive processes and skills; answers are provided on the Evolve student website.

In addition to content and design threads, these textbooks benefit from the advice and input of the Elsevier Advisory Board.

CONTENTS

Unit I explores pharmacology foundations, principles, life span considerations, the nursing process with pharmacology, and patient education. Unit II contains the unique Illustrated Atlas of Medication Administration that provides extensive step-by-step instructions and illustrations that show primary routes of administration and proper administration techniques for all forms of medications.

Units III through X provide an overview of each drug class, followed by narrative discussions of the most common individual drugs. The units and chapters are organized by body system.

CHAPTER ORGANIZATION

- Each drug chapter in Units III through X begins with an overview of a clinical problem and its management.
- The general nursing implications section includes clearly identified headings for Assessment, Implementation, and Patient Education. The Patient Education section helps the nurse incorporate patient education designed to promote health into the overall treatment plan.
- Drug monographs are provided for each major drug class. These monographs describe Actions, Uses, and Therapeutic Outcomes for each class.
- A drug class–specific nursing implications section for each drug monograph highlights Premedication Assessment, Product Availability, Dosing Instructions, Common Adverse Effects, Serious Adverse Effects, and Drug Interactions.

SPECIAL FEATURES

Clayton's Basic Pharmacology for Nurses includes special features designed to foster effective learning and comprehension.

- Chapter-opening features include lists of Objectives and Key Terms with pronunciations.

- Clinical Pitfall and Medication Safety Alert boxes highlight critically important clinical considerations to help students practice safety and reduce medication errors.
- Clinical Goldmine boxes put a spotlight on tips and best practices for clinical procedures.
- Life Span Considerations boxes focus on the implications of drug therapy for children, pregnant and breastfeeding women, and older adults.
- Herbal Interactions boxes discuss well-documented interactions among drugs, herbal therapies, and dietary supplements.
- A handy bulleted list of Key Points at the end of most chapters facilitates review of essential chapter content.

NEW TO THIS EDITION

- This edition includes the latest US Food and Drug Administration (FDA) approvals, including up-to-date clinical drug indications, guidelines for use, and recently released new drugs.
- Increased emphasis on medication safety that stresses imperative information for patient protection.
- Additional information on genetics, pharmacogenomics, and racial/gender factors in drug actions is included to highlight current research.
- New figures have been added to illustrate proper medication administration.
- End-of-chapter NCLEX-style questions that include NG types such as Cloze, Grid/Matrix, Drag and Drop, and Extended Multiple Response. These types cover the six cognitive skills: Recognize Cues, Analyze Cues, Prioritize Hypotheses, Generate Solutions, Take Action, and Evaluate Outcomes.

TEACHING AND LEARNING PACKAGE

FOR STUDENTS

- The Evolve Website provides free student resources, including answers and rationales for in-text Review Questions for the NCLEX® Examination, a math review, animations, video clips, a collection of Patient Teaching handouts, fully customizable Patient Self-Assessment Forms provided as "completable" PDF documents, and a collection of 500 NCLEX-style Review Questions.
- The revised Study Guide provides additional learning resources that complement those in the textbook. Questions for each chapter follow the objectives in the book for additional focus on these key concepts. Matching starts each chapter, and patient scenarios are included with the chapters that detail the medications. NG NCLEX-style questions are included, as are typical NCLEX questions. Each question includes the correct answer, rationale, NCLEX style used, and cognitive skill measured. Each question has a page number identified to help the student find the answer in the textbook. Answers to the Study Guide questions are available from instructors.

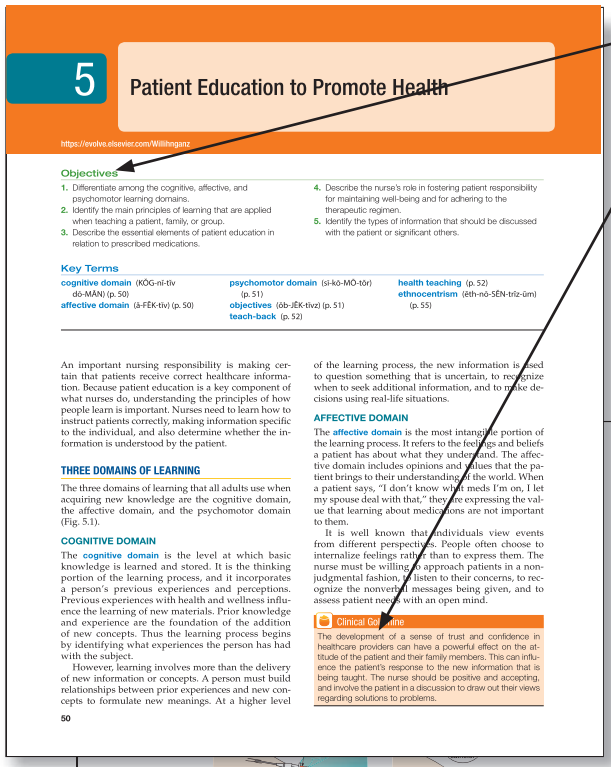
FOR INSTRUCTORS

The comprehensive *Evolve Resources with TEACH Instructor Resource* provides a rich array of resources that include the following:

- Updated TEACH Lesson Plans, based on textbook learning objectives, provide ready-to-use lesson plans that tie together all of the text and ancillary components provided for *Clayton's Basic Pharmacology for Nurses.*
- The collection of PowerPoint Lecture Slides is specific to the text.
- A Test Bank, delivered in ExamView, now provides an expanded collection of approximately 900 multiple-choice and alternate-format NCLEX-style questions. Each question includes the Correct Answer, Rationale, and corresponding text page numbers.
- The Image Collection contains every reproducible image from the text. Images are suitable for incorporation into classroom lectures, PowerPoint presentations, or distance-learning applications.
- Answer keys are provided for the Study Guide.

Special Features

Basic Pharmacology for Nurses focuses on medication safety through medication monitoring and patient education. Full-color art and design features accompany detailed, understandable discussions of drugs organized by body system.



5

Patient Education to Promote Health

https://evolve.elsevier.com/Willihnganz

Objectives

1. Differentiate among the cognitive, affective, and psychomotor learning domains.
2. Identify the main principles of learning that are applied when teaching a patient, family, or group.
3. Describe the essential elements of patient education in relation to prescribed medications.
4. Describe the nurse's role in fostering patient responsibility for maintaining well-being and for adhering to the therapeutic regimen.
5. Identify the types of information that should be discussed with the patient or significant others.

Key Terms

cognitive domain (KÓG-nĭ-tĭv dō-MĀN) (p. 50)
affective domain (à-FĚK-tĭv) (p. 50)
psychomotor domain (sī-kō-MŌ-tŏr) (p. 51)
objectives (ŏb-JĚK-tĭvz) (p. 51)
teach-back (p. 52)
health teaching (p. 52)
ethnocentrism (ĕth-nō-SĚN-trĭz-ŭm) (p. 55)

An important nursing responsibility is making certain that patients receive correct healthcare information. Because patient education is a key component of what nurses do, understanding the principles of how people learn is important. Nurses need to learn how to instruct patients correctly, making information specific to the individual, and also determine whether the information is understood by the patient.

THREE DOMAINS OF LEARNING

The three domains of learning that all adults use when acquiring new knowledge are the cognitive domain, the affective domain, and the psychomotor domain (Fig. 5.1).

COGNITIVE DOMAIN

The **cognitive domain** is the level at which basic knowledge is learned and stored. It is the thinking portion of the learning process, and it incorporates a person's previous experiences and perceptions. Previous experiences with health and wellness influence the learning of new materials. Prior knowledge and experience are the foundation of the addition of new concepts. Thus the learning process begins by identifying what experiences the person has had with the subject.

However, learning involves more than the delivery of new information or concepts. A person must build relationships between prior experiences and new concepts to formulate new meanings. At a higher level of the learning process, the new information is used to question something that is uncertain, to recognize when to seek additional information, and to make decisions using real-life situations.

AFFECTIVE DOMAIN

The **affective domain** is the most intangible portion of the learning process. It refers to the feelings and beliefs a patient has about what they understand. The affective domain includes opinions and values that the patient brings to their understanding of the world. When a patient says, "I don't know what meds I'm on, I let my spouse deal with that," they are expressing the value that learning about medications are not important to them.

It is well known that individuals view events from different perspectives. People often choose to internalize feelings rather than to express them. The nurse must be willing to approach patients in a nonjudgmental fashion, to listen to their concerns, to recognize the nonverbal messages being given, and to assess patient needs with an open mind.

Clinical Goldmine

The development of a sense of trust and confidence in healthcare providers can have a powerful effect on the attitude of the patient and their family members. This can influence the patient's response to the new information that is being taught. The nurse should be positive and accepting, and involve the patient in a discussion to draw out their views regarding solutions to problems.

50

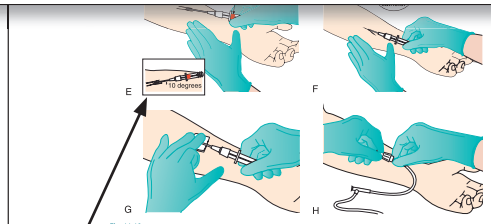


Fig. 11.13 (A) Apply a tourniquet using a slipknot that is placed 2 to 6 inches above the chosen *(shaded)* area. (B) Allow the veins to dilate. (C) Palpate the vein to feel its depth and direction. (D) Cleanse the skin surface with an antiseptic alcohol wipe, starting at the anticipated site of entry and working outward in a circular motion to the periphery. (E) For an over-the-needle catheter, hold the flashback chamber with the thumb and forefinger and insert the catheter with the needle at a 10- to 30-degree angle (or at the angle as specified in manufacturer's directions), with the bevel up. (F) Withdraw the needle from the catheter. (G) Apply gentle pressure over the catheter tip to prevent the excessive backflow of blood while the needle is removed and the intravenous line is attached. (H) Secure the connection of the intravenous tubing to the hub of the catheter.

glove on one hand so that the site can be touched again or to prepare the fingertip with antiseptic.)
12. Allow the area to air-dry.
13. Hold the catheter or butterfly needle to be inserted in the dominant hand, and remove the protective cover while maintaining the sterility of the needle. Approach the vein directly from above or from slightly to one side of the vein. Provide tension on the skin surface to stretch the skin and stabilize the vein.

5. Review the medicines that have been prescribed that may require dose adjustments. Plan to perform focused assessments to detect responses to therapy that would need to be reported to the healthcare provider.

Availability. ***PO:*** Sinemet is a combination product that contains both carbidopa and levodopa. The combination product is available in ratios of 10/100, 25/100, and 25/250 mg of carbidopa and levodopa, respectively. There is also a sustained-release tablet that contains either 25/100 or 50/200 mg of carbidopa and levodopa, respectively.

Rytary is an oral extended-release combination product that contains both carbidopa and levodopa. It is available in capsules in ratios of 23.75/95, 36.25/145, 48.75/195, and 61.25/245 mg of carbidopa and levodopa, respectively.

Duopa is an enteral suspension of carbidopa 4.63 mg and levodopa 20 mg/mL in 100-mL containers.

Dosage and administration. **Adult:** ***PO:*** For patients who are not receiving levodopa initially, give Sinemet 10/100 or 25/100 mg three times daily, increasing by 1 tablet every other day, until a dosage of 6 tablets daily is attained. As therapy progresses and patients show indications of needing more levodopa, substitute Sinemet 25/250 mg, 1 tablet three or four times daily. Increase by 1 tablet every other day to a maximum of 8 tablets daily. See the manufacturer's guidelines for converting a patient from the immediate-release to the sustained-release formulation of Sinemet.

Administer this medication with food or milk to reduce gastric irritation. Therapy for at least 6 months may be necessary to determine this medication's full therapeutic benefits.

Extended-Release Formulations: Sinemet Extended-Release Tablets: For patients not currently receiving levodopa initially, start with sustained-release tablet 50 mg/200 mg twice daily at intervals of 6 hours or more. Following an interval of at least 3 days between dosage adjustments, increase or decrease dosage based on response. Most patients are adequately treated with a dose that provides 400 to 1600 mg of levodopa per day in divided doses at intervals of 4 to 8 hours while awake. If an interval of less than 4 hours is used and/or if the divided doses are not equal, give the smaller doses at the end of the day.

Rytary Extended-Release Capsules: For patients not currently receiving levodopa initially, start with Rytary 23.75/95 mg three times daily for 3 days; on day 4, increase to 36.25/145 mg three times daily. The dose may be increased up to 97.5/390 mg three times daily, and the frequency of dosing may be increased to a maximum of five times daily if needed and tolerated (maximum: 612.5/2450 mg per day).

See the manufacturer's guidelines for converting a patient from immediate-release formulations to extended-release capsules.

Enteral Formulation: Duopa:

- See the manufacturer's guidelines for calculation and titration of morning dose and continuous infusion doses.
- Before initiation of therapy, convert patient from all forms of levodopa to oral immediate-release carbidopa-levodopa tablets (1:4 ratio). Total daily dose of levodopa consists of the morning dose, a continuous dose and any extra doses.
- See manufacturer's recommendations on frozen storage, thawing in a refrigerator for 96 hours, protection from light, administration by nasojejunal tube or PEG-J tube and type of pump to be used.
- Following discontinuation of the daily infusion, patients should receive their routine nighttime dosage or oral immediate release carbidopa-levodopa.

Common adverse effects. Levodopa causes many adverse effects, but most are dose related and reversible. Adverse effects vary greatly depending on the stage of the disease.

Gastrointestinal

Nausea, vomiting, anorexia. These effects can be reduced by slowly increasing the dose, dividing the total daily dosage into four to six doses, and administering the medication with food or antacids. See manufacturer's precautions pertaining to potential GI complications associated with enteral infusions.

Cardiovascular

Orthostatic hypotension. Although the effects are generally mild, levodopa may cause some degree of orthostatic hypotension; this is manifested by dizziness and weakness, particularly when therapy is initiated. Tolerance usually develops after a few weeks of therapy. Monitor the patient's blood pressure daily in both the supine and standing positions. Anticipate the development of postural hypotension and take measures to prevent such an occurrence. Teach patients to rise slowly from a supine or sitting position, and encourage them to sit or lie down if feeling faint.

Serious adverse effects

Neurologic

Chewing motions, bobbing, facial grimacing, rocking movements. These involuntary movements occur in about half of the patients who take levodopa for more than 6 months. A reduction in dosage may be beneficial.

Psychological

Nightmares, depression, confusion, hallucinations. Perform a baseline assessment of the patient's degree of alertness and orientation to name, place, and time before initiating therapy. Make regularly scheduled subsequent evaluations of mental status, and compare findings. Report alterations in mood. Provide for patient safety during these episodes. Reducing the daily dosage may control these adverse effects.

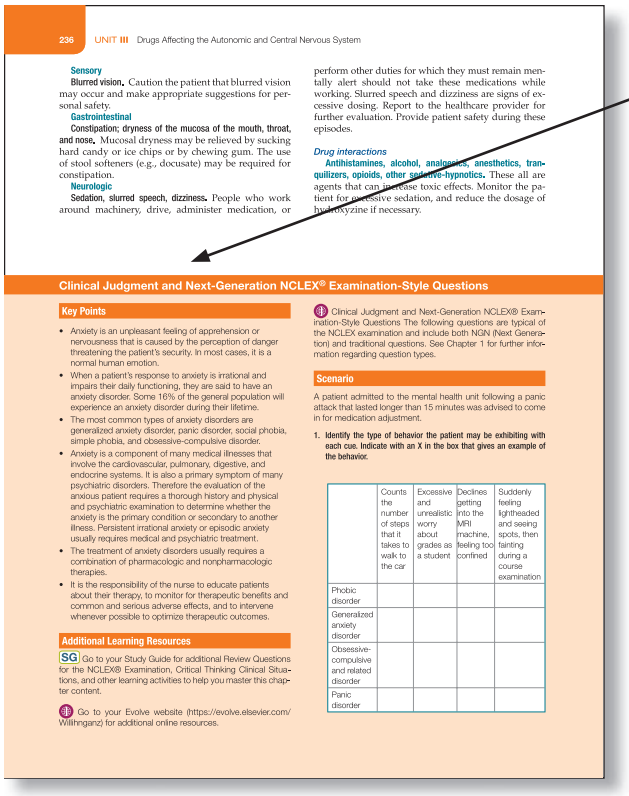
Cardiovascular

Tachycardia, palpitations. Take the patient's pulse at regularly scheduled intervals. Report any changes for further evaluation.

Chapters open with **Objectives** and **Key Terms** with pronunciations and page references.

Clinical Goldmine boxes focus on best practices in the clinical setting.

Step-by-step **full color art** shows proper medication administration techniques.



236 UNIT III Drugs Affecting the Autonomic and Central Nervous System

Sensory

Blurred vision. Caution the patient that blurred vision may occur and make appropriate suggestions for personal safety.

Gastrointestinal

Constipation; dryness of the mucosa of the mouth, throat, and nose. Mucosal dryness may be relieved by sucking hard candy or ice chips or by chewing gum. The use of stool softeners (e.g., docusate) may be required for constipation.

Neurologic

Sedation, slurred speech, dizziness. People who work around machinery, drive, administer medication, or perform other duties for which they must remain mentally alert should not take these medications while working. Slurred speech and dizziness are signs of excessive dosing. Report to the healthcare provider for further evaluation. Provide patient safety during these episodes.

Drug interactions

Antihistamines, alcohol, analgesics, anesthetics, tranquilizers, opioids, other sedative-hypnotics. These all are agents that can increase toxic effects. Monitor the patient for excessive sedation, and reduce the dosage of hydroxyzine if necessary.

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions

Key Points

- Anxiety is an unpleasant feeling of apprehension or nervousness that is caused by the perception of danger threatening the patient's security. In most cases, it is a normal human emotion.
- When a patient's response to anxiety is irrational and impairs their daily functioning, they are said to have an anxiety disorder. Some 16% of the general population will experience an anxiety disorder during their lifetime.
- The most common types of anxiety disorders are generalized anxiety disorder, panic disorder, social phobia, simple phobia, and obsessive-compulsive disorder.
- Anxiety is a component of many medical illnesses that involve the cardiovascular, pulmonary, digestive, and endocrine systems. It is also a primary symptom of many psychiatric disorders. Therefore the evaluation of the anxious patient requires a thorough history and physical and psychiatric examination to determine whether the anxiety is the primary condition or secondary to another illness. Persistent irrational anxiety or episodic anxiety usually requires medical and psychiatric treatment.
- The treatment of anxiety disorders usually requires a combination of pharmacologic and nonpharmacologic therapies.
- It is the responsibility of the nurse to educate patients about their therapy, to monitor for therapeutic benefits and common and serious adverse effects, and to intervene whenever possible to optimize therapeutic outcomes.

Additional Learning Resources

SG Go to your Study Guide for additional Review Questions for the NCLEX® Examination, Critical Thinking Clinical Situations, and other learning activities to help you master this chapter content.

Go to your Evolve website (https://evolve.elsevier.com/Willihnganz) for additional online resources.

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions The following questions are typical of the NCLEX examination and include both NGN (Next Generation) and traditional questions. See Chapter 1 for further information regarding question types.

Scenario

A patient admitted to the mental health unit following a panic attack that lasted longer than 15 minutes was advised to come in for medication adjustment.

1. **Identify the type of behavior the patient may be exhibiting with each cue. Indicate with an X in the box that gives an example of the behavior.**

	Counts the number of steps that it takes to walk to the car	Excessive and unrealistic worry about grades as a student	Declines getting into the MRI machine, feeling too confined	Suddenly feeling lightheaded and seeing spots, then fainting during a course examination
Phobic disorder				
Generalized anxiety disorder				
Obsessive-compulsive and related disorder				
Panic disorder				

Get Ready for the NCLEX® Examination! sections include Key Points, Additional Learning Resources, and Review Questions for the NCLEX® Examination.

- **Patient Education and Health Promotion** is emphasized in the overall treatment plan.
- **Life Span Considerations** boxes focus on implications of drug therapy for children, pregnant and breastfeeding women, and older adults.
- **Clinical Pitfall and Medication Safety Alert** boxes highlight critically important clinical considerations.
- **Herbal Interactions** boxes describe possible adverse effects of alternative therapies.
- Chapters open with **Objectives** and **Key Terms** with pronunciations and page references.

STUDY GUIDE

Includes *Practice Questions for the NCLEX® Examination* for each textbook chapter. Answers to the revised study guide are available from your instructor.

Contents

Drug Definitions, Standards, and Information Sources

1

https://evolve.elsevier.com/Willihnganz

Objectives

1. Differentiate between the chemical, generic, and brand names of drugs.
2. Identify the various methods used to classify drugs.
3. Identify sources of drug information available for healthcare providers.
4. Discuss the difference between prescription and nonprescription drugs.
5. Describe the process of developing and bringing new drugs to market.
6. Differentiate between the Canadian chemical names and the proper name of a drug.

Key Terms

pharmacology (făr-mă-KŎL-ŏ-jē) (p. 1)
therapeutic methods (thĕr-ă-PYŪ-tĭk MĔTH-ĕdz) (p. 1)
drugs (p. 1)
biologic therapies (p. 1)
chemical name (KĔM-ĭ-kŭl) (p. 2)
generic name (jĕ-NĂR-ĭk) (p. 2)
brand name (p. 2)
prescription drugs (p. 2)
nonprescription drugs (p. 2)
over-the-counter (OTC) drugs (p. 2)
illegal drugs (ĭl-LĒ-gŭl) (p. 2)
biosimilars (p. 2)
schedules (SKĔD-jūlz) (p. 5)
black box warnings (p. 8)
orphan drugs (ŌR-făn) (p. 8)
Food and Drugs Act and Regulations (p. 9)
Controlled Drugs and Substances Act (p. 10)

Pharmacology (from the Greek *pharmakon,* meaning "drugs," and *logos,* meaning "science") deals with the study of drugs and their actions on living organisms. Diseases that cause illness may be treated in several different ways, which are referred to as *therapies.* The various approaches to therapy are called **therapeutic methods**. Examples of therapeutic methods include the following:

- **Drug therapy:** Treatment with drugs
- **Diet therapy:** Treatment with diet (e.g., a low-salt diet for patients with cardiovascular disease)
- **Physiotherapy:** Treatment with natural physical forces (e.g., water, light, heat)
- **Psychological therapy:** The identification of stressors and methods that can be used to reduce or eliminate stress

Most illnesses caused by diseases require a combination of therapeutic methods for successful treatment.

Drugs (from the Dutch *droog,* meaning "dry") are chemical substances that have an effect on living organisms. Therapeutic drugs, which are often called *medicines,* are those drugs that are used for the prevention or treatment of diseases. Up until the early to mid-20th century, dried plants were the most abundant source of medicines, thus the word *drug* was applied to them.

Whereas most drugs are individual chemicals that cause a response in living tissues, a new class known as **biologic therapies** have been discovered that have transformed treatment of patients with disorders that attack the body's own organs, tissues, and cells (autoimmune disorders), blood (hematologic disorders), and cancers. Biologic agents are large, complex proteins manufactured in a living system such as a microorganism, or within plant or animal cells. Biologics have added major therapeutic choices for the treatment of many diseases for which no effective therapies were available or previously existing therapies were clearly inadequate.

DRUG NAMES, STANDARDS, LEGISLATION, AND DEVELOPMENT IN THE UNITED STATES

DRUG NAMES

All drugs have several names, which may cause confusion. When administering the prescribed drug, the spelling on the drug package must correspond exactly with the spelling of the drug ordered to ensure that the proper medicine is administered.

Each drug has three names: (1) a *chemical* name, (2) a *generic* name, and (3) a *brand* name. The **chemical name** is most meaningful to the chemist. By means of the chemical name, the chemist understands the exact chemical constitution of the drug and the exact placement of its atoms or molecular groupings.

Before a drug becomes official, it is given a **generic name** or common name. The generic name is simpler than the chemical name. It may be used in any country and by any manufacturer. The first letter of the generic name is not capitalized. Students are strongly encouraged to learn and refer to drugs by their generic names because formularies (i.e., lists of medicines available through a pharmacy) are maintained by generic names. When a therapeutically equivalent drug becomes available in generic form, the generic medicine is routinely substituted for the brand-name medicine.

Generic names are provided by the United States Adopted Names Council, which is an organization sponsored by the United States Pharmacopeial Convention, the American Medical Association, and the American Pharmacists Association. The official name, which is virtually always the generic name in the United States, is the name under which the drug is listed by the US Food and Drug Administration (FDA). The FDA is empowered by federal law to generically name the drugs for human use in the United States.

A trademark or **brand name** is followed by the symbol ®. This symbol indicates that the name is registered and that the use of the name is restricted to the owner of the drug, which is usually the manufacturer. Most drug companies place their products on the market under brand names rather than generic names. The brand names are deliberately made easier to pronounce, spell, and remember. The first letter of the brand name is capitalized.

Example of Chemical, Generic, and Brand Names for Drugs

Chemical name: [2-[4-[(4-Chlorophenyl)phenylmethyl]-1-piperazinyl]ethoxy]acetic acid dihydrochloride (Fig. 1.1)
Generic name: cetirizine
Brand name: Zyrtec Allergy

DRUG CLASSIFICATIONS

Drugs may be classified by a variety of methods according to the *body system* that they affect (e.g., the central nervous system, the cardiovascular system, the gastrointestinal system); their *therapeutic use* or *clinical indications* (e.g., antacids, antibiotics, antihypertensives, diuretics, laxatives); and their *physiologic* or *chemical action* (e.g., anticholinergics, beta-adrenergic blockers, calcium channel blockers, cholinergics).

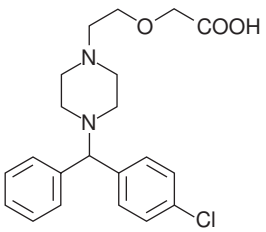


Fig. 1.1 Cetirizine, an antihistamine.

Drugs may be further classified as prescription or nonprescription. **Prescription drugs** require an order by a health professional who is licensed to prescribe drugs, such as a primary healthcare provider, a nurse practitioner, a physician assistant, a pharmacist, or a dentist. **Nonprescription drugs**, or **over-the-counter (OTC) drugs**, are sold without a prescription in a pharmacy or in the health section of department or grocery stores. **Illegal drugs**, sometimes referred to as *recreational drugs*, are drugs or chemical substances used for nontherapeutic purposes. These substances either are obtained illegally or have not received approval for use by the FDA. See Chapter 48 for further information about substance abuse.

A **biosimilar** is a biologic product that is close in structure and function to an existing approved biologic product, known as a *reference product*. For example, infliximab-dyyb (Inflectra) and infliximab-abda (Renflexis) are biosimilars for the reference product infliximab (Remicade) used to treat rheumatoid arthritis. With many patents for biologics expiring, biosimilar agents will become available. In 2010 legislation created an abbreviated licensure pathway for biologic products that are demonstrated to be biosimilar. Biosimilars offer an opportunity to increase access to biologics while lowering the cost of therapy. However, unlike generic medicines in which the active ingredients are identical to the reference small-molecule drugs, biosimilars will not be identical to the reference biologics. This is due to the inherent complexity of biologic proteins. Biosimilars made by different manufacturers will differ from the reference product and from each other, making each biosimilar a unique therapeutic option for patients (Table 1.1). Biosimilars are not generics and are not interchangeable. These agents cannot be substituted for the original reference molecule.

SOURCES OF DRUG STANDARDS AND DRUG INFORMATION

Drug products made by different manufacturers or in different batches by the same manufacturer must be uniformly pure and potent. The United States Pharmacopeial Convention is a nongovernment organization that promotes public health by establishing state-of-the-art standards to ensure the quality of medicines and other healthcare technologies. These standards are developed by a unique process of public involvement, and they are accepted worldwide. The Convention publishes a single-volume text, the *United States Pharmacopeia (USP)/National Formulary (NF)*, which is revised annually. The primary purpose of this volume is to provide standards for the identity, quality, strength, and purity of substances used in the practice of healthcare. The standards described in the *USP/NF* are enforced by the FDA as the

Table 1.1 Comparing and Contrasting Biosimilar and Generic Products

PROPERTIES	BIOSIMILAR DRUGS (BIOLOGICS)	GENERICS (SMALL-MOLECULE DRUGS)
Size	Large	Small
Structure	Complex with potential structural variations	Simple and well defined
Manufacturing	Unique bank of living cells Unlikely to achieve identical copy	Predictable chemical reaction Identical copy can be made
Complexity	Difficult to fully characterize	Easy to fully characterize
Stability	More sensitive to storage and handling conditions	Less sensitive to storage and handling conditions
Immunogenicity (promotes immune response; potential for allergy)	Higher potential	Lower potential
Approval requirements	Large clinical trials in patients	Small clinical trials for safety in healthy volunteers

official standards for the manufacture and quality control of medicines and nutritional supplements produced in the United States. The *USP/NF* is also recognized by the Canadian Food and Drugs Act as an authoritative source of drug standards in Canada.

Table 1.2 lists and describes the common sources of drug information available for the professional healthcare provider; additional resources are described in the following sections.

PACKAGE INSERTS

Manufacturers of drugs are required to develop a comprehensive but concise description of the drug, indications and precautions for clinical use, recommendations for dosage, known adverse reactions, contraindications, and other pharmacologic information relating to the drug. Federal law mandates that this material be approved by the FDA before the product is released for marketing and that it be presented on an insert that accompanies each package of the product.

The FDA adopted a format for package inserts to help reduce medication errors and to improve patient education. The labeling reduces practitioners' time looking for information, decreases the number of preventable medication errors, and improves treatment effectiveness and patient education. Because this labeling represents considerable effort and is most critical for newer and less familiar drugs, the formatting applies only to relatively new prescription drug products, developed since 2006.

Clinical Goldmine

DailyMed (see Online Resources), which is sponsored by the US National Library of Medicine, provides a database for new package inserts that is searchable by product name, indications, dosage and administration, warnings, description of drug product, active and inactive ingredients, and how the drug is supplied. See the section Electronic Databases.

NURSING JOURNALS

Many specialty journals have articles about drug therapy as it relates to a specific field of interest (e.g., *Geriatric Nursing*, *American Journal of Critical Care*). Nursing journals such as *RN* and *American Journal of Nursing* provide drug updates and articles that discuss nursing considerations related to drug therapy and drugs. Nurses must keep in mind that the purpose of using resources such as journals is to obtain professional knowledge of current evidence-based practice changes and they should not be used as a primary source for drug information. Nurses must be mindful of the accuracy of the information contained and should check the dates on articles to validate the currency of the information.

ELECTRONIC DATABASES

With the exponential growth of information about medicines and health, it is almost impossible to make the information available without the use of electronic databases. The National Library of Medicine (NLM) provides Medline and other searchable databases at no cost. Databases incorporated into the NLM include information on drugs and other chemicals that breastfeeding mothers may be exposed to and the levels in breast milk and infant blood with the possible adverse effects in the nursing infant. They also provide suggested therapeutic alternatives to the drugs. Information regarding the development and reproductive toxicology of drugs covering teratology is included. Most of the drug information sources listed in Table 1.2 are also available via electronic retrieval from libraries. Many college libraries subscribe to the Cumulative Index to Nursing and Allied Health Literature (CINAHL). These databases give nurses access to a wealth of information from sources published in the United States and other countries.

Databases for practitioners are also available by subscription. UpToDate, Lexicomp, and ePocrates are three vendors with several different packages of regularly updated information (see Online Resources). Lexicomp has a particularly strong database because the American Hospital Formulary Service is available through its portal.

Table 1.2 Sources of Drug Information for Healthcare Providers

SOURCES OF DRUG INFORMATION	DESCRIPTION
AHFS Drug Information	Contains monographs about virtually every single-entity drug available in the United States Describes therapeutic uses of drugs, including approved and unapproved uses Online version available
Drug Facts and Comparisons	Contains drug monographs that describe all drugs in a therapeutic class Monographs are formatted as tables to allow comparison of similar products, brand names, manufacturers, cost indices, and available dosage forms Online version available
ASHP's Handbook on Injectable Drugs	Collection of monographs about 360 injectable drugs with sections on available concentrations, compatibility with other drugs, dosage and rate of administration, stability, pH, and other useful information Interactive version available
Handbook of Nonprescription Drugs: An Interactive Approach to Self-Care	Most comprehensive text available about over-the-counter medications that can be purchased in the United States Online version available
Martindale: The Complete Drug Reference	Considered one of the most comprehensive texts available for information about drugs in current use throughout the world Contains extensive referenced monographs about the international names, pharmacologic activity, and side effects of more than 6400 drugs Online subscription available
Natural Medicines Comprehensive Database	Scientific gold standard for evidence-based information about herbal medicines and combination products involving herbal medicines Only available in an online database by subscription or at libraries
CANADIAN DRUG STANDARDS	
European Pharmacopoeia *Pharmacopée Française* *The International Pharmacopoeia (Ph. Int.)* *British Pharmacopoeia* *Canadian Formulary* *The National Formulary* *Pharmaceutical Codex* *United States Pharmacopeia-National Formulary*	All recognized by the Canadian Food and Drugs Act as authoritative sources of drug standards
CANADIAN DRUG INFORMATION	
Compendium of Pharmaceuticals and Specialties (CPS)	Published annually by the Canadian Pharmacists Association Comprehensive list of the pharmaceutical products distributed in Canada, as well as other practical information e-CPS available
Patient Self-Care: Helping Patients Make Therapeutic Choices	Published by the Canadian Pharmacists Association Provides comprehensive information for health professionals and consumers about nonprescription drug products available in Canada e-Therapeutics available
Compendium of Self-Care Products (CSCP)	Nonprescription companion to *CPS* and *Patient Self-Care* Offers at-a-glance comparative tables for thousands of products and monographs about hundreds of commonly used nonprescription products

AHFS, American Hospital Formulary Service; *ASHP,* American Society of Health-System Pharmacists; *USP,* United States Pharmacopeia.

The DailyMed system (see Online Resources) was developed in collaboration with federal agencies—including the FDA, the NLM, the Agency for Healthcare Research and Quality, the National Cancer Institute in the US Department of Health and Human Services, and the US Department of Veterans Affairs—to provide high-quality information about marketed drugs. DailyMed makes available to healthcare providers and the public a standard, comprehensive, up-to-date resource about medicines.

UNITED STATES DRUG LEGISLATION

Drug legislation approved by Congress provides the legal basis (Table 1.3) for drug manufacturing and protects the consumer from false claims made by a drug

Table 1.3 Selected Major US Legislation Pertaining to Safety of Medicines

LEGISLATION (LAW)	PURPOSE AND EFFECT
Food, Drug, and Cosmetic Act of 1938	Requires that new drugs be safe, as well as pure (but did not require proof of efficacy). Enforcement by FDA.
Durham-Humphrey Amendment (1951) to the Food, Drug, and Cosmetic Act	Gives the FDA the power to determine which products may be sold with and without a prescription.
Kefauver-Harris Amendment (1962) to the Food, Drug, and Cosmetic Act	Requires proof of efficacy as well as safety for medicines released since 1938; establishes guidelines for reporting of information about adverse reactions, clinical testing, and advertising of new drugs.
Comprehensive Drug Abuse Prevention and Control Act (1970) (Controlled Substances Act, 1970)	Outlines strict controls in the manufacture, distribution, and prescribing of habit-forming drugs; establishes drug schedules and programs to prevent and treat drug addiction. Established the Drug Enforcement Administration (DEA).
Dietary Supplement Health and Education Act (1994) (DSHEA Act–1994)	Under this act, almost all herbal medicines, vitamins, minerals, amino acids, and chemicals used for health are reclassified as **dietary supplements**, a food category. The legislation allows the label to include information about how these products affect the human body. Labels must contain a statement that the product has not been evaluated by the FDA for treating, curing, or preventing any disease. The law does not prevent nonlicensed personnel from making founded or unfounded claims about the therapeutic effects of supplement ingredients. The result is that dietary supplements are not required to be safe and effective, and unfounded claims of therapeutic benefit abound. See Chapter 47.

manufacturer. The FDA is the administrative body that oversees the drug evaluation process in the United States and grants approval for or removal of drug products from the market.

CONTROLLED SUBSTANCES ACT

The Comprehensive Drug Abuse Prevention and Control Act, which is commonly referred to as the *Controlled Substances Act,* is designed to improve the administration and regulation of the manufacturing, distribution, and dispensing of drugs that require tighter control by the government because of their higher incidence of abuse and potential for addiction. The basic structure of the Controlled Substances Act consists of five classifications, or **schedules**, of controlled substances. The degree of control, the conditions of record keeping, the particular order forms required, and other regulations depend on which schedule the individual drug is assigned (Box 1.1).

Drugs that are listed as Schedule I are not available for other than highly controlled research purposes because of their very high potential for abuse and addiction. Drugs in Schedule II have a high potential for abuse and addiction, but are available by prescription only, in limited quantities, usually with no more than a 7- to 30-day supply. The prescription cannot be refilled; a new prescription must be issued for continued use. Drugs categorized as Schedule III, IV, or V have a lower potential for abuse and addiction and may be ordered by prescription with a maximum supply of 30 days of medicine. If so written by the prescriber, the prescription may be refilled up to five times but outdates at 6 months, at which time a new prescription is required if the medicine is to be continued. Prescription medicines that are not classified as controlled substances may be refilled for up to a period of time defined by individual state law, if

Box 1.1 Examples of Medicines in the Controlled Substances Drug Schedules

SCHEDULE I DRUGS
Examples: lysergic acid diethylamide (LSD), peyote, heroin, hashish

SCHEDULE II DRUGS
Examples: amphetamines, morphine, hydrocodone/acetaminophen (Vicodin), hydrocodone/acetaminophen (Lortab), hydrocodone/acetaminophen (Norco), methadone, oxycodone/aspirin (Percodan), methylphenidate (Ritalin), amphetamine/dextroamphetamine (Adderall)

SCHEDULE III DRUGS
Examples: aspirin/codeine (Empirin with codeine), aspirin/butalbital/caffeine (Fiorinal), acetaminophen/codeine (Tylenol with codeine)

SCHEDULE IV DRUGS
Examples: phenobarbital, chlordiazepoxide, diazepam, flurazepam, temazepam

SCHEDULE V DRUGS
Example: atropine/diphenoxylate (Lomotil, Virtussin AC)

approved by the prescriber. Most state laws mandate that a prescription outdates in 1 year and must be rewritten if therapy is to be continued.

Drug Enforcement Administration

The US Drug Enforcement Administration (DEA) was organized to enforce the Controlled Substances Act, to gather intelligence, to train its officers, and to conduct research in the area of dangerous drugs and drug abuse.

Every manufacturer, primary healthcare provider, nurse practitioner, physician assistant, dentist, pharmacy, and hospital that manufactures, prescribes, or dispenses any of the drugs listed in the five schedules must register biannually with the DEA. A healthcare provider's prescription for substances named in this law must contain the healthcare provider's name, address, DEA registration number, and signature; the patient's name and address; and the date of issue. The pharmacist cannot fill such a prescription for a controlled substance without this information on the prescription.

Possession of Controlled Substances by Individuals

Federal and state laws make the possession of controlled substances without a valid prescription a crime, except in specifically exempted cases. The law makes no distinction between professional and practical nurses with regard to the possession of controlled drugs. Nurses may give controlled substances only under the direction of a healthcare provider who has been licensed to prescribe or dispense these agents. Nurses may not have controlled substances in their possession unless the following conditions are met: (1) the nurse is giving them to a patient under an order from a healthcare provider, (2) the nurse is a patient for whom a healthcare provider has prescribed scheduled drugs, or (3) the nurse is the official custodian of a limited supply of controlled substances on a unit or for a department of the hospital. Controlled substances that are ordered for patients but not used must be returned to the source from which they were obtained (i.e., the primary healthcare provider or pharmacy). Violation of or failure to comply with the Controlled Substances Act is punishable by fine, imprisonment, or both and by the possible loss of professional licensing.

EFFECTIVENESS OF DRUG LEGISLATION

The effectiveness of drug legislation depends on the interest and determination used to enforce these laws, the appropriation by government of adequate funds for enforcement, and the vigor used by proper authorities in enforcement. The interest and cooperation of healthcare professionals and the public with regard to the benefits of appropriate drug use and the possible consequences of indiscriminate use of drugs can be very beneficial. Many individuals assist in this education through support of national and state professional organizations, consumer advocacy groups, and local, state, and county health departments.

NEW DRUG DEVELOPMENT

It currently takes an average of 8 to 15 years and more than $2 billion in research and development costs to bring a single new drug to market; healthcare professionals and consumers alike often have a lack of understanding about this process. The Pharmaceutical Research and Manufacturers of America estimates that only 1 of 10,000 chemicals investigated is actually found to be "safe and effective" and ultimately brought to the pharmacist's shelf.

The Food, Drug, and Cosmetic Act of 1938 charged the FDA with the responsibility of regulating new drugs. Rules and regulations evolved by the FDA divide new drug development into four stages: (1) preclinical research and development; (2) clinical research and development; (3) New Drug Application (NDA) review; and (4) postmarketing surveillance (Fig. 1.2).

PRECLINICAL RESEARCH AND DEVELOPMENT STAGE

The preclinical research phase of new drug development begins with the discovery, synthesis, and purification of the drug. The goal at this stage is to use laboratory studies to determine whether the experimental drug has therapeutic value and whether the drug appears to be safe in animals. Enough data must be gained to justify testing the experimental drug in humans.

The preclinical phase of data collection may require 1 to 3 years, although the average length of time is 18 months. Near the end of this phase, the investigator (often a pharmaceutical manufacturer) submits an Investigational New Drug (IND) application to the FDA; this application describes all of the studies completed to date, discusses the expected safety of the drug, and explains the testing that is planned for human subjects. Within 30 days, the FDA must make a decision on the basis of safety considerations about whether to allow the human study to proceed. Only about 20% of the chemicals tested in the preclinical phase advance to the clinical testing phase.

CLINICAL RESEARCH AND DEVELOPMENT STAGE

The stage in which humans are first tested (i.e., the clinical research or IND stage) is usually subdivided into three phases. Phase 1 studies determine an experimental drug's pharmacologic properties, such as its pharmacokinetics, metabolism, safe dosage range, potential for toxicity at a certain dosage, and safe routes of administration. The study population is composed of normal volunteers or the intended treatment population, such as those patients for whom the standard

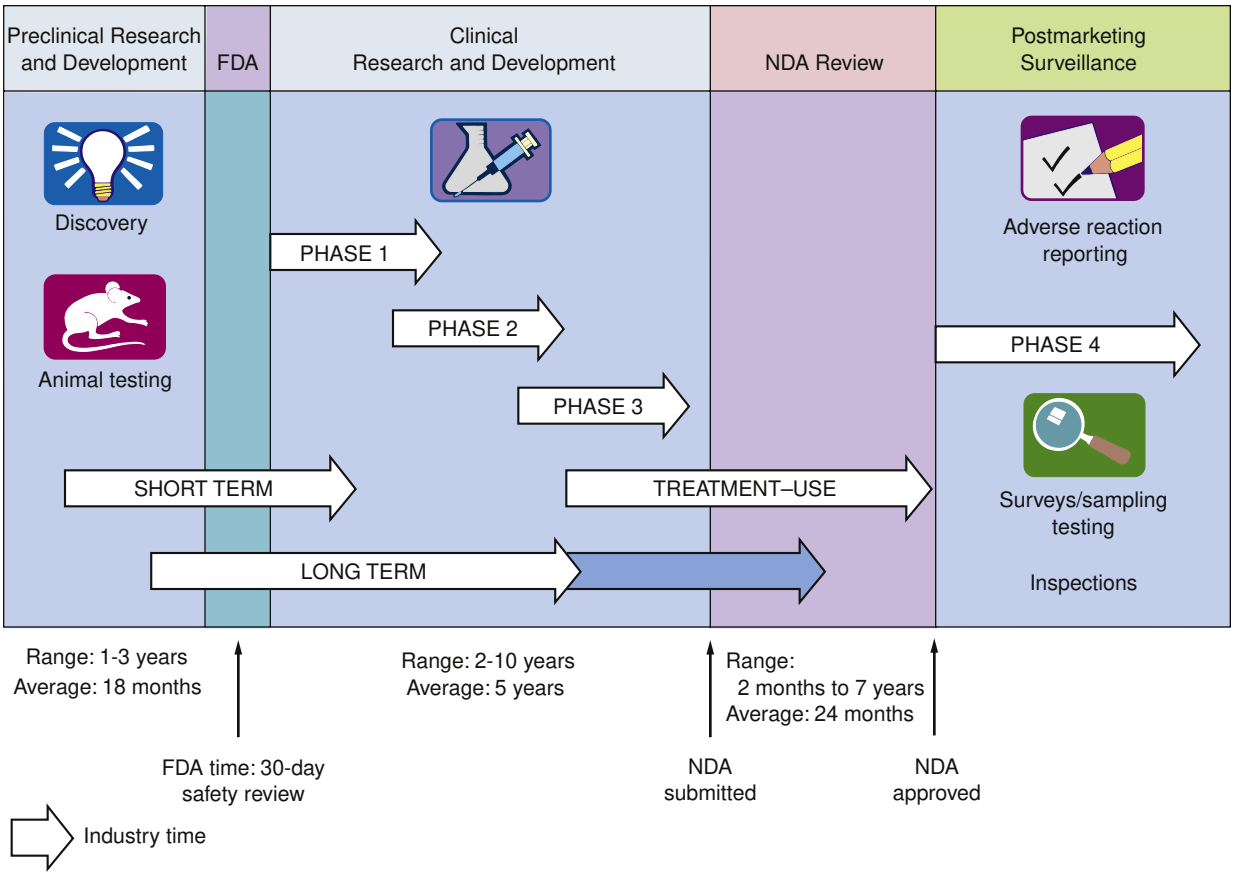


Fig. 1.2 The new drug review process. *FDA,* US Food and Drug Administration; *NDA,* New Drug Application.

treatments of certain cancers or dysrhythmias have been ineffective. Phase 1 studies usually require 20 to 100 subjects who are treated for 4 to 6 weeks.

If phase 1 trials are successful, the drug is moved to phase 2 trials, which involve a smaller population of patients who have the condition that the drug is designed to treat. Studies at various dosages are conducted to determine the success rate and safety of a drug for its intended use. If successful, the drug is advanced to phase 3 trials, in which larger patient populations are used to ensure the statistical significance of the results. Phase 3 studies also provide additional information about proper dosing and safety.

The entire clinical research phase may require 2 to 10 years, with the average experimental drug requiring 5 years. Each study completed is reviewed by the FDA to help ensure patient safety and efficacy. Only one of five drugs that enter clinical trials makes it to the marketplace. The others are eliminated because of efficacy or safety problems or a lack of commercial interest.

Fast Tracking

To expedite the development and approval of drugs for the treatment of life-threatening illnesses (e.g., acquired immunodeficiency syndrome), the FDA has drafted rules that allow certain INDs to receive the highest priority for review within the agency. This procedure is sometimes known as *fast tracking.* Additional rules allow INDs to be used for the treatment of a life-threatening disease in a particular patient—even if the patient does not fit the study protocol for the drug—when there is no alternative therapy. These cases are known as *treatment INDs.* A potentially lifesaving drug may be allowed for treatment IND status during late phase 2 studies, during phase 3 studies, or after all clinical studies have been completed but before marketing approval.

Parallel Tracking

Another mechanism to make INDs available to patients with life-threatening illnesses is known as *parallel tracking.* With this procedure, an IND may be used for patients who cannot participate in controlled clinical trials and when there is no satisfactory standard therapeutic alternative. Parallel track studies are conducted along with the principal controlled clinical trials; however, unlike a controlled study, the parallel track study does not involve a concurrent control group.

Investigators and patients must realize that there may be greater uncertainty regarding the risks and benefits of therapy with agents that are in relatively early stages of testing and development. Parallel tracking is similar to the treatment IND process but allows for access to investigational agents when there is less accumulated evidence of efficacy than required for a treatment

IND. A drug may be released through the parallel track mechanism when phase 2 trials have been given approval to proceed but have not necessarily been started.

NEW DRUG APPLICATION REVIEW

When sufficient data have been collected to demonstrate that the experimental drug is both safe and effective, the investigator submits an NDA to the FDA to formally request approval to market a new drug for human use. Thousands of pages of NDA data are reviewed by a team of pharmacologists, toxicologists, chemists, primary healthcare providers, and others (as appropriate), who then make a recommendation to the FDA about whether the drug should be approved for use. The average NDA review takes 24 months. After a drug is approved by the FDA, it is the manufacturer's decision as to when to bring a product to the marketplace.

POSTMARKETING SURVEILLANCE STAGE

If the manufacturer decides to market the medicine, the postmarketing surveillance stage begins; this is the fourth stage of drug product development. This process consists of an ongoing review of adverse effects of the new drug and periodic inspections of the manufacturing facilities and the resulting products. Other studies completed during the fourth stage include identifying other patient populations for whom the drug may be useful, refining dosing recommendations, and exploring potential drug interactions.

Clinical Goldmine

Healthcare providers make a significant contribution to the knowledge of drug safety by reporting adverse effects to the FDA using the MedWatch program for the voluntary reporting of adverse events and product problems (see Online Resources).

BLACK BOX WARNING

Although the FDA's drug approval process is one of the most stringent in the world, the value of ongoing safety review of medicines has been demonstrated through the use of the MedWatch program. If safety concerns are identified after a drug is approved for marketing, the FDA can issue **black box warnings** to the package insert of the product. When a medication's risks and known dangers outweigh its benefits, the FDA and/or the manufacturer may decide that the product should be withdrawn from the market.

The probability of a drug acquiring a new black box warning or being withdrawn from the market within 25 years of being released is estimated at 20%. Consequently, it is the responsibility of all healthcare professionals to constantly monitor their patients for adverse effects of drugs and to complete a MedWatch form when adverse effects are suspected. More than 200,000 MedWatch forms are filed with the FDA annually. Health Canada has a program for reporting adverse effects (Canada Vigilance Program: https://www.canada.ca/en/health-canada/services/drugs-health-products/medeffect-canada/canada-vigilance-program.html).

From a safety standpoint, prescribers and patients should be aware that recently marketed medicines carry a risk of causing unsuspected serious adverse effects. Even with the high probability that there will be no serious complications, the devastating—and sometimes fatal—consequences cannot be ignored. When choosing medicines for treatment, it becomes important to consider whether an equally effective alternative drug is already available. At a minimum, this reduces the risk of an undiscovered adverse drug reaction, and it is often less expensive. At a maximum, the patient, the family, and the prescriber are saved the anguish of an avoidable adverse drug reaction.

RARE DISEASES AND THE DEVELOPMENT OF ORPHAN DRUGS

The National Organization for Rare Disorders, which is a coalition of 140 rare-disease groups, estimates that more than 6000 rare health conditions exist in about 20 million Americans. Examples of these rare diseases are cystic fibrosis, Hansen disease (leprosy), sickle cell anemia, blepharospasm, infant botulism, and *Pneumocystis jiroveci* pneumonia (see Online Resources). Historically, pharmaceutical manufacturers have been reluctant to develop products that could be used to treat these illnesses. The medicines that are developed for these conditions are known as **orphan drugs** because the manufacturers have been unable to recover the costs of the research on account of the very limited use of the final product. Because no companies were willing to "adopt" the diseases to complete extensive research to develop products for treatment, the diseases became known as *health orphans.*

In 1983 Congress passed the Orphan Drug Act to stimulate the development and market availability of products that are used for the treatment of rare diseases. The act defines the term *rare disease* as a condition that affects fewer than 200,000 people in the United States. The FDA's Office of Orphan Products Development (OOPD) promotes the development of products that demonstrate promise for the diagnosis or treatment of rare diseases or conditions. The OOPD interacts with medical and research communities, professional organizations, academia, and the pharmaceutical industry, as well as with rare-disease groups. The OOPD administers the major provisions of the Orphan Drug Act, which provide incentives for sponsors to develop products for rare diseases.

The law provides research grants, protocol development assistance by the FDA, special tax credits for the cost of clinical trials, and 7 years of exclusive marketing rights after the product has been approved. On average, an orphan drug receives FDA approval 10 to 11 months sooner than a nonorphan drug. The act has been quite successful: more than 200 new drugs have been approved by the FDA for rare diseases, benefiting several million people. Examples include

pentamidine and atovaquone for *Pneumocystis jiroveci* pneumonia, thalidomide for Hansen disease, zidovudine for the human immunodeficiency virus, dornase alfa (Pulmozyme) for cystic fibrosis, and cladribine (Leustatin) for hairy cell leukemia.

DRUG NAMES, STANDARDS, AND LEGISLATION IN CANADA

CANADIAN DRUG NAMES

OFFICIAL DRUG

The term *official drug* pertains to any drug for which a standard is described specifically in the Food and Drug Regulations or in any publication named in the Food and Drugs Act as being satisfactory for officially meeting the standards for drugs in Canada.

CHEMICAL NAME

The *chemical name* is most meaningful to the chemist. By means of the chemical name the chemist understands the exact chemical constitution of the drug and exact placing of its atoms or molecular groupings. The chemical name is the same in both Canada and the United States.

PROPER NAME OR GENERIC NAME

The *proper name* is the nonproprietary (generic) name, which is used to identify an official drug in Canada. The *generic name* is the same in both Canada and the United States.

BRAND NAME

The *brand name* (or proprietary name) is the name assigned to the drug by its manufacturer to distinguish the drug for advertisement and sale. Brand names for the same generic drug product are frequently different between Canada and the United States. The following example and Fig. 1.3 depict the application of terminology to drug nomenclature.

Example of Canadian Drug Names

Chemical name: 4-dimethylamino-1,4,4a,5,5a,6,11,12a-octahydro-3,6,10,12,12a-pentahydroxy-6-methyl-1,11,dioxo-2-napthacene carboxamide (see Fig. 1.3)
Proper name: tetracycline
Official name: Tetracycline, USP
Brand names: Apo-Tetra; Nu-Tetra

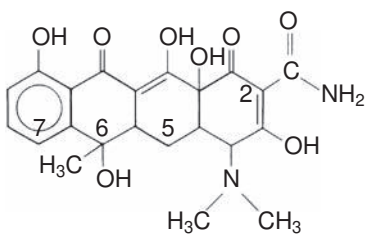


Fig. 1.3 Tetracycline, an antibiotic.

SOURCES OF CANADIAN DRUG STANDARDS

The Food and Drugs Act recognizes the standards described by international authoritative books as being acceptable for official drugs in Canada (see Table 1.2).

CANADIAN DRUG LEGISLATION

FOOD AND DRUGS ACT AND REGULATIONS

The **Food and Drugs Act** (1927) and **Regulations** (1953, 1954, 1979) empower Health Canada to protect the public from foreseeable risks related to the manufacture and sale of drugs, cosmetics, food, and therapeutic devices. The legislation provides for a review of the safety and efficacy of drugs before their clearance for marketing in Canada and determines whether the medicine is *prescription* or *nonprescription*. Also included in this legislation are requirements for good manufacturing practices, adequate labeling, and fair advertising.

In Canada (as in the United States), an effort has been made to align the provincial drug schedules so that the conditions for the sale of medicines are consistent across Canada. The National Association of Pharmacy Regulatory Authorities (NAPRA) governs national drug schedules but each province's regulatory body can regulate how a particular drug can be sold-sold/dispensed. The National Association of Pharmacy Regulatory Authorities (NAPRA) proposed a new national drug scheduling model. This model is in various stages of implementation across the provinces and territories of Canada. With the use of this model, all medicines in Canada are assigned to one of four categories:

Schedule I: All prescription drugs, including narcotics
Schedule II: Restricted-access nonprescription drugs
Schedule III: Pharmacy-only nonprescription drugs
Unscheduled: Drugs that are not assigned to the previous categories

Schedule II drugs are available for sale directly from the pharmacist and are kept "behind the counter." Examples include insulin, pseudoephedrine, glucagon, loperamide (for children younger than age 12 years), and nitroglycerin sublingual spray and tablets (other dosage forms are Schedule I). These medications are in two categories: (1) those that patients may require urgently and cannot delay taking until after an appointment with a prescriber (e.g., insulin, nitroglycerin, glucagon); and (2) those that require appropriate counseling to avoid improper use (e.g., loperamide, pseudoephedrine). Placement with a pharmacist does not allow for patient self-selection and allows for pharmacist intervention for these medications. This restriction is meant to ensure the following: (1) that patients are not self-diagnosing medically serious diseases (e.g., diabetes mellitus, angina); and (2) that patients are educated about the proper use of these drugs through appropriate counseling from the pharmacist.

Schedule III drugs are pharmacy-only nonprescription drugs. These medicines can be sold only

through pharmacies and include levonorgestrel emergency contraception, diphenhydramine, child preparations of antihistamines, and the low-dose histamine-2 antagonists. It is expected that if patients have questions, they could easily consult with a pharmacist.

Medicines that are not categorized in Schedule I, II, or III are considered to be "unscheduled" (e.g., nicotine gum and patches, acetylsalicylic acid, lower-dose ibuprofen, some lower-dosage "cough and cold" preparations) and can be sold at any retail outlet. Adequate information is available for the patient to make a safe and effective choice, and labeling is sufficient to ensure the appropriate use of the drug without professional supervision.

Drugs requiring a prescription—except for controlled drugs—are listed on Schedule F of the Food and Drug Regulations. Schedule F drugs may be prescribed only by qualified healthcare providers because they would normally be used most safely under supervision. Most antibiotics, antineoplastics, corticosteroids, cardiovascular drugs, and antipsychotics are Schedule F drugs.

CONTROLLED DRUGS AND SUBSTANCES ACT

The **Controlled Drugs and Substances Act** (1997) established the requirements for the import, production, export, distribution, and possession of substances classified as narcotics and substances of abuse in Canada. The Controlled Drugs and Substances Act describes eight schedules of controlled substances. Assignment to a schedule is based on the potential for abuse and the ease with which illicit substances can be manufactured in illegal laboratories. The degree of control; the conditions of record keeping; assignment of penalties for possession, trafficking, and manufacturing; and other regulations depend on these classifications. (Note that Schedules I, II, and III under the US Food and Drugs Act as described earlier are different from Schedules I through VIII of the Canadian Controlled Drugs and Substances Act). Examples of controlled substances schedule assignment are as follows:

Schedule I: Opium poppy and its derivatives (e.g., heroin, morphine); coca and its derivatives (e.g., cocaine), pethidine (meperidine), methadone, fentanyl

Schedule II: Cannabis

Schedule III: Amphetamines, methylphenidate, lysergic acid diethylamide (LSD), methaqualone, psilocybin, mescaline

Schedule IV: Sedative-hypnotic agents (e.g., barbiturates, benzodiazepines); butorphanol, anabolic steroids

Schedule V: Propylhexedrine, phenylpropanolamine, pyrovalerone

Schedule VI: Part I class A precursors (e.g., ephedrine, pseudoephedrine, norephedrine [phenylpropanolamine], ergotamine) and part II precursors (e.g., acetone, ethyl ether, hydrochloric acid, sulfuric acid, toluene)

Schedule VII: Cannabis resin (3 kg); cannabis (marijuana) (3 kg) (must be read in conjunction with Schedule II)

Schedule VIII: Cannabis resin (1 g); cannabis (marijuana) (30 g) (must be read in conjunction with Schedule II)

The Controlled Drugs and Substances Act and accompanying regulations provide for the nonprescription sale of certain codeine preparations (e.g., Tylenol No. 1 with codeine, Benylin with codeine). The content must not exceed the equivalent of 8 mg of codeine phosphate per solid dosage unit or 20 mg per 30 mL of a liquid preparation, and the preparation must also contain two additional nonnarcotic medicinal ingredients. These preparations may not be advertised or displayed, and they may be sold only by pharmacists (see previous discussion of Schedule II drugs). In hospitals, the pharmacy usually requires strict inventory control of these products and other narcotics.

Requirements for the legitimate administration of drugs to patients by nurses are generally similar in Canada and the United States. Individual hospital policy determines specific record-keeping requirements on the basis of federal and provincial laws. Violations of these laws will result in fines or imprisonment in addition to the loss of professional licensing.

NONPRESCRIPTION DRUGS

The NAPRA drug schedules list three categories of nonprescription drugs: Schedule II, Schedule III, and unscheduled drugs (see discussion under Food and Drugs Act and Regulations).

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions

Key Points

- In the classification system used in the United States, each drug has three names: a *chemical* name, a *generic* name, and a *brand* name. The chemical name is most meaningful to the chemist. The generic name is simpler than the chemical name. The first letter of the generic name is not capitalized. The brand names are selected by the manufacturer and deliberately made easier to pronounce, spell, and remember. A brand name is followed by the symbol ®. The first letter of the brand name is capitalized.
- Drugs may be classified by a variety of methods according to the *body system* that they affect (e.g., the central nervous system, the cardiovascular system, the gastrointestinal system); their *therapeutic use* or *clinical indications* (e.g., antacids, antibiotics, antihypertensives, diuretics, laxatives); and their *physiologic* or *chemical action* (e.g., anticholinergic agents, beta-adrenergic blockers, calcium channel blockers, cholinergic agents).
- Table 1.2 lists and describes the common sources of drug information available for the healthcare provider.
- Prescription drugs require an order by a healthcare provider who is licensed to prescribe drugs, such as a primary healthcare provider, a nurse practitioner, a physician assistant, a pharmacist, or a dentist. Nonprescription or over-the-counter (OTC) drugs are sold without a prescription in a pharmacy or in the health section of department or grocery stores.
- Rules and regulations evolved by the FDA divide new drug development into four stages: (1) preclinical research and development; (2) clinical research and development; (3) new drug application review; and (4) postmarketing surveillance (see Fig. 1.2).
- In Canada, the *proper name* is the nonproprietary (generic) name, which is used to identify an official drug. The *generic name* is the same in both Canada and the United States.

Additional Learning Resources

SG Go to your Study Guide for additional Review Questions for the NCLEX® Examination, Critical Thinking Clinical Situations, and other learning activities to help you master this chapter content.

Go to your Evolve website (https://evolve.elsevier.com/Clayton) for additional online resources.

Online Resources

- DailyMed: https://dailymed.nlm.nih.gov/dailymed/index.cfm
- ePocrates: http://www.epocrates.com/
- iPharmacy: https://itunes.apple.com/us/app/ipharmacy-drug-guide-pubmed-direct/id378721295
- Lexicomp: http://www.wolterskluwercdi.com/lexicomp-online/
- MedicinesComplete: https://about.medicinescomplete.com/#/
- MedWatch: https://www.fda.gov/Safety/MedWatch/default.htm
- National Organization for Rare Disorders (NORD): https://rarediseases.org/
- UpToDate: https://www.uptodate.com/home
- US National Library of Medicine: https://www.nlm.nih.gov/

Online Resources for Canadian Practitioners

- Controlled Substances and Drugs Act (Justice Laws Website): http://laws-lois.justice.gc.ca/eng/acts/c-38.8/
- Drug Product Database: https://www.canada.ca/en/health-canada/services/drugs-health-products/drug-products/drug-product-database.html
- National Association of Pharmacy Regulatory Authorities (NAPRA) proposal for drug schedule outlines: http://napra.ca/national-drug-schedules

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questionsn

The National Council of State Boards of Nursing (NCSBN) is the body that develops and administers the NCLEX (National Council Licensure Exam). Recent studies indicate that graduates need to develop the skill of clinical decision making, so the NCLEX examination is changing with different types of questions that are designed to develop clinical judgment in patient situations. These type of questions are referred to as Next Generation NCLEX or NGN. The following questions are typical of the NCLEX examination and include both NGN (Next Generation) and traditional questions. Within each chapter the NCLEX section will identify the objective associated with it, the type of NCLEX question that will be used, and the cognitive skill associated with the item type. Six essential cognitive skills of clinical judgment are being tested: recognize cues; analyze cues; prioritize hypotheses; generate solutions; take action; and evaluate outcomes. These six clinical judgment skills build on and expand the nursing process (NCSBN, 2019).

TRADITIONAL NCLEX-TYPE QUESTIONS	NGN-TYPE QUESTIONS
Multiple Choice Test Item Multiple Response Test Item Ordering Test Item	• Enhanced Hot Spot Test Item • Cloze Test Item • Extended Multiple Response Test Item • Extended Drag and Drop Test Item • Matrix Text Item

1. **A patient has received a prescription from his primary care provider for the drug metoprolol (Lopressor). He asks the nurse why there are two names for the same drug. The nurse responds with which statements(s)?** *(Select all that apply.)*
   1. "One of the names is the brand name of the drug, and the other is the generic name."
   2. "When drugs are discovered, all drugs are given a detailed chemical name and a simple generic name. If the company that discovered the drug brings it to the marketplace for sale, the manufacturer will give it a distinctive brand name."
   3. "Lopressor is the generic name, and metoprolol is the brand name."
   4. "The two names are used to determine whether the drug is a Schedule III or a Schedule IV drug."
   5. "Generally, the generic product of the drug is less expensive than the brand name product."

   Objective: Differentiate between the chemical, generic, and brand names of drugs.
   NCLEX test item: Multiple response
   Cognitive skill: Application

2. **Drugs can be classified using various methods; identify the different classification and examples as indicated.**

   Choose the most likely option for the information missing from the statements below by selecting from the list of options provided.

   Medications such as _____1_____ are classified by the _____2_____ method, whereas medications such as _____1_____ are classified by the _____2_____ method.

OPTIONS FOR 1	OPTIONS FOR 2
• antacids • antibiotics • calcium channel blockers • Diuretics • Cholinergics	• body systems • chemical action • clinical indication

   Objective: Identify the various methods used to classify drugs.
   NGN test item: Cloze
   Cognitive skill: Analyze cues

3. **A young mother with a 2-month-old infant tells the nurse that she is concerned about the use of any medications because she is breastfeeding her baby. The nurse reviews the possible information sources to discuss with the mother.**

Indicate with an X in the "recommended by the nurse" column the source of drug information listed in the left column the nurse can recommend for the mother to use. Note that not all drug information sources will be used.

DRUG INFORMATION SOURCE	RECOMMENDED BY THE NURSE
Nursing journals	
Electronic databases	
Package inserts	
Natural medicines database	

Objective: Identify sources of drug information available for healthcare providers.
NGN test item: Extended drag and drop
Cognitive skill: Take action

4. **The nurse knows which of these factors are the differences between prescription and nonprescription drugs?** *(Select all that apply.)*
   1. Nonprescription drugs are available over-the-counter.
   2. Prescription drugs are those drugs that may be prescribed by dentists, pharmacists, nurse practitioners, and primary healthcare providers.
   3. Recreational drugs are available by prescription only.
   4. Over-the-counter drugs are available at a pharmacy or health section of grocery stores.
   5. Prescription drugs have been approved for use by the FDA.

   Objective: Discuss the difference between prescription and nonprescription drugs.
   NCLEX test item: Multiple response
   Cognitive skill: Application

5. **During which stage of the process of new drug development does testing on humans start?**
   1. The preclinical research and development stage
   2. The postmarketing surveillance stage
   3. The postclinical research and development stage
   4. The clinical research and development stage

   Objective: Describe the process of developing and bringing new drugs to market.
   NCLEX test item: Multiple choice
   Cognitive skill: Knowledge

6. **A nurse is teaching a patient from Canada the names of her medications and reviews the differences between Canadian names. Which statement indicates that the patient understands the instructions?**
   1. "The proper name of the medication is the same as the brand name in Canada."
   2. "The proper name of the medication is the same as the generic name in Canada."
   3. "The chemical name is the one used the most when buying medications in Canada."
   4. "The chemical names and the brand names are the only names used in Canada."

   Objective: Differentiate between the Canadian *chemical* name and the *proper* name of a drug.
   NCLEX test item: Multiple choice
   Cognitive skill: Evaluation

Basic Principles of Drug Action and Drug Interactions

2

https://evolve.elsevier.com/Willihnganz

Objectives

1. Identify common drug administration routes.
2. Identify the meaning and significance of the term *half-life* when used in relation to drug therapy.
3. Describe the process of how a drug is metabolized in the body.
4. Compare and contrast the following terms that are used in relationship to medications: *desired action, common adverse effects, serious adverse effects, allergic reactions,* and *idiosyncratic reactions.*
5. Identify what is meant by a drug interaction.
6. Differentiate among the terms *additive effect, synergistic effect, antagonistic effect, displacement, interference,* and *incompatibility.*
7. Identify one way in which alternatives in metabolism create drug interactions.

Key Terms

receptors (rē-SĔP-tĕrz) (p. 13)
pharmacodynamics (fär-mă-kō-dī-NĂM-ĭks) (p. 13)
agonists (ĂG-ŏ-nĭsts) (p. 13)
antagonists (ăn-TĂG-ŏ-nĭsts) (p. 13)
partial agonists (PĂR-shŭl ĂG-ŏ-nĭsts) (p. 13)
enteral (ĔN-tĕr-ăl) (p. 14)
parenteral (pă-RĔN-tĕr-ăl) (p. 14)
percutaneous (pĕr-kū-TĀ-nē-ŭs) (p. 14)
pharmacokinetics (fär-mă-kō-kĭ-NĔT-ĭks) (p. 14)
absorption (ăb-SŎRP-shŭn) (p. 14)
distribution (dĭs-trĭ-BŪ-shŭn) (p. 15)
drug blood level (p. 15)
metabolism (mĕ-TĂB-ō-lĭz-ĕm) (p. 15)
excretion (ĕks-KRĒ-shŭn) (p. 15)
half-life (p. 16)
onset of action (p. 17)
peak action (p. 17)
duration of action (p. 17)
desired action (p. 17)
side effects (p. 17)
common adverse effects (ĂD-vŭrs ĕ-FĔKTS) (p. 17)
serious adverse effects (p. 17)
idiosyncratic reaction (ĭd-ē-ō-sĭn-KRĂT-ĭk rē-ĂK-shŭn) (p. 18)
allergic reactions (ă-LŬR-jĭk) (p. 18)
drug interaction (p. 18)
unbound drug (ŭn-BŎWND) (p. 18)
additive effect (ĂD-ĭ-tĭv) (p. 19)
synergistic effect (sĭn-ĕr-JĬS-tĭk) (p. 19)
antagonistic effect (ăn-tăg-ŏ-NĬST-ĭk) (p. 19)
displacement (dĭs-PLĀS-mĕnt) (p. 19)
interference (ĭn-tŭr-FĒR-ĕns) (p. 19)
incompatibility (ĭn-kŏm-păt-ĭ-BĬL-ĭ-tē) (p. 19)

BASIC PRINCIPLES RELATED TO DRUG THERAPY

DRUG RESPONSES IN THE BODY

When administered to the body, drugs do not create new responses but rather alter existing physiologic activity in several different ways. Usually the drug forms chemical bonds with specific sites, called **receptors**, within the body. This bond forms only if the drug and its receptor have similar shapes and if the drug has a chemical affinity for the receptor. The relationship between a drug and a receptor is similar to that seen between a key and lock (Fig. 2.1A). The study of the interactions between drugs and their receptors and the series of events that result in a pharmacologic response is called **pharmacodynamics**. Most drugs have several different atoms within each molecule that interlock into various locations on a receptor. The better the fit between the receptor and the drug molecule, the better the response from the drug. The intensity of a drug response is related to how well the drug molecule fits into the receptor and to the number of receptor sites that are occupied. Drugs that interact with a receptor to stimulate a response are known as **agonists** (Fig. 2.1B). Drugs that attach to a receptor but do not stimulate a response are called **antagonists** (Fig. 2.1C). Drugs that interact with a receptor to stimulate a response but inhibit other responses are called **partial agonists** (Fig. 2.1D).

Drug response must be stated in relation to the physiologic activity expected in response to the drug therapy (e.g., an antihypertensive agent is successful if the patient's blood pressure is lower after receiving the drug than it was before the drug was started). Therefore it is important to perform a thorough nursing assessment to identify the baseline data. After that is done, results from regular assessments can be compared

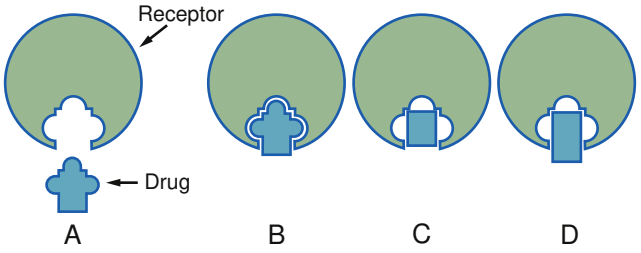


Fig. 2.1 (A) Drugs act by forming chemical bonds with specific receptor sites, similar to a key and lock. The better the fit, the better the response. (B) Drugs with complete attachment and response are called *agonists.* (C) Drugs that attach but do not elicit a response are called *antagonists.* (D) Drugs that attach and elicit a small response but also block other responses are called *partial agonists.*

Table 2.1 Drug Therapy Used in Disease Management[a]

DISEASES/ILLNESSES	CLASSIFICATION OF THE DRUGS USED
Cancer	Chemotherapy, immunotherapy
Mental illness	Antidepressants and antipsychotic agents
Hypertension	Antihypertensive agents
Diabetes	Antidiabetic agents
Infections	Antimicrobial agents
Inflammatory diseases	Antiinflammatory agents
Nausea and vomiting	Antiemetic agents
Constipation	Laxatives
Diarrhea	Antidiarrheal agents
GERD	Antacids

[a]List is not inclusive.
GERD, Gastroesophageal reflux disease.

with the baseline data by the primary healthcare provider, the nurse, and the pharmacist to evaluate the effectiveness of the drug therapy. Table 2.1 lists examples of drug therapies and their related diseases.

ROUTES OF DRUG ADMINISTRATION

The most common routes of drug administration are the enteral, parenteral, and percutaneous routes. When using the **enteral** route, the drug is administered directly into the gastrointestinal (GI) tract by the oral, rectal, or nasogastric route. The **parenteral** route bypasses the GI tract with the use of subcutaneous (subcut), intramuscular (IM), or intravenous (IV) injection. The **percutaneous** route involves drugs being absorbed through the skin and mucous membranes. Methods of the percutaneous route include inhalation, sublingual (under the tongue), and topical (on the skin) administration.

LIBERATION, ABSORPTION, DISTRIBUTION, METABOLISM, AND EXCRETION

After they have been administered, all drugs go through five stages: ***l***iberation, ***a***bsorption, ***d***istribution, ***m***etabolism, and ***e***xcretion (LADME). After liberation from the dosage form, each drug has its own unique ADME characteristics. The study of the mathematical relationships among the ADME features of individual medicines over time is called **pharmacokinetics**.

Liberation

Regardless of the route of administration, a drug must be released from the dosage form (i.e., liberated) and dissolved in body fluids before it can be absorbed into body tissues. For example, before a solid drug that is taken orally can be absorbed into the bloodstream for transport to the site of action, the dosage form (usually a capsule or tablet) must disintegrate and the active drug must dissolve in the GI fluids so that it can be transported across the stomach or intestinal lining into the blood. The process of converting the drug into a form that will activate a response can be partially controlled by the pharmaceutical dosage form used (e.g., solution, suspension, capsule, tablet [with various coatings]). This conversion process can also be influenced by administering the drug with or without water or food in the patient's stomach.

Absorption

Absorption is the process whereby a drug is transferred from its site of entry into the body to the circulating fluids of the body (i.e., blood and lymph) for distribution around the body. The rate at which this occurs depends on the route of administration, the blood flow through the tissue where the drug is administered, and the solubility of the drug. It is therefore important to do the following: (1) administer oral drugs with an adequate amount of fluid (usually a large [8-ounce] glass of water); (2) give parenteral forms properly so that they are deposited in the correct tissue for enhanced absorption; and (3) reconstitute and dilute drugs only with the diluent recommended by the manufacturer in the package literature so that drug solubility is not impaired. Equally important are nursing assessments that reveal poor absorption (e.g., if insulin is administered subcutaneously and a lump remains at the site of injection 2 to 3 hours later, absorption from that site may be impaired).

The rate of absorption when a drug is administered by a parenteral route depends on the rate of blood flow through the tissues. Circulation or blood flow must be determined before the administration of drugs by the parenteral route to identify any circulatory insufficiency. If any such insufficiency is noted, injections will not be absorbed properly, and the drug will not be effective. Subcut injections have the slowest absorption rate, especially if peripheral circulation is impaired. IM injections are more rapidly absorbed because of greater blood flow per unit weight of muscle compared with subcut tissue. Cooling the area of injection slows the rate of absorption, whereas heat or massage hastens the rate of absorption. Drugs are dispersed throughout the body most rapidly when they are administered by IV injection. The nurse must be thoroughly educated

regarding the responsibilities and techniques associated with administering IV medications. It is important to remember that after a drug enters the patient's bloodstream, it cannot be retrieved.

The absorption of topical drugs that have been applied to the skin can be influenced by the drug concentration, the length of contact time, the size of the affected area, the thickness of the skin surface, the hydration of the tissue, and the degree of skin disruption. Percutaneous (i.e., across-the-skin) absorption is greatly increased in newborns and young infants, who have thin, well-hydrated skin. When drugs are inhaled, their absorption can be influenced by the depth of the patient's respirations, the fineness of the droplet particles, the available surface area of the patient's mucous membranes, the contact time, the hydration state, the blood supply to the area, and the concentration of the drug itself.

Distribution

The term **distribution** refers to the ways in which a drug is transported throughout the body by the circulating body fluids to the sites of action or to the receptors that the drug affects. *Drug distribution* refers to the transport of the drug throughout the entire body by the blood and lymphatic systems and the transport from the circulating fluids into and out of the fluids that bathe the receptor sites. Organs with the most extensive blood supplies (e.g., heart, liver, kidneys, brain) receive the distributed drug most rapidly. Areas with less extensive blood supplies (e.g., muscle, skin, fat) receive the drug more slowly.

After a drug has been dissolved and absorbed into the circulating blood, its distribution is determined by the chemical properties of the drug and how it is affected by the blood and tissues that it contacts. Two factors that influence drug distribution are protein binding and lipid (fat) solubility. Most drugs are transported in combination with plasma proteins (especially albumin), which act as carriers for relatively insoluble drugs. Drugs that are bound to plasma proteins are pharmacologically inactive because the large size of the complex keeps them in the bloodstream and prevents them from reaching the sites of action, metabolism, and excretion. Only the free, or *unbound*, portion of a drug is able to diffuse into tissues, interact with receptors, and produce physiologic effects; it is also only this portion that can be metabolized and excreted. The same proportions of bound and free drug are maintained in the blood at all times. Thus as the free drug acts on receptor sites or is metabolized, the decrease in the serum drug level causes some of the bound drug to be released from protein to maintain the ratio between bound and free drug.

When a drug leaves the bloodstream, it may become bound to tissues other than those with active receptor sites. The more lipid-soluble drugs have a high affinity for adipose tissue, which serves as a repository site for these agents. Because there is a relatively low level of blood circulation to fat tissues, the more lipid-soluble drugs tend to stay in the body much longer. Equilibrium is established between the repository site (i.e., lipid tissue) and the circulation so that as the **drug blood level** drops as a result of binding at the sites of physiologic activity, metabolism, or excretion, more drug is released from the lipid tissue. By contrast, if more drug is given, a new equilibrium is established among the blood, the receptor sites, the lipid tissue repository sites, and the metabolic and excretory sites.

Distribution may be general or selective. Some drugs cannot pass through certain types of cell membranes, such as the blood-brain barrier (i.e., the central nervous system) or the placental barrier (i.e., the placenta), whereas other types of drugs readily pass into these tissues. The distribution process is very important because the amount of drug that actually gets to the receptor sites determines the extent of pharmacologic activity. If little of the drug actually reaches and binds to the receptor sites, the response will be minimal.

Metabolism

Metabolism is the process whereby the body inactivates drugs. The enzyme systems of the liver are the primary sites for the metabolism of drugs, but other tissues and organs (e.g., white blood cells, GI tract, lungs) metabolize certain drugs to a minor extent. Genetic, environmental, and physiologic factors are involved in the regulation of drug metabolism reactions. The most important factors for the conversion of drugs to their metabolites are genetic variations of enzyme systems, the concurrent use of other drugs, exposure to environmental pollutants, concurrent illnesses, and age. (For more information, see Chapter 3.)

Excretion

The elimination of drug metabolites and, in some cases, of the active drug itself from the body is called **excretion**. The two primary routes of excretion are through the GI tract into the feces and through the renal tubules into the urine. Other routes of excretion include evaporation through the skin, exhalation from the lungs, and secretion into saliva and breast milk.

Because the kidneys are major organs of drug excretion, the nurse should review the patient's chart for the results of urinalysis and renal function tests. A patient with renal failure often has an increase in the action and duration of a drug if the dosage and frequency of administration are not adjusted to allow for the patient's reduced renal function.

Fig. 2.2 shows a schematic review of the ADME process of an oral medication. It is important to note how little of the active ingredient actually reaches the receptor sites for action.

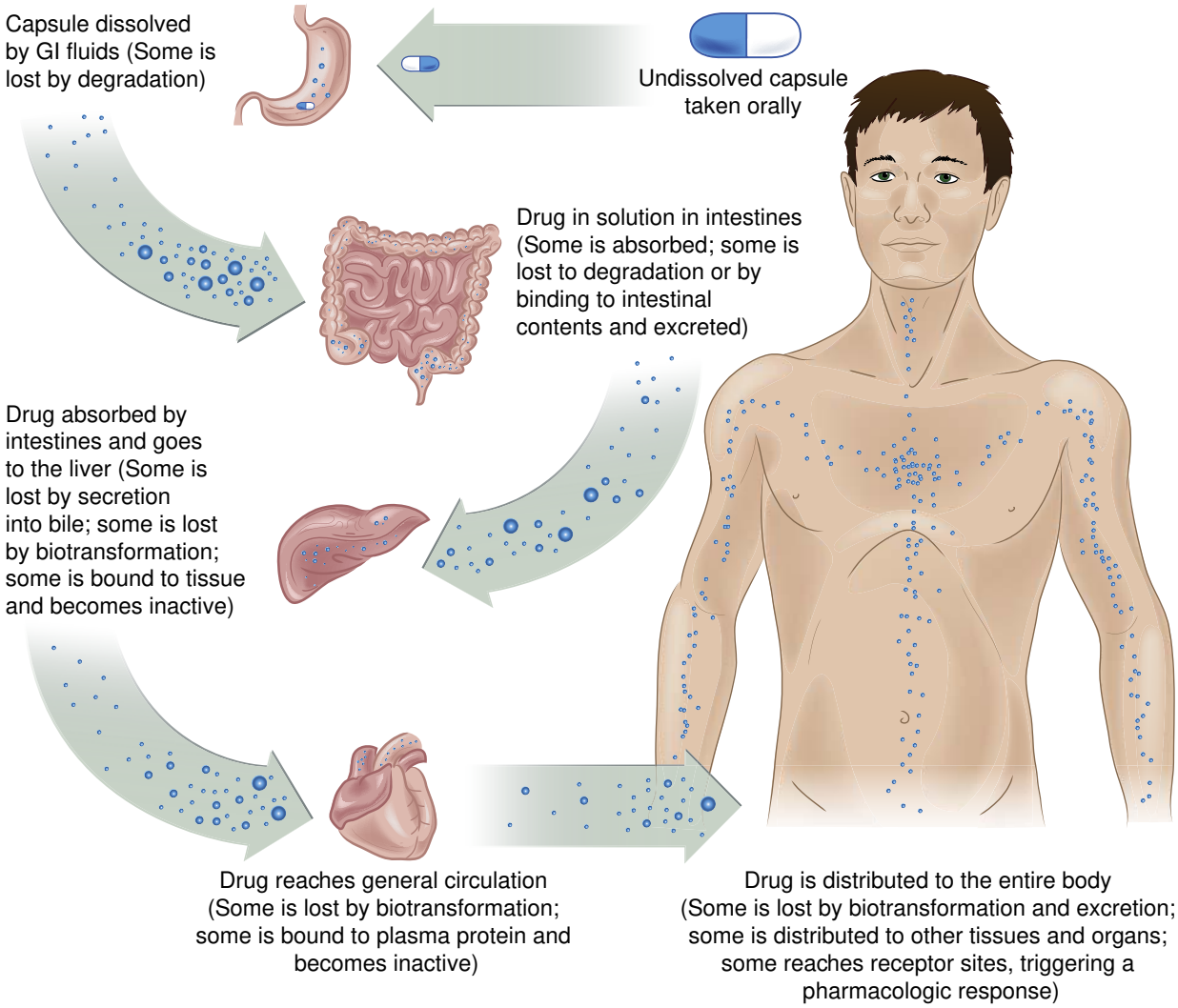


Fig. 2.2 Factors that modify the quantity of drug that reaches a site of action after a single oral dose. *GI*, Gastrointestinal.

HALF-LIFE

Drugs are eliminated from the body by means of metabolism and excretion. A measure of the time required for elimination is the half-life. The **half-life** is defined as the amount of time required for 50% of the drug to be eliminated from the body. For example, if a patient is given 100 mg of a drug that has a half-life of 12 hours, the following would be observed:

TIME (HOURS)	HALF-LIFE	DRUG REMAINING IN BODY (%)
0	—	100 mg (100)
12	1	50 mg (50)
24	2	25 mg (25)
36	3	12.5 mg (12.5)
48	4	6.25 mg (6.25)
60	5	3.12 mg (3.12)

Note that as each 12-hour period (i.e., one half-life) passes, the amount remaining is 50% of what was there 12 hours earlier. After six half-lives, more than 98% of the drug has been eliminated from the body.

The half-life is determined by an individual's ability to metabolize and excrete a particular drug. Because most patients metabolize and excrete a particular drug at approximately the same rate, the approximate half-lives of most drugs are now known. When the half-life of a drug is known, dosages and frequency of administration can be calculated. Drugs with long half-lives (e.g., digoxin, with a half-life of 36 hours) need to be administered only once daily, whereas drugs with short half-lives (e.g., aspirin, with a half-life of 5 hours) need to be administered every 4 to 6 hours to maintain therapeutic activity. For patients who have impaired hepatic or renal function, the half-life may become considerably longer because of their reduced ability to metabolize or excrete the drug. For example, digoxin has a half-life of about 36 hours in a patient with normal renal function; however, it has a half-life of about 105 hours in a patient with complete renal failure. Monitoring diagnostic tests that measure renal or hepatic function is important. Whenever laboratory data reflect impairment of

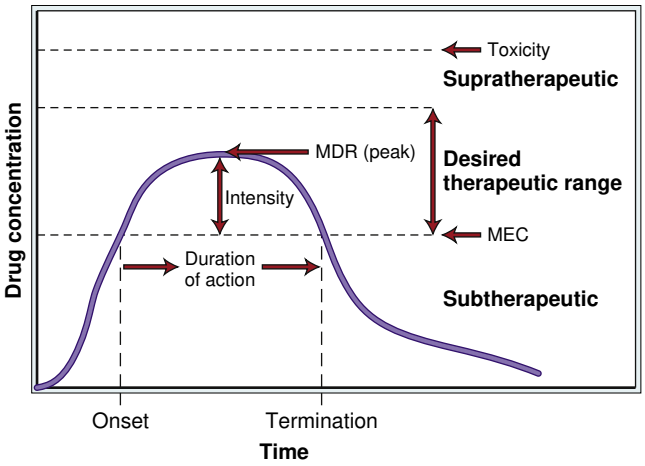


Fig. 2.3 A time-response curve, which is also known as a *drug concentration–time profile*, demonstrates the relationship between the administration of a drug and the patient's response. If the drug level does not reach the minimum effective concentration *(MEC)*, there will be no pharmacologic effect. If the peak level exceeds the toxicity threshold, toxic effects will result. The optimal drug concentration is in the middle of the therapeutic range. *MDR*, Maximum drug response (peak effect).

either function, the nurse should notify the healthcare provider.

DRUG ACTIONS

All drug actions have an onset, peak, and duration of action. The **onset of action** is when the concentration of a drug at the site of action is sufficient to start a physiologic (pharmacologic) response. Many factors—such as the route of administration and the rates of absorption, distribution, and binding to receptor sites—affect the onset of action. In general, increasing the dose of the drug hastens the onset of action by shortening the time required to achieve the necessary concentration of drug at the target site. **Peak action** is the time at which the drug reaches the highest concentrations on the target receptor sites, thereby inducing the maximal pharmacologic response for the dose given. The **duration of action** is how long the drug has a pharmacologic effect. The onset, peak, and duration of action of a drug are often illustrated by a time-response curve, which is also known as a drug concentration–time profile (Fig. 2.3). A time-response curve demonstrates the relationship between the administration of a drug and the associated response. If the drug level does not reach the minimum effective concentration, there will be no pharmacologic effect. If the peak level exceeds the toxicity threshold, toxic effects will result. Generally, the drug concentration is targeted to be in the middle of this range, between the minimum effective response and the toxic response; this is referred to as the *therapeutic range.*

DRUG BLOOD LEVEL

When a drug is circulating in the blood, a blood sample may be drawn and assayed to determine the amount of drug present. This is known as a *drug blood level.* It is important for certain drugs (e.g., anticonvulsants, aminoglycoside antibiotics) to be measured to ensure that the drug blood level is within the therapeutic range. If the drug blood level is low, the dosage must be increased, or the medicine must be administered more frequently. If the drug blood level is too high, the patient may develop signs of toxicity; in this case, the dosage must be reduced or the medicine administered less frequently.

ADVERSE EFFECTS OF DRUGS

No drug has a single action. When a drug enters a patient and is then absorbed and distributed, the **desired action** (i.e., the expected response) usually occurs. However, all drugs have the potential to affect more than one body system simultaneously, thereby producing responses that are known as **side effects** or **common adverse effects**, which are mild, or **serious adverse effects**, which can lead to toxicity. The World Health Organization's definition of an adverse drug reaction (ADR) is "any noxious, unintended, and undesired effect of a drug, which occurs at dosages used in humans for prophylaxis, diagnosis, or therapy." A more common definition is as follows: "Right drug, right dose, right patient, bad effect." ADRs should not be confused with medication errors or adverse drug events (ADEs), which are defined as "an injury resulting from medical intervention related to a drug." (For more information, see Chapter 6.)

Recent studies have indicated the following:

- ADRs may be responsible for more than 100,000 deaths among hospitalized patients per year, which makes them one of the top six leading causes of death in the United States.
- An average of 6% of hospitalized patients experience a significant ADR at some point during their hospitalizations.
- Between 5% and 9% of hospitalization costs are attributable to ADRs.
- The most commonly seen ADRs are rash, nausea, itching, thrombocytopenia, vomiting, hyperglycemia, and diarrhea.
- The classes of medicines that account for the largest number of ADRs are antibiotics, cardiovascular medicines, cancer chemotherapy agents, analgesics, and antiinflammatory agents.

Most ADEs are predictable because of the pharmacologic effects of a drug, and patients should be monitored so that dosages can be adjusted to allow for the maximum therapeutic benefits with a minimum of adverse effects. As described in Units III through X of this text, each drug has a series of parameters (e.g., therapeutic actions to expect, adverse effects, probable drug interactions) that should be monitored by the nurse, primary healthcare provider, pharmacist, and patient to optimize therapy while reducing the possibility of serious adverse effects.

Accurate and appropriate drug-drug interaction information must be available to prescribers, and continual attention is currently focused on this issue. Further

population-based studies still need to be conducted to meet federal initiatives to promote the meaningful use of information technologies and to integrate knowledge databases with clinical decision systems. Ideally, clinical decision systems and the databases of drug interactions that interface with them help the prescriber to identify and avoid potential medication interactions.

All hospitals have internal mechanisms for reporting suspected ADRs, and healthcare providers should not hesitate to report possible reactions. By monitoring and tracking the occurrences of ADRs, clinical protocols and improved patient screening will reduce the frequency of recurrence. The US Food and Drug Administration's MedWatch program is also available for the voluntary reporting of adverse events. (For more information, see MedWatch on Evolve.)

Idiosyncratic Reaction

Two other types of drug actions are much more unpredictable: idiosyncratic reactions and allergic reactions. An **idiosyncratic reaction** occurs when something unusual or abnormal happens when a drug is first administered. The patient usually demonstrates an unexpectedly strong response to the action of the drug. This type of reaction is generally the result of a patient's inability to metabolize a drug because of a genetic deficiency of certain enzymes. Fortunately, this type of reaction is rare.

Allergic Reaction

Allergic reactions, which are also known as *hypersensitivity reactions*, occur in about 6% to 10% of patients who are taking medications. Allergic reactions occur among patients who have previously been exposed to a drug and whose immune systems have developed antibodies to the drug. On reexposure to the drug, the antibodies cause a reaction; this reaction is most commonly seen as raised, irregularly shaped patches on the skin known as *hives*, which cause severe itching, known as *urticaria.*

Occasionally, a patient has a severe, life-threatening reaction that causes respiratory distress and cardiovascular collapse; this is known as an *anaphylactic reaction.* This condition is a medical emergency, and it must be treated immediately. Fortunately, anaphylactic reactions occur much less often than the more mild urticarial reactions.

If a patient has a mild reaction, it should be understood as a warning to not take the medication again. The patient is much more likely to have an anaphylactic reaction during their next exposure to the drug. Patients should receive information about the drug name and be instructed to tell healthcare providers that they have had such reactions and that they must not receive the drug again. In addition, patients should wear a medical alert bracelet or necklace that explains the allergy.

DRUG INTERACTIONS

A **drug interaction** is said to occur when the action of one drug is altered or changed by the action of another drug. Drug interactions are elicited in two ways: (1) by agents that, when combined, *increase* the actions of one or both drugs; and (2) by agents that, when combined, *decrease* the effectiveness of one or both drugs. Some drug interactions are beneficial, such as the use of caffeine, a central nervous system stimulant, with an antihistamine, a central nervous system depressant. The stimulatory effects of the caffeine counteract the drowsiness caused by the antihistamine without eliminating the antihistaminic effects. The mechanisms of drug interactions can be categorized as those that change the absorption, distribution, metabolism, or excretion of a drug and those that enhance the pharmacologic effect of a drug.

CHANGES IN ABSORPTION

Most drug interactions that change absorption take place in the GI tract, usually the stomach. Examples of this type of interaction include the following:

- Antacids inhibit the dissolution of ketoconazole tablets by increasing the gastric pH. The interaction is managed by giving the antacid at least 2 hours after ketoconazole administration.
- Aluminum-containing antacids inhibit the absorption of tetracycline. Aluminum salts form an insoluble chemical complex with tetracycline. The interaction is managed by separating the administration of tetracycline and antacids by 3 to 4 hours.

CHANGES IN DISTRIBUTION

Drug interactions that cause a change in distribution usually affect the binding of a drug to an inactive site (e.g., circulating plasma albumin, muscle protein). When a drug is absorbed into the blood, it is usually transported throughout the body bound to plasma proteins. It often binds to other proteins, such as those in muscle. A drug that is highly bound (e.g., >90% bound) to a protein-binding site may be displaced by another drug that has a higher affinity for that binding site. Significant interactions can take place this way because little displacement is required to have a major impact. Remember, only the **unbound drug** is pharmacologically active. If a drug is 90% bound to a protein, then 10% of the drug is providing the physiologic effect. If another drug is administered with a stronger affinity for the protein-binding site and it displaces just 5% of the bound drug, there is now 15% unbound for physiologic activity; this is the equivalent of a 50% increase in dosage (i.e., from 10% to 15% active drug). For example, the anticoagulant action of warfarin is increased by administration with furosemide, which is a loop diuretic. Furosemide displaces warfarin from albumin-binding sites, thereby increasing the amount of unbound anticoagulant. This interaction is managed by decreasing the warfarin dosage.

CHANGES IN METABOLISM

Drug interactions usually result from a change in metabolism that involves inhibiting or inducing (stimulating)

the enzymes that metabolize a drug. Medicines known to bind to enzymes and to slow the metabolism of other drugs include verapamil, ketoconazole, amiodarone, cimetidine, and erythromycin. Serum drug levels usually increase as a result of inhibited metabolism when these drugs are given concurrently, and the dosages of the inhibited drugs usually must be reduced to prevent toxicity. For example, erythromycin inhibits the metabolism of theophylline; therefore the dose of theophylline must be reduced on the basis of theophylline serum levels and signs of toxicity. Because erythromycin (an antibiotic) is usually administered only in short courses, the theophylline dosage usually needs to be increased when the erythromycin is discontinued.

Common drugs that bind to enzymes and increase the metabolism of other drugs (enzyme inducers) are phenobarbital, carbamazepine, rifampin, and phenytoin. Rapidly metabolized drugs include doxycycline, warfarin, metronidazole, theophylline, and verapamil. When administered with enzyme inducers, the dosages of the more rapidly metabolized drugs should generally be increased to provide therapeutic activity. The patient must be monitored closely for adverse effects. For example, if a woman who is taking oral contraceptives (see Chapter 40) requires a course of rifampin antimicrobial therapy, the rifampin will induce the enzymes that metabolize both the progesterone and estrogen components of the contraceptive, thereby causing an increased incidence of menstrual abnormalities and reduced effectiveness of conception control. This interaction is managed by advising the patient to use an additional form of contraception while she is receiving rifampin therapy. Adverse effects may also occur if an enzyme inducer is discontinued. The metabolism of the induced drug then decelerates, leading to accumulation and toxicity if the dosage is not reduced.

CHANGES IN EXCRETION

Drug interactions that cause a change in excretion usually act in the kidney tubules by changing the pH to enhance or inhibit excretion. The classic example of altered urine pH is the combination of acetazolamide (which elevates urine pH) and quinidine. The alkaline urine produced by acetazolamide causes quinidine to be reabsorbed in the renal tubules, which potentially increases the physiologic and toxic effects of quinidine. The frequent monitoring of quinidine serum levels and assessments for signs of quinidine toxicity are used as guides for reducing quinidine dosage.

DRUGS THAT ENHANCE THE PHARMACOLOGIC EFFECTS OF OTHER DRUGS

Major drug interactions also occur between drugs. This may occur when one drug enhances the physiologic effects of another drug. Alcohol and sedative-hypnotic agents both cause sedation, but when used together can cause significant central nervous system depression. Another drug interaction that can have serious consequences is the interaction between aminoglycoside antibiotics (gentamicin, tobramycin) and a neuromuscular blocking agent such as pancuronium. When used together, the antibiotic increases the neuromuscular blockade, prolonging return to normal respirations and recovery time. Table 2.2 defines the terminology related to drug-drug interactions.

Because it is impossible to memorize all possible drug interactions, the nurse must check for drug interactions when they are suspected. The nurse must take the time to consult drug resource books and pharmacists to ensure that a patient who is receiving multiple medications does not experience unanticipated drug interactions.

Table 2.2 Terminology Related to Drug-Drug Interactions

TERM	DEFINITION	EXAMPLE
Additive effect	Two drugs with similar actions are taken for an increased effect.	hydrocodone + acetaminophen = added analgesic effect
Synergistic effect	The combined effect of two drugs is greater than the sum of the effect of each drug given together.	aspirin + codeine = much greater analgesic effect
Antagonistic effect	One drug interferes with the action of another.	tetracycline + antacid = decreased absorption of the tetracycline
Displacement	The displacement of the first drug from protein-binding sites (i.e., bound drugs are inactive) by a second drug increases the activity of the first drug because more unbound drug is available.	warfarin + valproic acid = increased anticoagulant effect
Interference	The first drug inhibits the metabolism or excretion of the second drug, thereby causing increased activity of the second drug.	probenecid + ampicillin = prolonged antibacterial activity of ampicillin because probenecid blocks the renal excretion of ampicillin
Incompatibility	The first drug is chemically incompatible with the second drug, thereby causing deterioration when the drugs are mixed in the same syringe or solution or are administered together at the same site. Signs include haziness, formation of a precipitate, or a change in the color of the solution when the drugs are mixed.	ampicillin + gentamicin = ampicillin inactivates gentamicin

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions

Key Points

- The most common routes of drug administration are the enteral, parenteral, and percutaneous routes.
- The half-life of a drug is defined as the amount of time required for 50% of the drug to be eliminated from the body.
- After administration, all drugs go through five stages: *l*iberation, *a*bsorption, *d*istribution, *m*etabolism, and excretion (LADME). The enzyme systems of the liver are the primary sites for the metabolism of drugs, but other tissues and organs (e.g., white blood cells, GI tract, lungs) metabolize certain drugs to a minor extent.
- When a drug enters a patient and is absorbed and distributed, the desired action usually occurs. However, all drugs have the potential to affect more than one body system simultaneously, causing common adverse effects, which are generally mild, or serious adverse effects, which can be more severe and lead to toxicity.
- Drug interactions are elicited in two ways: (1) by agents that, when combined, *increase* the actions of one or both drugs; and (2) by agents that, when combined, *decrease* the effectiveness of one or both of the drugs.
- The mechanisms of drug interactions can be categorized as those that change the absorption, distribution, metabolism, or excretion of a drug and those that enhance the pharmacologic effect of a drug.

Additional Learning Resources

SG Go to your Study Guide for additional Review Questions for the NCLEX® Examination, Critical Thinking Clinical Situations, and other learning activities to help you master this chapter content.

Go to your Evolve website (https://evolve.elsevier.com/Willihnganz) for additional online resources.

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions

The following questions are typical of the NCLEX exam and include both NGN (Next Generation) and traditional questions. See Chapter 1 for further information regarding question types and formats.

1. A nurse is reviewing the drug route for an order written to be given via nasogastric tube and understands that this means that the drug will be administered by which route?

1. Enteral
2. Parenteral
3. Percutaneous
4. Intramuscular

Objective: Identify common drug administration routes.
NCLEX test item: Multiple choice
Cognitive skill: Knowledge

2. A patient takes 50 mg of a drug that has a half-life of 12 hours. What percentage of the dose remains in the body 36 hours after the drug is administered?

1. 50 mg (100%)
2. 25 mg (50%)
3. 12.5 mg (25%)
4. 6.25 mg (12.5%)

Objective: Identify the meaning and significance of the term half-life when used in relation to drug therapy.
NCLEX test item: Multiple choice
Cognitive skill: Comprehension

3. The nurse reviews the patient's charts for laboratory tests that relate to how well the patient's organ systems are working because drug metabolism is influenced by certain body systems.

Choose the most likely options for the information missing from the sentence below by selecting from the lists of options provided.

Metabolism is the process that deactivates drugs; sites for metabolism of drugs are _____1_____ and _____1_____ and _____1_____, and factors that influence these drug metabolism reactions are _____2_____ and _____2_____.

OPTIONS FOR 1	OPTIONS FOR 2
kidneys	exercise tolerance
white blood cells	environmental pollutants
GI tract	repository sites
liver	concurrent use of other drugs
heart	receptor sites

Objective: Describe the process of how a drug is metabolized in the body.
NGN test item: Cloze
Cognitive skill: Recognize cues

4. When an antihypertensive drug causes a drop in blood pressure to the normal range, what is this effect called?

1. Antagonistic effect
2. Desired therapeutic effect
3. Side effect
4. Additive effect

Objective: Compare and contrast the following terms that are used in relationship to medications: desired action, common adverse effects, serious adverse effects, allergic reactions, and idiosyncratic reactions.
NCLEX test item: Multiple choice
Cognitive skill: Understanding

5. The nurse noticed that, after administering an antibiotic ampicillin in the patient's IV line, the solution in the tubing started to turn milky and hazy after injecting another drug in the same tubing. The precipitate that was created meant the nurse needed to do what next? *(Select all that apply.)*

1. Recognize that the two drugs are incompatible and notify the healthcare providers.
2. Flush the line still connected to the patient until the precipitate is gone.

3. Stop the infusion, disconnect the IV line, flush the precipitate out, and reconnect the line.
4. Request that the drugs be placed on different schedules so that they are not administered at the same time.
5. Recognize that the two drugs are having a synergistic effect and notify the healthcare providers.

Objective: Differentiate among the terms: additive effect, synergistic effect, antagonistic effect, displacement, interference, and incompatibility.
NCLEX test item: Multiple response
Cognitive skill: Application

6. A patient is experiencing a rash over their torso and legs accompanied by severe itching after receiving an antibiotic for an ear infection. What does the nurse suspect is happening? *Select all that apply.*

1. The patient is having an idiosyncratic reaction.
2. The patient is having an antagonistic effect.
3. The patient is having an allergic reaction.
4. The patient is having a common adverse effect.
5. The patient is having the desired effect.
6. The patient is having a serious adverse effect.
7. The patient is having an anaphylactic reaction.

Objective: Compare and contrast the following terms that are used in relationship to medications: desired actions, common adverse effects, serious adverse effects, allergic reactions, and idiosyncratic reactions.
NGN test item: Extended multiple response
Cognitive skill: Recognize cues

7. When a patient who was prescribed warfarin and valproic acid begins experiencing an increased effect of warfarin (bruising on arms, bleeding gums), what is this known as?

1. Synergistic effect
2. Antagonistic effect
3. Idiosyncratic effect
4. Displacement effect

Objective: Compare and contrast the following terms that are used in relationship to medications: desired action, common adverse effects, serious adverse effects, allergic reactions, and idiosyncratic reactions.
NCLEX test item: Multiple choice
Cognitive skill: Knowledge

8. The nurse is aware that a patient who has an increased metabolic rate (e.g., hyperthyroidism) generally requires what type of dosage?

1. Normal dosage
2. Lower-than-normal dosage
3. Higher-than-normal dosage
4. A dosage that is based on the patient's thyroid function levels

Objective: Identify one way in which alternatives in metabolism create drug interactions.
NCLEX test item: Multiple choice
Cognitive skill: Comprehension

9. The nurse studied the terms for drug interactions and recognized that there are medications that will create an antagonistic effect when given together.

Choose the most likely option for the information missing from the statements below by selecting from the list of options provided.

An example of the drug interaction that causes an antagonistic effect is between _____1_____ and _____2_____ in which there is a decrease in the absorption of the second drug.

OPTIONS FOR 1	OPTIONS FOR 2
antacid	codeine
warfarin	ampicillin
probenecid	tetracycline
aspirin	valproic acid

Objective: Differentiate among the following terms: additive effect, synergistic effect, antagonistic effect, displacement, interference, and incompatibility.
NGN test item: Cloze
Cognitive skill: Analysis cues

10. The nurse is aware of enzymes that affect metabolism and therefore affect drug actions that are caused by alterations in enzyme activity.

Indicate with an arrow (up or down) whether the reaction by the enzyme activity will increase or decrease metabolism of a drug.

ENZYME ACTIVITY	CHANGE IN DRUG ACTION CAUSED BY ALTERED METABOLISM
Enzyme inhibitors	
Enzyme inducers	
Enzyme enhancers	
Enzyme metabolizers	

Objective: Identify one way in which alternatives in metabolism create drug interactions.
NGN test item: Extended Drag and Drop
Cognitive skill: Recognize cues

11. The nurse reviews terms used to describe the therapeutic effects of drugs and knows they include the additive effect and the synergistic effect.

Choose the most likely option for the information missing from the statements below by selecting from the list of options provided.

An example of a synergistic effect is one that is caused by the combination of _____1_____ and _____2_____, which increases the therapeutic analgesic effect of the drugs.

OPTIONS FOR 1	OPTIONS FOR 2
antacid	codeine
warfarin	ampicillin
probenecid	tetracycline
aspirin	valproic acid

Objective: Differentiate among the following terms: additive effect, synergistic effect, antagonistic effect, displacement, interference, and incompatibility.
NGN test item: Cloze
Cognitive skill: Analysis cues

3 Drug Action Across the Life Span

https://evolve.elsevier.com/Clayton

Objectives

1. Explain the impact of the placebo effect and the nocebo effect.
2. Identify the importance of drug dependence and drug accumulation.
3. Discuss the effects of age on drug absorption, distribution, metabolism, and excretion.
4. Explain the gender-specific considerations of drug absorption, distribution, metabolism, and excretion.
5. Describe where a nurse will find new information about the use of drugs during pregnancy and lactation.
6. Discuss the impact of pregnancy and breastfeeding on drug absorption, distribution, metabolism, and excretion.
7. Discuss the role of genetics and its influence on drug action.

Key Terms

gender-specific medicine (JĚN-dŭr spĕ-SĬ-fĭk) (p. 23)
placebo effect (plă-SĒ-bō ĕf-FĔKT) (p. 23)
nocebo effect (nō-SĒ-bō) (p. 23)
placebo (plă-SĒ-bō) (p. 23)
tolerance (TŎL-ŭr-ŭns) (p. 24)
drug dependence (dē-PĚN-dĕns) (p. 24)
drug accumulation (ă-kyū-mū-LĀ-shŭn) (p. 24)
carcinogenicity (kăr-sĭn-ō-jĕn-ĬS-ĭ-tē) (p. 24)
passive diffusion (PĂ-sĭv dĭ-FYŪ-shŭn) (p. 25)
hydrolysis (hī-DRŎ-lĭ-sĭs) (p. 25)
intestinal transit (ĭn-TĔS-tĭ-năl TRĂN-sĭt) (p. 25)
protein binding (PRŌ-tēn BĪN-dĭng) (p. 26)
drug metabolism (mĕ-TĂB-ō-lĭz-ĕm) (p. 26)
metabolites (mĕ-TĂB-ō-līts) (p. 27)
therapeutic drug monitoring (thĕr-ă-PYŪ-tĭk) (p. 27)
polypharmacy (pŏl-ē-FĂR-mă-sē) (p. 31)
teratogens (TĔR-ă-tō-jĕnz) (p. 31)
genetics (jĭ-NĔT-ĭks) (p. 35)
genome (JĒ-nōm) (p. 35)
polymorphisms (pŏl-ē-MŎR-fĭz-ĭmz) (p. 35)
pharmacogenetics (făr-mă-kō-jĭ-NĔT-ĭks) (p. 35)

FACTORS THAT AFFECT DRUG THERAPY

Patients often say "That drug really knocked me out!" or "That drug didn't touch the pain!" The effects of drugs are unexpectedly potent in some patients, whereas other patients show little response at the same dosage. In addition, some patients react differently to the same dosage of a drug that is administered at different times. Because of individual patient variation, exact responses to drug therapy are difficult to predict. The following factors have been identified as contributors to the variable response to drugs.

AGE

Infants and the very old tend to be the most sensitive to the effects of drugs. There are important differences with regard to the absorption, distribution, metabolism, and excretion of drugs in premature neonates, full-term newborns, and children. The aging process brings about changes in body composition and organ function that can affect the older patient's response to drug therapy. Thus the age of the patient can have a significant impact on drug therapy. When discussing the effect of age on drug therapy, it is helpful to subdivide the population into the following categories:

AGE	STAGE
<38 wk gestation	Premature
0–1 mo	Newborn, neonate
1–24 mo	Infant, toddler
3–5 yr	Young child
6–12 yr	Older child
13–18 yr	Adolescent
19–54 yr	Adult
55–64 yr	Older adult
65–74 yr	Elderly
75–84 yr	The aged
85 yr or older	The very old

BODY WEIGHT

Compared with the general population, patients who are considerably overweight may require an increase in drug dosage to attain the same therapeutic response.

Conversely, patients who are underweight, compared with the general population, tend to require lower dosages for the same therapeutic response. It is important to obtain an accurate height and weight on patients because dosages of medicines are often calculated with these parameters.

Most pediatric dosages are calculated by milligrams of drug per kilogram of body weight (mg/kg) to adjust for growth rate. The dosages of other medicines, particularly chemotherapeutic agents, are ordered on the basis of the body surface area (see Appendix A); this calculation requires both height and weight. For accurate measurements, the patient's weight should be taken at the same time of day and while the patient is wearing similar-weight clothing.

GENDER

Gender-specific medicine is a developing science that studies differences in the normal function of men and women and addresses how people of each gender perceive and experience disease. In almost every body system, men and women function differently, as well as perceive and experience disease differently. In the case of angina (heart pain), women will present with nausea, indigestion, and upper back and jaw pain, whereas men will generally present with left-sided chest pain or pressure. A study published in 2016 indicated that women with type 1 diabetes have a fourfold increased risk for cardiovascular disease compared with nondiabetic women, contrasted with men with diabetes who are at twice the risk over nondiabetic men of developing cardiovascular disease. This indicates that diabetes affects women differently from men and further research is needed to fully understand the impact. Unfortunately, few scientific data exist to document differences in the pharmacokinetics of most drugs in women compared with men. In 1993 the US Food and Drug Administration (FDA) issued guidelines stating that drug development must evaluate the effects on both genders. Testing is also needed to assess differences in pharmacokinetic parameters between women and men. In the women's studies, the research must distinguish between premenopausal and postmenopausal women and among women in different phases of the menstrual cycle.

METABOLIC RATE

Patients with a higher-than-average metabolic rate (e.g., patients with hyperthyroidism) tend to metabolize drugs more rapidly, thus requiring larger doses or more frequent administration. The converse is true for those patients with lower-than-average metabolic rates (e.g., patients with hypothyroidism). Chronic smoking enhances the metabolism of some drugs (e.g., clozapine, olanzapine), thereby requiring larger doses to be administered more frequently for a therapeutic effect.

ILLNESS

Pathologic conditions may alter the rate of absorption, distribution, metabolism, and excretion of a drug. For example, patients who are in shock have reduced peripheral vascular circulation and will absorb intramuscularly or subcutaneously injected drugs more slowly. Patients who are vomiting may not be able to retain a medication in the stomach long enough for dissolution and absorption. Patients with conditions such as nephrotic syndrome or malnutrition may have reduced amounts of serum proteins in the blood that are necessary for adequate distribution of drugs. Patients with kidney failure generally will excrete drugs at a slower rate and must have significant reductions in dosages of medications that are excreted by the kidneys (Table 3.1).

PSYCHOLOGY

Attitudes and expectations play a major role in a patient's response to therapy and in their willingness to take the medication as prescribed. When the disease state physically affects the patient's ability to function, the treatment protocol is generally followed, as in a patient with insulin-dependent diabetes who needs insulin or a patient with arthritis who needs pain medication. When the disease has few symptoms (e.g., hypertension, dyslipidemia), it becomes harder to follow the treatment protocol because body cues are not present to remind patients. Patients frequently voluntarily discontinue treatment because their current lifestyle is not affected by the hypertension or dyslipidemia.

Other psychological considerations are the placebo effect and the nocebo effect. It is well documented that a patient's positive expectations about treatment and the care received can positively affect the outcome of therapy; this is a phenomenon known as the **placebo effect** (from Latin, meaning "I will please"). Although more difficult to prove because of ethical considerations, it is also believed that negative expectations about therapy and the care received can have a **nocebo effect** (from Latin, meaning "I will harm"), which results in less-than-optimal outcomes of therapy. It is thought that the nocebo effect plays a major role in psychogenic illness, especially in stress-related problems, because the patient may worry about their condition or treatment. A **placebo** is a drug dosage form (e.g., tablet, capsule) that has no pharmacologic activity because the dosage form has no active ingredients. However, when the placebo is taken, the patient may report a therapeutic response. Placebos are frequently used in studies of new medicines to measure the pharmacologic effects of a new medicine compared with the inert placebo. The American Pain Society and the Agency for Healthcare Research and Quality recommend the avoidance of the deceitful use of placebos in current clinical practice guidelines for pain management. It is thought that the deceitful use of placebos in

Table 3.1 Selected Medications That Require Dosage Adjustment for Renal Failure[a]

THERAPEUTIC CATEGORY	DRUG CLASS	EXAMPLES
Antibiotics	Aminoglycosides	amikacin, gentamicin, tobramycin
	Cephalosporins	cefotaxime, cefotetan, ceftazidime, ceftriaxone, cefuroxime, cefpodoxime
	Penicillins	ampicillin, piperacillin, ticarcillin
	Quinolones	ciprofloxacin, levofloxacin
	Others	vancomycin, minocycline, aztreonam, imipenem, cotrimoxazole, ethambutol
Antifungal agents	—	amphotericin B, fluconazole
Antiviral agents	—	acyclovir, ganciclovir, stavudine
Cardiovascular agents	Angiotensin-converting enzyme inhibitors	benazepril, captopril, ramipril
	Antiarrhythmic agents	dofetilide
	Beta-adrenergic blocking agents	atenolol, labetalol, pindolol, metoprolol, nadolol, propranolol
	Digitalis glycoside	digoxin
Gastrointestinal agents	Histamine-2 antagonists	cimetidine, ranitidine
Other	—	lithium, allopurinol, meperidine, methotrexate

[a]Medicines are representative examples only. See the *Physicians' Desk Reference*. 71st ed. Montvale, NJ: PDR Network LLC; 2020, or the *AHFS Drug Information 2020*. Bethesda, MD: American Society of Health-System Pharmacists; 2020, for appropriate dosing and monitoring parameters.

pain management violates a patient's right to receive the highest quality of care possible.

TOLERANCE

Tolerance occurs when a person begins to require a higher dosage of a medication to produce the same effects that a lower dosage once provided. An example is the person who is addicted to heroin. After a few weeks of use, larger doses are required to provide the same "high." Tolerance can be caused by psychological dependence, or the body may metabolize a particular drug more rapidly than before, thereby causing the effects of the drug to diminish more rapidly.

DEPENDENCE

Drug dependence, which is also known as *addiction* or *habituation*, occurs when a person is unable to control a desire for ingestion of drugs. The dependence may be *physiologic*, in which the person develops withdrawal symptoms if the drug is withdrawn for a certain period, or *psychological*, in which the patient is emotionally attached to the drug. Drug dependence occurs most commonly with the use of the scheduled or controlled medications listed in Chapter 1 (e.g., hydrocodone, diazepam). Many people, especially older adults, worry about becoming addicted to pain medication and therefore may not take their pain medication, even when it is needed. The nurse needs to assure these individuals that studies have shown that less than 1% of patients using opioids for acute pain relief become addicted and that it is important for their overall well-being to be as free of pain as possible. (See Chapter 48 for more information.)

CUMULATIVE EFFECT

A drug may accumulate in the body if the next dose is administered before the previously administered dose has been metabolized or excreted. Excessive **drug accumulation** may result in drug toxicity. An example of drug accumulation is the excessive ingestion of alcoholic beverages. A person becomes "drunk" or "inebriated" when the rate of consumption exceeds the rate of metabolism and excretion of the alcohol.

Carcinogenicity is the ability of a drug to induce living cells to mutate and become cancerous. Many drugs have this potential, so all drugs are tested in several animal species before human investigation to eliminate this potential.

FACTORS THAT INFLUENCE DRUG ACTIONS

ABSORPTION

Drug absorption refers to the process by which drugs are absorbed in the body. This occurs by way of different routes through which the drugs are administered. For example, the most common way to administer a drug is orally (by mouth), and then the drug is absorbed by the gastrointestinal (GI) tract (enterally). Other routes include intramuscularly (in the muscle) or intravenously (in the vein). The rate of absorption is dependent on various factors such as blood flow to the area in which the drug has been administered.

Age

Pediatric and geriatric patients each require special considerations for medication administration. Medicines given intramuscularly are usually erratically

absorbed in neonates and older adults. Differences in muscle mass, blood flow to muscles, and muscle inactivity in patients who are bedridden make absorption unpredictable.

Topical administration with percutaneous absorption is usually effective for infants because their outer layer of skin (the stratum corneum) is not fully developed. Because the skin is more fully hydrated at this age, water-soluble drugs are absorbed more readily. Infants who wear plastic-coated diapers are also more susceptible to skin absorption because the plastic acts as an occlusive dressing that increases the hydration of the skin. Inflammation (e.g., diaper rash) also increases the amount of drug that is absorbed.

Transdermal administration in geriatric patients is often difficult to predict. Although dermal thickness decreases with aging and may enhance absorption, factors that may diminish absorption can be seen, including drying, wrinkling, and a decrease in the number of hair follicles. With aging, decreased cardiac output and diminishing tissue perfusion may also affect transdermal drug absorption.

In most cases, medicines are administered orally. Infants and older adults often lack a sufficient number of teeth for chewable medicines. Chewable tablets should not be given to children or to any patient with loose teeth. Geriatric patients often have reduced salivary flow, which makes chewing and swallowing more difficult. However, tablet and capsule forms are often too large for pediatric or geriatric patients to swallow safely. It is often necessary to crush a tablet for administration with food or to use a liquid formulation for easier and safer administration. Taste also becomes a factor when administering oral liquids because the liquid comes into contact with the taste buds. Timed-release tablets, enteric-coated tablets, and sublingual tablets should not be crushed because this will increase their absorption rate and thus the potential for toxicity.

The GI absorption of medicines is influenced by various factors, including gastric pH, gastric emptying time, the motility of the GI tract, enzymatic activity, the blood flow of the mucous lining of the stomach and intestines, the permeability and maturation of the mucosal membrane, and concurrent disease processes. Absorption by **passive diffusion** across the membranes and gastric emptying time depend on the pH of the environment.

Newborns and geriatric patients have reduced gastric acidity and prolonged transit time compared with adults. Premature infants have a high gastric pH (6 to 8) as a result of the immature acid-secreting cells in their stomachs. In a full-term newborn, the gastric pH is also 6 to 8, but within 24 hours the pH decreases to 2 to 4 in response to gastric acid secretion. At 1 year old, the child's stomach pH approximates that of an adult (i.e., pH of 1 to 2 when empty, up to 5 when full).

Geriatric patients often have a higher gastric pH because of the loss of acid-secreting cells. Drugs that are destroyed by gastric acid (e.g., ampicillin, penicillin) are more readily absorbed in older adults because of the decrease in acid production, which results in higher serum concentrations. By contrast, drugs that depend on an acidic environment for absorption (e.g., phenobarbital, acetaminophen, phenytoin, aspirin) are more poorly absorbed, thereby resulting in lower serum concentrations in older adults.

Premature infants and geriatric patients also have a slower gastric emptying time, partly because of their reduced acid secretion. A slower gastric emptying time may allow the drug to stay in contact with the absorptive tissue longer, thereby allowing for increased absorption with a higher serum concentration. There is also the potential for toxicity caused by extended contact time in the stomach for drugs that have the potential to cause gastric ulcers (e.g., nonsteroidal anti-inflammatory drugs).

Another factor that affects drug absorption in the newborn is the absence of the enzymes needed for **hydrolysis**. Hydrolysis is the process that uses water to initiate a chemical reaction. Infants cannot metabolize palmitic acid from chloramphenicol palmitate (an antibiotic), thereby preventing the absorption of the chloramphenicol. Oral phenytoin dosages are also greater in infants who are less than 6 months old because of poor absorption (i.e., in neonates, the dosage is 15 to 20 mg/kg/24 hr compared with infants and children, in whom the dosage is 4 to 7 mg/kg/24 hr).

The **intestinal transit** refers to the speed at which the intestine moves foods, secretions, and other ingested matter along, and this rate varies with age. Premature and full-term newborns have a slower transit time. As the healthy newborn matures into infancy, the GI transit rate increases to a relatively standard rate by about 4 months of age. Older adults develop decreased GI motility and intestinal blood flow. This has the potential for altering the absorption of medicines and for causing constipation or diarrhea, depending on the medicine.

Gender

Generally, a woman's stomach empties solids more slowly than a man's does, and it may have lower gastric acidity causing a higher pH in the stomach (pH > 3 or 5), thus slowing the absorption of certain types of medicines (e.g., aspirin). A slower gastric emptying time may allow the drug to stay in contact with the absorptive tissue longer, thereby allowing for more absorption and a higher serum concentration. Women also have lower gastric levels of the enzyme alcohol dehydrogenase, which is needed to metabolize ingested alcohol. Thus larger amounts of ingested alcohol may be absorbed instead of metabolized in the stomach, thereby leading to a higher blood alcohol level in a woman than in a man for equal amounts of ingested alcohol. Other factors, such as body weight and drug distribution (see the next section of this chapter), may

Table 3.2 Proportions of Body Water[a]

AGE (WEIGHT)	EXTRACELLULAR WATER (%)	INTRACELLULAR WATER (%)	TOTAL BODY WATER (%)
Premature (1.5 kg)	60	40	83
Full term (3.5 kg)	56	44	74
5 mo (7 kg)	50	50	60
1 yr (10 kg)	40	60	59
Adult male	40	60	60

[a]Developmental changes from birth to adulthood. Extracellular and intracellular water values are expressed as percentages of total body weight.
Data from Friis-Hansen B. Body composition during growth. *Pediatrics*. 1971;47(suppl 2):264.

aggravate the higher blood alcohol level and state of intoxication in women compared with men.

DISTRIBUTION

The term *distribution* refers to the ways in which drugs are transported by the circulating body fluids to the sites of action (receptors), metabolism, and excretion. Distribution is dependent on pH, body water concentrations (i.e., intracellular, extracellular, and total body water), the presence and quantity of fat tissue, protein binding, cardiac output, and regional blood flow.

Age and Gender

Most medicines are transported either dissolved in the circulating water (i.e., in blood) of the body or bound to plasma proteins within the blood. Total body water content of a preterm infant is 83%, whereas that of an adult man is 60%; this drops to 50% in older persons. The significance of this is that infants have a larger volume of distribution for water-soluble drugs and thus require a higher dose on a milligram-per-kilogram basis than an older child or an adult (Table 3.2).

With aging, lean body mass and total body water decrease and total fat content increases. The body weight of a preterm infant may be composed of 1% to 2% fat, whereas a full-term newborn may have 15% fat. Adult total body fat ranges from 18% to 36% for men and 33% to 48% for women between the ages of 18 and 35 years. Drugs that are highly fat soluble (e.g., antidepressants, phenothiazines, benzodiazepines, calcium channel blockers) require a longer onset of action and accumulate in fat tissues, thereby prolonging their action and increasing the potential for toxicity. For water-soluble drugs (e.g., ethanol, aminoglycoside antibiotics), a woman's greater proportion of body fat produces a higher blood level compared with that of a man when the drug is given as an equal dose per kilogram of body weight. In the case of ethanol, this effect tends to cause a higher level of ethanol in the brain cells, which results in greater intoxication. Highly fat-soluble medicines (e.g., diazepam) must be given in smaller milligram-per-kilogram dosages to low-birth-weight infants, because there is less fat tissue to bind the drug, thereby leaving more drug to be active at receptor sites.

Drugs that are relatively insoluble are transported in the circulation by being bound to plasma proteins (albumin and globulins), especially albumin. **Protein binding** is reduced in preterm infants because of decreased plasma protein concentrations, lower binding capacity of protein, and decreased affinity of proteins for drug binding. Drugs that are known to have lower protein binding in neonates than in adults include phenobarbital, phenytoin, theophylline, propranolol, lidocaine, and penicillin. Because serum protein binding is diminished, the drugs are distributed over a wider area of the neonate's body, and a larger loading dose is required than is needed in older children to achieve therapeutic serum concentrations. Several drugs that are used to treat neonatal conditions may compete for binding sites. Little difference exists between albumin protein in men and women, although there are some differences between the globulin proteins (i.e., corticosteroid-binding and sex-hormone–binding globulins). In adults who are more than 40 years old, the composition of body proteins begins to change. Although the total body protein concentration is unaffected, albumin concentrations gradually decrease and other protein levels (e.g., globulins) increase. As albumin levels diminish, the level of unbound active drug increases. Increased levels of naproxen and valproate have been found in older adults, presumably as a result of decreased albumin levels. Disease states such as cirrhosis, renal failure, and malnutrition can lower albumin levels. Initial doses of highly protein-bound drugs (e.g., warfarin, phenytoin, propranolol, diazepam) should be reduced and then increased slowly if there is evidence of decreased serum albumin. Lower protein binding may also lead to a greater immediate pharmacologic effect because more active drug is available; however, the duration of action may be reduced because more of the unbound drug is available for metabolism and excretion.

METABOLISM

Drug metabolism is the process whereby the body inactivates medicines. It is controlled by factors such as genetics, diet, age, health, and the maturity of enzyme systems. Enzyme systems, primarily in the liver, are the major pathways of drug metabolism.

Age

All enzyme systems are present at birth, but they mature at different rates, taking several weeks to a year to fully develop. Liver weight, the number of functioning hepatic cells, and hepatic blood flow decrease with age; this results in the slower metabolism of drugs in older adults. Reduced metabolism can be seriously aggravated by the presence of liver disease or heart failure. Drugs that are extensively metabolized by the liver (e.g., morphine, lidocaine, propranolol) can have substantially prolonged durations of action if hepatic blood flow is reduced. Dosages usually must be reduced or the time interval between doses extended to prevent the accumulation of active medicine and potential toxicity. Drug metabolism can also be affected in all age groups by genetics, smoking, diet, gender, other medicines, and diseases (e.g., hepatitis, cirrhosis). Liver enzymes are monitored to determine any elevated levels during the course of drug therapy. No specific laboratory tests are available for measuring liver function that can be used to adjust drug dosages (Table 3.3). Renal function must be assessed and dosages adjusted based on creatinine clearance.

Gender

It is now recognized that males and females differ with regard to the concentrations of enzyme systems throughout life. The CYP3A4 component of the cytochrome P450 (CYP) system of enzymes metabolizes more than 50% of all drugs, and it is 40% more active in women. Drugs such as erythromycin, prednisolone, verapamil, and diazepam are metabolized faster in women than in men.

EXCRETION

Metabolites of drugs, which are the products of metabolism—and, in some cases, the active drug itself—are eventually excreted from the body. The primary routes are through the renal tubules into the urine and through the GI tract into the feces. Other generally minor routes of excretion include evaporation through the skin, exhalation from the lungs, and secretion into the saliva and breast milk.

Age

At birth, a preterm infant has up to 15% of the renal capacity of an adult, whereas a full-term newborn has approximately 35% of that capacity. The filtration capacity of an infant increases to about 50% of adult capacity at 4 weeks of age and is equivalent to full adult function at 9 to 12 months. Drugs that are excreted primarily by the kidneys (e.g., penicillin, gentamicin, tobramycin, vancomycin) must be administered in increased dosages or given more often to maintain adequate therapeutic serum concentrations as renal function matures.

As the body ages, important physiologic changes take place in the kidneys, including decreased renal blood flow caused by atherosclerosis and reduced cardiac output, a loss of glomeruli, and decreased tubular function and urine-concentrating ability. However, there is a great degree of individual variation with regard to changes in renal function, and no prediction of renal function can be made solely on the basis of a person's age. The renal function of older adult patients should be estimated using equations that factor in the patient's age. More optimally, renal function should be calculated by measuring urine creatinine levels over time. Serum creatinine can give a general estimate of renal function, but in older adult patients these determinations tend to exaggerate actual functional capability. This happens because the production of creatinine depends on muscle mass, which is diminished in older adults. Significant elevations occur only when there has been major deterioration of renal function. Blood urea nitrogen concentration is also a poor predictor of renal function because it is significantly altered by diet, status of hydration, and blood loss (Table 3.4).

THERAPEUTIC DRUG MONITORING

Therapeutic drug monitoring is the measurement of a drug's concentration in biologic fluids to correlate the dosage administered and the level of medicine in the body with the pharmacologic response. Assays of blood (serum) samples for drug concentrations are most commonly used, but assays that involve the use of saliva are being perfected for some medicines. Saliva samples have the advantage of the easy collection of specimens without pain or the loss of blood that may require replacement by transfusion at a later date. Therapeutic drug monitoring is essential for neonates, infants, and children to ensure that drugs are within an appropriate therapeutic range, given the major physiologic changes that affect drug absorption, distribution, metabolism, and excretion.

The dosage and the frequency of administration must often be adjusted to help maintain therapeutic serum concentrations. Therapeutic drug monitoring is routine for conditions such as epilepsy (e.g., phenytoin, carbamazepine, valproic acid, phenobarbital), stroke (e.g., warfarin), heart failure (e.g., digoxin), and antimicrobial therapy (e.g., gentamicin, tobramycin, vancomycin) to prevent toxicities and to ensure that dosages are adequate to provide appropriate therapeutic levels. Blood levels of drugs can be measured if toxicity is suspected. The extent to which a serum drug level is elevated may dictate how the toxicity should be treated (e.g., acetaminophen, digoxin). Blood and urine samples can also be obtained for legal purposes if it is suspected that drugs (e.g., ethanol, amphetamines, marijuana, benzodiazepines, cocaine) have been consumed illicitly.

The timing of the drug's administration and the collection of the specimen are crucial to the accurate interpretation of the data obtained after assay. Certain

Table 3.3 Medications That Require Hepatic Monitoring[a,b]

GENERIC NAME	BRAND NAME	GENERIC NAME	BRAND NAME
acetaminophen	Tylenol	methotrexate	Rheumatrex
amiodarone	Pacerone	methsuximide	Celontin
atorvastatin	Lipitor	naproxen	Naprosyn
azathioprine	Imuran	nevirapine	Viramune
carbamazepine	Tegretol	niacin	Niaspan
diclofenac	Voltaren	oxcarbazepine	Trileptal
efavirenz	Sustiva	pentamidine	Pentam
ethosuximide	Zarontin	pioglitazone	Actos
ethotoin	Peganone	piroxicam	Feldene
felbamate	Felbatol	pravastatin	Pravachol
fenofibrate	Tricor	rifampin	Rifadin
fluvastatin	Lescol	ritonavir	Norvir
gemfibrozil	Lopid	rosiglitazone	Avandia
griseofulvin	Gris-PEG	rosuvastatin	Crestor
indinavir	Crixivan	simvastatin	Zocor
isoniazid	Nydrazid	tacrine	Cognex
ketoconazole	Nizoral	terbinafine	Lamisil
lamivudine	Epivir	tizanidine	Zanaflex
leflunomide	Arava	tolcapone	Tasmar
lovastatin	Mevacor	valproic acid	Depakote
meloxicam	Mobic		

[a]This is a list of the more common drugs that require periodic liver function tests, usually at the beginning of therapy and then every few weeks to months thereafter (see individual monographs).
[b]Enzymes that are routinely monitored for liver function are alkaline phosphatase, alanine aminotransferase, and aspartate aminotransferase. If the patient's levels become elevated, the primary healthcare provider should be notified for individualized treatment.
Data from Tice SA, Parry D. Medications that require hepatic monitoring. *Hosp Pharm*. 2001;36(4):456-464; Tice SA, Parry D. Medications that require hepatic monitoring. *Hosp Pharm*. 2004;39(6):595-606; Porter RS, Kaplan JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2012; American Geriatrics Society 2015 Beers Criteria Update Expert Panel. American Geriatrics Society 2015 Updated Beers criteria for potentially inappropriate medication use in older adults. *J Am Geriatr Soc*. 2015;63(11):2227-2246.

medicines (e.g., aminoglycosides, gentamicin, tobramycin) require that blood be drawn before and after the administration of the drug to assess subtherapeutic levels and the potential for toxicity. One sample is drawn immediately before the next dose is to be administered to obtain the *trough,* or lowest, blood level of medicine, and another is drawn 20 minutes after the medicine has been administered intravenously or 60 minutes after the medicine has been administered orally to obtain the *peak,* or highest, blood level. All institutions have policies that prescribe the best approach to therapeutic drug monitoring with specific medicines to ensure the accuracy and usefulness of results. To coordinate blood draws with the timing of drug administration, institutional policies regarding the handling of laboratory requests should be checked.

NURSING IMPLICATIONS WHEN MONITORING DRUG THERAPY

Chapter 4 discusses in detail the nursing process as it applies to pharmacology. In this chapter, which discusses drug action across the life span, it is appropriate to discuss nursing actions that relate to high-risk populations, such as pediatric patients, older adult patients, pregnant patients, and breastfeeding patients.

MONITORING PARAMETERS

All medicines have a number of parameters (e.g., expected therapeutic actions, common adverse effects, serious adverse effects, and any drug interactions) that a nurse must be knowledgeable about before taking on the responsibility of administering medications to patients. When peak and trough blood levels for a medication have been ordered, it is important that the nurse check the laboratory results in a timely manner and make sure that the prescriber is notified of the laboratory results. The next dose of the medication should not be given until the dosage has been clarified on the basis of the blood levels measured.

Although many of the same monitoring parameters (e.g., vital signs, urine output, renal function tests) are used to plan dosages and to monitor the effects of drug therapy in patients of all ages, it is absolutely crucial that the normal values for these monitoring parameters and laboratory tests be related to the age of the

Table 3.4 Overview of Factors That Influence Drug Actions With Regard to Age and Gender

FACTOR	AGE/GENDER	PHYSIOLOGIC VARIABLES
Absorption	Infants	• Erratic absorption for intramuscular (IM) medications resulting from underdeveloped muscles • Topical medications absorbed faster because skin underdeveloped • Reduced gastric acidity and prolonged transit time for medications orally
	Elderly	• Unpredictable absorption for IM medications; muscle mass, blood flow, and muscle activity are factors • Topical medications affected by skin thickness, tissue perfusion • Reduced gastric acidity, slower gastric emptying time for oral medications
	Gender	• Women have slower gastric emptying time
Distribution	Infants	• Greater total body water content • Total fat content low • Protein binding lower, with lower circulating plasma proteins
	Elderly	• Lower total body water content • Total fat content increases as one ages • Protein binding lower, albumin levels diminish after 40 yr of age
	Gender	• Women have greater proportion of body fat than men
Metabolism	Infants	• Liver enzyme systems are immature
	Elderly	• Liver function decreases with age, slowing metabolism
	Gender	• Women have more active cytochrome P450 enzymes, which metabolize drugs faster than men
Excretion	Infants	• Renal capacity is 15% of that of an adult at full-term birth; lower with preterm birth
	Elderly	• Renal function based on serum creatinine; creatinine production is based on muscle mass, which may be lower in the elderly
	Gender	• Both renal blood flow and glomerular filtration rate (GFR) are higher in men than in women • Women show a slower clearance of drugs that are eliminated via the kidneys • During pregnancy the GFR may double, requiring an increased dosage or more frequent administration of drugs excreted by glomerular filtration to maintain a therapeutic effect

patient being monitored. For example, neonates have higher respiratory and heart rates and lower normal blood pressures than adults. As with all medications, patient education is important. Involving the appropriate family members, caregivers, and the school nurse in the overall health teaching plan is essential (see Chapter 5).

Pediatric Patients

Children are not just smaller versions of adults; therefore the principles of drug therapy cannot be extrapolated to infants and children only on the basis of size. Infants and children are at greater risk for complications from drug therapy because their body and organ functions are in an ongoing state of development.

General principles that a nurse can apply to the care of a pediatric patient include the following:

- Although infants and young children have a higher total body water content, they are more susceptible to dehydration from fever, vomiting, or diarrhea.
- Weight variations and growth spurts are expected in pediatric patients during normal maturation. Dosage adjustments are frequently necessary for patients who are taking medicine on a regular basis (e.g., seizure medicines, allergy medicines) because they outgrow their dosages (see Appendix A for a nomogram for estimating body surface area). Therefore it is important to obtain accurate height and weight measurements on a regular basis.
- Therapeutic drug monitoring is essential for neonates, infants, and children to ensure that drugs are within an appropriate therapeutic range. The nurse must document the precise times that blood samples are drawn and the time over which the medicine was infused for accurate interpretation of the results.
- It is often difficult to assess the therapeutic response to the medicines administered to neonates, infants, and young children because these patients are often nonverbal or cannot tell us where it hurts. The nurse must rely more on laboratory values and assessment parameters such as temperature, pulse, respirations, heart sounds, lung sounds, bowel sounds, intake and output data, appetite, general appearance, and responsiveness.
- Nurses may find it difficult to measure and administer doses of oral medicines to pediatric patients accurately. The volume delivered by a household teaspoon ranges from 2.5 to 7.5 mL and may vary when the same spoon is used by different caregivers. The

American Academy of Pediatrics recommends the use of appropriate devices for liquid administration, such as a medication cup, an oral dropper, or an oral syringe. Although tablets and capsules can usually be swallowed by a child who is 5 years old or older, the nurse should evaluate each child's ability to swallow a tablet before administration. Tablets that are not sustained-release or enteric-coated formulations may be crushed. Most capsules may be opened and the contents sprinkled on small amounts of food (e.g., applesauce, jelly, pudding). Box 3.1 provides selected pediatric administration guidelines for oral administration.

- Oral and parenteral medicines available in powder form must be diluted properly in accordance with the manufacturer's directions to allow for the accurate measurement of doses and to prevent hyperosmolar solutions from being administered. When taken orally, hyperosmolar solutions may cause diarrhea and dehydration.
- Many medicines are not approved by the FDA for use in children. Primary healthcare providers may still legally prescribe medicines for what is termed *off-label use*, but it is important for the nurse to question a specific dose of medicine if it is not readily available for cross-checking with reference texts or with the drug information service in the pharmacy. The nurse must document in the nurses' notes that the drug order was verified before the prescribed medicine was administered. Nurses must be well versed in the monitoring parameters of the drug, and report adverse effects to the healthcare provider.
- In general, salicylates (aspirin) should not be administered to pediatric patients from infancy through adolescence. These children are susceptible to a life-threatening illness known as Reye syndrome if they ingest aspirin at the time of or shortly after viral infection with chickenpox or influenza.
- Medicines that are routinely used for analgesia and antipyresis (fever reduction) in pediatric patients are ibuprofen and acetaminophen.
- Allergic reactions can occur rapidly in children, particularly if the medicine is administered intravenously. Reactions occur most commonly to antibiotics, especially penicillins. The nurse needs to be observant for responses to medication administration; if an event should occur, prompt intervention is needed. The first symptoms may be intense anxiety, weakness, sweating, and shortness of breath. Other symptoms may include hypotension, shock, dysrhythmia, respiratory congestion, laryngeal edema, nausea, and defecation. The nurse should summon assistance (call a code if severity warrants), stay with the child to provide comfort, facilitate breathing (administer oxygen, as needed), and, if the child stops breathing, initiate cardiopulmonary resuscitation.

Box 3.1 Selected Guidelines for the Administration of Oral Medicine to Pediatric Patients[a]

INFANTS
- Use a calibrated dropper or an oral syringe.
- Support the infant's head while holding the infant in the lap.
- Give small amounts of medicine to prevent choking.
- If desired, crush non–enteric-coated or slow-release tablets into a powder and then sprinkle the powder on small amounts of food.
- Provide physical comforting while administering medications to help calm the infant.

TODDLERS
- Allow the toddler to choose a position in which to take the medication.
- If necessary, disguise the taste of the medication with a small volume of flavored drink or a small amount of food; also, a rinse with a flavored drink or water will help remove any unpleasant aftertaste.
- Use simple commands in the toddler's jargon to obtain cooperation.
- Allow the toddler to choose which medication to take first if more than one is being taken.
- Provide verbal and tactile responses to promote cooperation.
- Allow the toddler to become familiar with the oral dosing device.

PRESCHOOL CHILDREN
- If possible, place a tablet or capsule near the back of the tongue, and then provide water or a flavored liquid to help with the swallowing of the medication.
- If the child's teeth are loose, do not use chewable tablets.
- Use a straw to administer medications that could stain teeth.
- Use a follow-up rinse with a flavored drink to help minimize any unpleasant aftertaste.
- Allow the child to help make decisions about the dosage formulation, the place of administration, which medication to take first, and the type of flavored drink to use.

[a]For all age groups listed, use a liquid dosage form, if available.
From Brown LM, Isetts BJ. Patient assessment and consultation. In: Krinsky DL, Berardi RR, eds. *Handbook of Nonprescription Drugs: An Interactive Approach to Self-Care.* 17th ed. Washington, DC: American Pharmacists Association; 2012:27. Reproduced with permission from the American Pharmacists Association.

Geriatric Patients

Geriatric patients represent an ever-increasing portion of the population. Although people who are more than 65 years old represent about 14% of the US population, they consume more than 25% of all prescription medicines and 33% of all nonprescription medicines sold. The prevalence of prescription medication use in the ambulatory adult population increases with advancing age. A recent study of the US noninstitutionalized adult population has indicated that more than 90% of persons 65 years old or older use at least one medication per week. More than 40% use 5 or more

medications and 12% use 10 or more different medications per week.

Life Span Considerations

Older Adults

It is important that healthcare professionals understand the physiologic and pathologic changes that develop with advancing age and adjust drug therapy for the individual patient accordingly. Factors that place older adults at greater risk for drug interactions or drug toxicity include reduced renal and hepatic function, chronic illnesses that require multidrug therapy (**polypharmacy**), and a greater likelihood of malnourishment.

Unfortunately, a lack of complete understanding of the effects of medicines in older adults also leads to a problem that is the opposite of overuse: underuse. Caregivers walk a fine line between polypharmacy and undertreatment because of the complexity of chronic illnesses, changes in physiology and nutrition, compliance with multidrug regimens, and the pharmacokinetic factors associated with drug therapy during the later decades of a person's life. Although medicines may impair an older patient's quality of life, medicines are also the most cost-effective treatment for preventing illness and disability in the geriatric population.

When caring for a geriatric patient, it is important to complete a thorough drug history that includes the patient's use of nonprescription and herbal medicines (especially laxatives and antacids), nutritional and herbal supplements, and alternative therapies (e.g., aromatherapy, heat therapy, cold therapy). Similarly, a thorough nutrition history should be completed for the patient. Determine whether the patient's diet is balanced with regard to carbohydrates, fats, proteins, and vitamins. Assess whether a loss of teeth or loose-fitting dentures could interfere with chewing. A functional health assessment that includes sight and fine-motor control should be completed to assess the patient's ability to self-medicate.

When evaluating a new symptom in a geriatric patient, determine first whether it was induced by medicines that the patient is taking. The adjustment of dosages or the elimination of certain medicines is often the easiest, quickest, and most cost-effective therapy available.

When discontinuing drug therapy, it is important to taper the dosage when appropriate (e.g., beta blockers, antidepressants) to prevent symptoms that could occur as a result of sudden discontinuation.

When initiating therapy with a geriatric patient, remember the following:

- Start at one-third to one-half of the normal adult recommended dosage, and then gradually increase the dosage at appropriate intervals to assess for the therapeutic effect and the development of adverse effects.
- Keep multidrug regimens simple; use aids such as a calendar or a pillbox with time slots to prevent confusion.
- Use therapeutic drug monitoring when serum drug level data are available for a particular medicine.
- Offer assistance with destroying expired prescriptions to minimize confusion with the current medication regimen.
- Periodically review the regimen to see whether any medications can be discontinued (e.g., allergy medicines outside of allergy season). Ask whether new prescriptions from other healthcare providers or nonprescription or herbal medicines have been started.
- Be alert to prescriptions for the medications listed in Table 3.5. This list of medicines is part of the Beers Criteria, which are used to evaluate prescription quality and safety in nursing homes. These medicines are considered to be potentially inappropriate (but not contraindicated) for older patients. Their use should be documented as the best alternative for a patient's particular needs. The Centers for Medicare and Medicaid Services has incorporated the Beers Criteria into federal safety regulations for long-term care facilities.
- Geriatric patients may have difficulty with swallowing large tablets or capsules. Tablets may need to be broken in half or crushed if there is a score mark on the tablet. Remember that timed-release tablets, enteric-coated tablets, and sublingual tablets should never be crushed because of the effect on the absorption rate and the potential for toxicity. Applesauce, ice cream, pudding, and jelly are good foods to use to administer crushed medications.
- It is extremely important that patients understand the purposes of the medications that they are taking and any complications that could occur if they discontinue their drugs.
- When handing a patient a new prescription to be filled, inquire about their ability to pay for the new medicine. Do not let an inability to pay be a barrier to therapy; refer the patient to social services, as needed.

Pregnant Patients

During pregnancy, the fetus is exposed to most medicines and foreign substances that are circulating in the mother's blood. Fetuses are particularly sensitive to toxic substances while in utero for the following reasons: (1) they have few circulating proteins that can bind drugs; (2) their enzyme systems, which will later metabolize drugs, are not yet developed or are immature; and (3) their excretory systems are only minimally functioning. Some drugs known as **teratogens** will cause the abnormal development of key tissues (i.e., birth defects) if they are taken at a certain time during pregnancy (Table 3.6).

Table 3.5 Potentially Inappropriate Drugs for Older Adult Patients[a]

GENERIC NAME	BRAND NAME	RATIONALE
MEDICATIONS TO AVOID		
Antidepressants		
amitriptyline	Elavil	Highly anticholinergic Sedating and cause orthostatic hypotension
doxepin greater than 6 mg		
paroxetine	Paxil	
Antihistamines		
chlorpheniramine	Chlor-Trimeton	Highly anticholinergic Risk of confusion, dry mouth, and constipation Diphenhydramine used for acute treatment of severe allergic reactions may be appropriate
cyproheptadine		
diphenhydramine	Benadryl	
hydroxyzine	Vistaril	
Antiinfective		
nitrofurantoin	Macrobid	Potential for pulmonary toxicity, hepatoxicity, and peripheral neuropathy, especially with long-term use; safer alternatives available Avoid in individuals with creatinine clearance of less than 30 mL/min or for long-term suppression of bacteria
Antispasmodics		
dicyclomine	Bentyl	Highly anticholinergic
hyoscyamine	Levsin	
Antipsychotics		
First Generation (Typical)		All increase risk of cerebrovascular accident and greater cognitive decline and mortality in patients with dementia Do not use for behavior problems of dementia or delirium Avoid, except for schizophrenia, bipolar disorder, or as antiemetic during chemotherapy
fluphenazine		
haloperidol	Haldol	
Second Generation (Atypical)		
aripiprazole	Abilify	
quetiapine	Seroquel	
Benzodiazepines		
Short and Intermediate Acting		Older patients are very sensitive to benzodiazepines and have decreased ability to metabolize long-acting benzodiazepines All benzodiazepines increase risk of cognitive impairment, delirium, falls, and fractures Long-acting benzodiazepines may be appropriate for seizure disorders, ethanol withdrawal, severe generalized anxiety disorder
alprazolam	Xanax	
lorazepam	Ativan	
temazepam	Restoril	
Long Acting		
clonazepam	Klonopin	
diazepam	Valium	
flurazepam		
Cardiovascular Drugs		
Antiarrhythmics		
amiodarone	Pacerone	Amiodarone is effective for maintaining sinus rhythm but has greater toxicities than other antiarrhythmics; avoid as first line unless patient has heart failure
digoxin	Lanoxin	Digoxin may be associated with increased mortality in atrial fibrillation and heart failure; do not use first line and limit dose to less than 0.125 mg/day
Peripheral Alpha-1 Blockers		High risk of orthostatic hypotension; avoid use to treat hypertension
doxazosin	Cardura	
terazosin	Hytrin	
Central Alpha Blockers		High risk of central nervous system effects; may cause bradycardia and orthostatic hypotension; not recommended to routinely treat hypertension
clonidine	Catapres	

Continued

Table 3.5 Potentially Inappropriate Drugs for Older Adult Patients[a]—cont'd

GENERIC NAME	BRAND NAME	RATIONALE
Gastrointestinal Drugs		
metoclopramide	Reglan	Can cause extrapyramidal effects, including tardive dyskinesia; risk may be greater in frail older adults and with prolonged exposure Avoid, unless for gastroparesis do not used for more than 12 wk.
Proton-pump inhibitors		Risk of *Clostridium difficile* infection and bone loss and fractures Do not use for >8 wk unless for high-risk patients (e.g., oral corticosteroids or chronic NSAID use, Barret esophagitis)
Nonsteroidal Antiinflammatory Drugs		
aspirin greater than 325 mg		Increased gastrointestinal bleeding Avoid chronic use
ibuprofen	Motrin	
naproxen	Naprosyn	
Nonbenzodiazepines		
eszopiclone	Lunesta	Have adverse effects similar to benzodiazepines
zolpidem	Ambien	

[a]These medicines are still approved for use; however, it is believed that the adverse effects are generally more common, and thus the medicines should be avoided in older adult patients unless treatment has failed with other medicines.
Data from American Geriatrics Society 2019 Beers Criteria Update Expert Panel. American Geriatrics Society 2019 Updated AGS Beers Criteria for Potentially Inappropriate Medication Use in Older Adults. *J Am Geriatr Soc*. 2019;67(4):674-694.

Table 3.6 Drugs Known to Be Teratogens

DRUG CLASS	EXAMPLE(S)
Androgenic and estrogenic hormones	oral contraceptives, diethylstilbestrol, conjugated estrogens, clomiphene, exemestane
Angiotensin-converting enzyme inhibitors	benazepril, captopril, enalapril, fosinopril, lisinopril, moexipril, perindopril, ramipril, trandolapril
Angiotensin II receptor antagonists	azilsartan, candesartan, eprosartan, irbesartan, losartan, olmesartan, telmisartan, valsartan
Anticonvulsants	carbamazepine, phenytoin, trimethadione, valproic acid
Antimanic agents	lithium
Antithyroid drugs	propylthiouracil, methimazole
Chemotherapeutic agents	busulfan, cyclophosphamide, methotrexate
Hydroxymethylglutaryl coenzyme A reductase inhibitors (statins)	atorvastatin, fluvastatin, lovastatin, pravastatin, rosuvastatin, simvastatin
Other teratogens	ambrisentan, anastrozole, azathioprine, cocaine, dronedarone, dutasteride, ethanol (high dose, frequent use), isotretinoin, alitretinoin, ribavirin, tetracycline, thalidomide, vitamin A (>18,000 units/day), warfarin

Because of the potential for injury to the developing fetus, drug therapy during pregnancy should be avoided if at all possible. However, studies indicate that about two-thirds of women take at least one drug while pregnant and that about two-thirds of the medicines are nonprescription self-care remedies. The medicines that are most commonly taken include acetaminophen, antacids, and cold and allergy products. Because few data are available for determining the safety of medicines in humans during pregnancy, very few medicines can be considered completely safe for use during pregnancy.

In 2015 the FDA instituted new rules for drug labels that replace the lettered categories with new categories on pregnancy, lactation, and reproductive potential. In addition to including information that summarizes the risks of using a drug during pregnancy (increasing the risk to the fetus for birth defects, called teratogenicity) and lactation, labeling must now include relevant information about contraception, pregnancy testing, and infertility to inform the healthcare provider prescribing drugs for females and males of reproductive potential (and for the consumer). It will be several years before the older system is completely phased out, but the new format will allow for consistency of information regarding risks and benefits of prescription drugs used during pregnancy and lactation and by females and males of reproductive potential. Information regarding drug use in pregnancy, in lactation, and in females and males of reproductive potential is found in section 8 of the package insert and in other online drug information resources such as ePocrates and Lexicomp. Two

Table 3.7 Drugs and Nursing Infants

DRUGS' POTENTIAL ADVERSE EFFECTS	EXAMPLES
Drugs that may interfere with the metabolism of a nursing infant	cyclophosphamide, cyclosporine, doxorubicin, methotrexate, capecitabine, cytarabine, gemcitabine, pemetrexed
Drugs of abuse reported to have adverse effects on nursing infants	amphetamine, cocaine, heroin, marijuana, phencyclidine, ethanol
Drugs for which effect on nursing infants is unknown but may be of concern	
Antianxiety medications	Benzodiazepines: alprazolam, diazepam, quazepam
Antidepressants	Cyclic antidepressants: amitriptyline, clomipramine, nortriptyline, desipramine, imipramine, doxepin, bupropion, trazodone Serotonin reuptake inhibitors: fluoxetine, fluvoxamine, paroxetine, sertraline Antipsychotic drugs: chlorpromazine, clozapine, haloperidol, mesoridazine, trifluoperazine
Others	amiodarone, lamotrigine, metronidazole
Drugs associated with significant effects on nursing infants[a]	aspirin, beta-adrenergic blocking agents (acebutolol, atenolol), clemastine, lithium, phenobarbital, primidone

[a]Drugs for which the effect on nursing infants is unknown but may be of concern. Give to nursing mothers with caution.

excellent resources—LactMed and DART—are available on the National Library of Medicine's TOXNET website. These resources include information on nonprescription medications, whereas the new labeling requirements do not provide information on these drugs. (See Online Resources for links.)

General principles that a nurse can apply to the care of a pregnant patient include the following (see also Chapter 39):

- When taking a history, be alert to the possibility of pregnancy in any woman of childbearing age, especially in those showing symptoms of early pregnancy, including nausea, vomiting (especially in the morning), and frequent urination.
- Complete a thorough drug history, including the use of nonprescription and herbal medicines and nutritional supplements.
- Complete a thorough nutrition history; assess for a diet that is balanced with regard to carbohydrates, fats, proteins, and vitamins. Good nutrition with the appropriate ingestion of vitamins (especially folic acid) and minerals (calcium and phosphorus) is particularly important for preventing birth defects.
- Instruct the patient to avoid drugs in general at any stage of pregnancy, unless such use is recommended by the patient's primary healthcare provider.
- Advise against the consumption of alcohol during pregnancy. Excessive use may cause the child to be born with fetal alcohol syndrome, which is a lifelong condition that can be avoided by eliminating alcohol during pregnancy. If the woman is planning to become pregnant, it is recommended that she stop using alcohol 2 to 3 months before the planned conception.
- Advise against the use of tobacco. Mothers who smoke have a higher frequency of miscarriage, stillbirths, premature births, and low-birth-weight infants.
- Before they use medicines, advise pregnant women to try nonpharmacologic treatments. For morning sickness, the patient can try lying down when she feels nauseated; ingesting crackers or sipping small quantities of liquids before arising; eating small, frequent meals that are high in carbohydrates; and lowering fat content of meals. Pregnant women with morning sickness should avoid spicy foods, dairy products, and smells or situations that might cause vomiting.
- Herbal medicines that have not been scientifically tested in women during pregnancy should be avoided.

Breastfeeding Infants

Many drugs are known to enter the breast milk of nursing mothers and have the potential to harm the infant. The American Academy of Pediatrics provides a list of medicines and their potential effects on nursing infants (Table 3.7).

Nurses should keep in mind when caring for patients who are breastfeeding that although drug levels in breast milk may be safe, it is always best for the mother to discuss all medicines she uses—including prescription, nonprescription, and herbal products—with a healthcare provider before taking them. If medicine is being taken, encourage the mother to take it immediately after the infant finishes breastfeeding or just before the infant's longer sleep periods. Educate the mother about what adverse effects of the drug might occur in the infant so that other therapy can be considered.

GENETICS AND DRUG METABOLISM

Genetic composition serves as the basic foundation for all drug responses and their duration of action in

the body throughout the person's lifetime. Many other factors have an impact on drug action and duration, but the foundation starts with the genetic blueprint. **Genetics** is the study of how living organisms inherit the characteristics or traits of their ancestors, such as hair color, eye color, and skin pigmentation. Other much less obvious—but extremely important—traits of inheritance include the function of the metabolic pathways and susceptibility to illnesses (e.g., heart disease or cancer).

A **genome** is the complete package of genetic coding of an organism. The human genome is composed of 23 chromosome pairs, 22 of which are known as autosomal (i.e., not gender related) pairs; the remaining pair is the X or Y chromosome that determines the presence of male or female sex characteristics. Twenty-three chromosomes each are donated by the biologic mother and father. Genetic information is carried on the chromosomes by a large molecule called *deoxyribonucleic acid* (DNA), which is copied and passed on to future generations. Traits are carried in DNA as instructions for building and operating an organism. These instructions are contained in segments of DNA called *genes.* The sequence of the DNA linkages in a gene determines what traits the gene controls. The sequence of DNA is similar to a sequence of words that are linked together to form a meaningful sentence. Several genes are frequently responsible for a specific trait or function. The sequence of genes is known as the *genetic code.* The organism reads the sequence of these units and decodes the instructions. **Polymorphisms** are naturally occurring variations in the structures of genes and the instructions that they give to the organism.

In 1989 the National Center for Human Genome Research was created to lead the US contribution to the Human Genome Project, an international public effort to sequence all 3 billion DNA base pairs of the human genetic blueprint. The Human Genome Project was completed in April 2003, and the database is now available for worldwide biomedical research.

An unfolding science based on genetics is **pharmacogenetics**, which is the study of how drug response may vary in accordance with inherited differences. As described in Chapter 2, drug action depends on five factors: liberation, absorption, distribution, metabolism, and excretion. Each of these factors is greatly influenced by genetic polymorphisms, but each also varies on the basis of such factors as age, gender, organ function, other drug therapy, and drug interactions. Research has shown significant differences among racial and ethnic groups with regard to the metabolism, clinical effectiveness, and side effect profiles of different medications.

Most studies to date have concentrated on cardiovascular and psychiatric drugs, analgesics, antihistamines, and ethanol. The research so far primarily applies to African Americans, whites, and Asians, but more research is now focusing on Hispanic Americans because they represent the largest racial or ethnic group after whites in the United States. It is anticipated that discoveries in pharmacogenetics will allow a blood sample to be analyzed for specific gene characteristics (genotyped) that are important determinants of drug pharmacokinetics and pharmacodynamics, thereby allowing drug selection to be tailored to the individual patient's genetic makeup.

Monoclonal antibodies are early examples of medicines that were synthesized to attack certain types of cancers on the basis of the presence of genetically determined types of cells in some cancers. Laboratory tests are used to determine the presence of these proteins in a patient's cancer cells and whether the cancer cells will be susceptible to the monoclonal antibody. Another recent discovery is the potential for fatal skin reactions (i.e., Stevens-Johnson syndrome, toxic epidermal necrolysis) that can be caused by carbamazepine therapy in patients with the human leukocyte antigen allele HLA-B*1502. This allele is most common in persons of Asian and South Asian Indian ancestry (see the discussion of carbamazepine in Chapter 18). The FDA maintains a website that lists genomic biomarkers that have been identified (see Online Resources). These can be tested for before the initiation of drug therapy to target therapy or prevent potentially fatal drug reactions.

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions

Key Points

- The placebo effect occurs when a patient believes they had a positive response to a drug, even though the patient did not have any chemically active drug. The nocebo effect occurs when the patient has negative expectations about therapy and the patient believes that a drug is not working.
- Drug dependence occurs when a patient develops physical withdrawal symptoms if the drug is withdrawn for a certain period, or when a patient is emotionally attached to a drug.
- The age of the patient has significant effects on the absorption, distribution, metabolism, and excretion of the drug. Pediatric patients and elderly patients are more susceptible to the effects of drugs than adult patients. Physical changes that occur during the aging process can alter the effect drugs will have on the elderly patient.
- Men and women often do not respond to drugs or physical disease states in the same way, and gender differences can alter the effect of drugs.
- Pregnant and breastfeeding women need to be aware that any drug they take will have an effect on their unborn fetus and/or infant.
- Pharmacogenetics currently focuses on determining the appropriate drug to use based on the individual's genetic composition.

Additional Learning Resources

SG Go to your Study Guide for additional Review Questions for the NCLEX® Examination, Critical Thinking Clinical Situations, and other learning activities to help you master this chapter content.

evolve Go to your Evolve website (https://evolve.elsevier.com/Clayton) for additional online resources.

Online Resources

- DART: https://toxnet.nlm.nih.gov/newtoxnet/dart.htm
- LactMed: https://toxnet.nlm.nih.gov/newtoxnet/lactmed.htm
- Pharmacogenomic biomarkers: https://www.fda.gov/Drugs/ScienceResearch/ucm572698.htm

Clinical Judgment and Next-Generation NCLEX® Examination-Style Questions

The following questions are typical of the NCLEX examination and include both NGN (Next Generation) and traditional questions. See Chapter 1 for further information regarding question types.

1. A patient who has been asked to participate in a study asks the nurse what the term *placebo* means. What would be an appropriate response by the nurse?

1. "The word *placebo* refers to the type of abnormal response that may occur when taking medications."
2. "That term means the body has built up a resistance to a drug and that more of the drug is needed to get the same response."
3. "The term *placebo* refers to a dosage form that has no active ingredients; these are frequently used in studies to determine the effect of a new medication."
4. "The word *placebo* comes from Latin and means 'I will harm.'"

Objective: Explain the impact of the placebo effect and the nocebo effect.
NCLEX test item: Multiple choice
Cognitive skill: Evaluation

2. Why is it important for the nurse to understand the difference between drug dependence and drug accumulation?

1. Drug accumulation can be detected more easily than drug dependence.
2. Drug accumulation may result in drug toxicity, and drug dependence can result in cell mutation.
3. Drug dependence can be prevented, and drug accumulation is inevitable.
4. Drug dependence can be the result of taking addictive substances for a prolonged time, and drug accumulation can result in drug overdose.

Objective: Identify the importance of drug dependence and drug accumulation.
NCEX test item: Multiple choice
Cognitive skill: Understanding

3. The nurse knows that drug absorption in the elderly is affected by which of these physiologic factors? *(Select all that apply.)*

1. Changes in albumin levels
2. Increased filtration capacity of the kidneys
3. Reduced cardiac output
4. Higher gastric pH
5. Decreased GI motility

Objective: Discuss the effects of age on drug absorption, distribution, metabolism, and excretion.
NCLEX test item: Multiple response
Cognitive skill: Application

4. Which nursing action(s) would be essential when monitoring drug therapy in the geriatric patient? *(Select all that apply.)*

1. Monitoring renal and liver function
2. Monitoring for drug interactions
3. Completing a thorough drug history, including over-the-counter and alternative therapies
4. Inquiring about the ability to pay for medications
5. Educating the patient and caregivers about all drugs and potential complications

Objective: Discuss the effects of age on drug absorption, distribution, metabolism, and excretion.
NCLEX test item: Multiple response
Cognitive skill: Application

5. The nurse caring for an elderly patient understands that when giving medications there are aging factors that affect how the drug will work.

Indicate with an X the factors that influence drug actions related to aging.

AGING FACTORS AND OTHER EFFECTS	DRUG ABSORPTION	DRUG DISTRIBUTION	DRUG METABOLISM	DRUG EXCRETION
Genetics, smoking, diet, gender, other medications and diseases				
Albumin levels diminish				
Decreased renal blood flow				
Muscle inactivity and changes in muscle mass				

Objective: Discuss the effects of age on drug absorption, distribution, metabolism, and excretion.
NGN test item: Matrix
Cognitive skill: Recognize cues

6. While discussing with a mother the importance of administering furosemide orally to an infant with a cardiac abnormality, the nurse would recognize the need for further explanation if the mother makes which statement?

1. "I know that my baby needs this drug every day at approximately the same time."
2. "My baby will have no problem taking this tablet."
3. "I will check to make sure that the furosemide is working by monitoring the number of wet diapers."
4. "I understand that my baby will continue to grow even while taking this drug."

Objective: Discuss the effects of age on drug absorption, distribution, metabolism, and excretion.
NCLEX test item: Multiple choice
Cognitive skill: Comprehension

7. The nurse recognized there are gender considerations to keep in mind with regard to drug actions.

Choose the most likely options for the information missing from the sentence below by selecting from the lists of options provided.

The gender considerations to keep in mind with regard to drug actions are that _____1_____ will affect _____2_____ and that _____1_____ will affect _____2_____, as well as that _____1_____ will affect _____2_____.

OPTIONS FOR 1	OPTIONS FOR 2
• women have longer life spans	• distribution
• women have greater proportion of body fat	• excretion
• women have slower gastric emptying time	• metabolism
• women have more active cytochrome P450 enzymes	• absorption

Objective: Explain the gender-specific considerations of drug absorption, distribution, metabolism, and excretion.
NGN test item: Cloze
Cognitive skill: Analyze cues

8. A pregnant woman asked a nurse at the obstetrician's clinic how she could determine which drug was safe to take during pregnancy. What would be an appropriate response by the nurse?

1. "Because there are few studies done to determine the safe use of drugs during pregnancy, it is okay to keep taking what was previously prescribed by your primary healthcare provider."
2. "Because there are few studies done to determine the safe use of drugs during pregnancy, it is advisable to ask your primary healthcare provider or pharmacist regarding taking prescription and over-the-counter drugs."
3. "You are not to take any drugs during pregnancy."
4. "It would be fine to take over-the-counter drugs, since they never cause any issues."

Objective: Describe where a nurse will find new information about the use of drugs during pregnancy and lactation.
NCLEX test item: Multiple choice
Cognitive skill: Comprehension

9. An expecting mother asks the nurse if it would be okay for her to take some cold medicine. What would be an appropriate response by the nurse?

1. "There are not a lot of studies done with regard to how safe medications are to take during pregnancy."
2. "I am sure it is safe to take, no problem."
3. "I believe the cold medication is contraindicated for pregnant women."
4. "Animal studies have revealed no evidence of harm to the fetus using these drugs."

Objective: Discuss the impact of pregnancy and breastfeeding on drug absorption, distribution, metabolism, and excretion.
NCLEX test item: Multiple choice
Cognitive skill: Understanding

10. A patient was discussing with the nurse the idea that in the future we will be able to determine which drug will be effective depending on a person's genetic makeup. Which term does this refer to?

1. Polymorphisms
2. Pharmacogenetics
3. Genome coding
4. Pharmacokinetics

Objective: Discuss the role of genetics and its influence on drug action.
NCLEX test item: Multiple choice
Cognitive skill: Knowledge

4 The Nursing Process and Pharmacology

https://evolve.elsevier.com/Willihnganz

Objectives

1. Discuss the components and purpose of the nursing process.
2. Explain what the nurse does to collect patient information during an assessment.
3. Discuss how nursing diagnosis statements are written.
4. Differentiate between a nursing diagnosis and a medical diagnosis.
5. Discuss how evidence-based practice is used in planning nursing care.
6. Differentiate between nursing interventions and outcome statements.
7. Explain how Maslow's hierarchy of needs is used to prioritize patient needs.
8. Compare and contrast the differences between dependent, interdependent, and independent nursing actions.
9. Discuss how the nursing process applies to pharmacology.

Key Terms

nursing process (NŬR-sĭng PRŎ-sĕs) (p. 38)
assessment (ă-SĔS-mĕnt) (p. 39)
nursing diagnosis (NŬR-sĭng dī-ăg-NŌ-sĭs) (p. 40)
defining characteristics (dĕ-FĪN-ĭng kăr-ăk-tĕr-ĬS-tĭks) (p. 41)
medical diagnosis (p. 41)
focused assessment (FŌ-kŭst ă-SĔS-mĕnt) (p. 41)
planning (p. 41)
nursing care plan (p. 42)
critical pathways (KRĬ-tĭ-kŭl PĂTH-wāz) (p. 42)
evidence-based practice (ĔV-ĭ-dĕns BĀSD PRĂK-tĭs) (p. 42)
core measures (p. 42)
priority setting (prī-ŌR-ĭ-tē SĔT-tĭng) (p. 42)
measurable outcome statement (MĔ-zhŭr-ĕ-bŭl GŌL STĀT-mĕnt) (p. 42)
implementation (ĭm-plĕ-mĕn-TĀ-shŭn) (p. 44)
nursing interventions (p. 44)
nursing actions (p. 44)
dependent actions (dē-PĔN-dĕnt) (p. 44)
interdependent actions (ĭn-tŭr-dē-PĔN-dĕnt) (p. 44)
independent actions (ĭn-dē-PĔN-dĕnt) (p. 44)
drug history (HĬS-tō-rē) (p. 45)
primary source (PRĪ-măr-ē SŌRS) (p. 45)
subjective data (sŭb-JĔK-tĭv DĀ-tă) (p. 45)
objective data (ŏb-JĔK-tĭv DĀ-tă) (p. 45)
secondary sources (SĔK-ŏn-dār-ē SŌR-sĕz) (p. 45)
tertiary sources (TĔR-shē-ăr-ē) (p. 45)
drug monographs (MŎN-ō-grăfs) (p. 45)
therapeutic intent (thĕr-ă-PYŪ-tĭk) (p. 46)

THE NURSING PROCESS

The practice of nursing is an art and science that uses a systematic approach to identify and solve the potential problems that individuals may experience as they strive to maintain basic human function along the wellness-illness continuum. The focus of all nursing care is to help individuals maximize their potential for maintaining the highest possible level of independence for the meeting of self-care needs.

The **nursing process** is the foundation for the clinical practice of nursing. It provides the framework for consistent nursing actions and involves the use of a problem-solving approach. The nursing process also provides a method for evaluating the outcomes of the therapy delivered.

Many nursing education programs and healthcare facilities use a five-step nursing process model: (1) assessment, (2) nursing diagnosis, (3) planning, (4) implementation, and (5) evaluation. These five steps are actually an overlapping process (Fig. 4.1). Information from each step is used to formulate and develop the next step in the process. Box 4.1 illustrates the process that is used to assemble data and organize information into categories to identify the patient's strengths and problem areas. Thereafter, nursing diagnosis statements can be developed and focused nursing assessments can be initiated. Planning can be individualized, and measurable goals can be identified. Individualized nursing interventions can be developed to coincide with the individual's abilities and resources, as well as

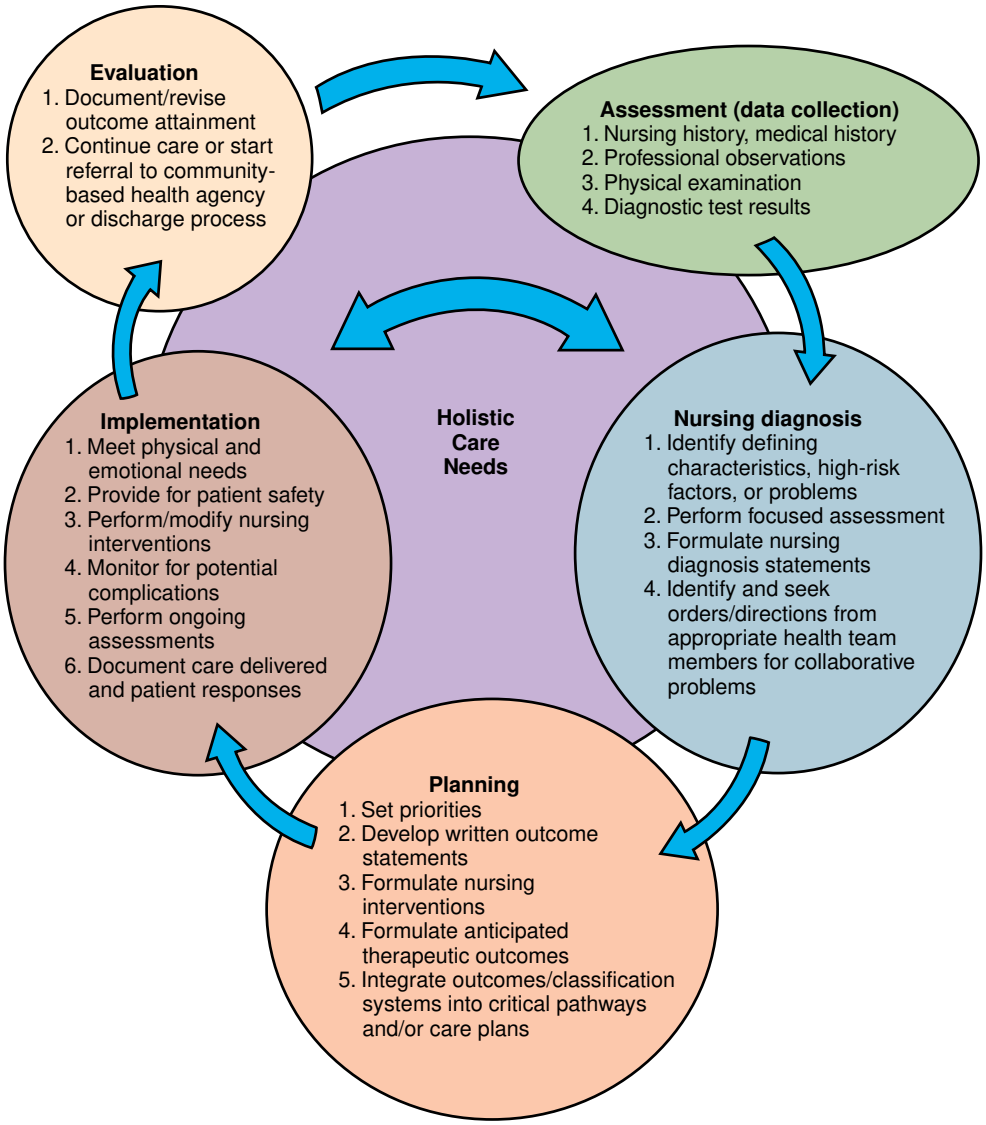


Fig. 4.1 The nursing process and the holistic needs of the patient.

the disease processes being treated. During the implementation process, the individual's physical, psychosocial, and cultural needs must be considered. The assessment process should continue to focus not only on the evolving changes in the presenting symptoms and problems but also on the detection of potential complications that may occur.

Nurses should familiarize themselves with the nurse practice act in the state in which they practice to identify the educational and experiential qualifications that are necessary for the performing of assessments and the development of nursing diagnoses. The formulation of nursing diagnoses requires a broad knowledge base to make the discriminating judgments needed to identify the individual patient's care needs. All members of the healthcare team need to contribute data regarding the patient's care needs and their response to the prescribed treatment regimen.

Just as body functions are constantly undergoing adjustments to maintain homeostasis in the internal and external environments, the nursing process is an ongoing cyclic process that must respond to the changing requirements of the patient. The nurse must continually interact with people in a variety of settings to establish and execute nursing functions creatively and cooperatively to meet the holistic care needs of patients (see Fig. 4.1).

ASSESSMENT

Assessment is the first phase of the five-step nursing process. It is the problem-identifying phase of the nursing process. The initial assessment must be performed by a registered nurse with the necessary skills to complete the physical examination. The assessment identifies patient problems based on defining characteristics (i.e., signs, symptoms, and clinical evidence). In addition, the nurse should identify risk factors that make an individual vulnerable to developing certain problems in response to a disease process or to its prescribed therapy (e.g., adverse effects of drugs).

Box 4.1 Principles of the Nursing Process and Their Application to Pharmacologic Needs

ASSESSMENT

- Collect all relevant data associated with the individual patient's symptoms; their history and physical, laboratory, and diagnostic data; and medical diagnosis to detect actual and risk/high-risk problems that require intervention.
- Data sources can be primary, secondary, or tertiary.
- Specific assessments related to the patient's pharmacologic needs include collecting the drug history; allergies; height and weight; age and disease process; hepatic function results (AST, ALT, alkaline phosphatase, LDH, bilirubin [total and direct]); and renal function results (serum creatinine, creatinine clearance, BUN, urinalysis, protein [total and 24-hour urine]), as well as discussing the patient's understanding of drug therapy and the treatment plan and determining their readiness to learn.

NURSING DIAGNOSIS

- On the basis of the data collected, formulate a statement about the behaviors or problems of concern and their cause.
- Formulate nursing diagnosis statements for problems that are amenable to nursing actions.
- Identify and seek orders or direction from appropriate healthcare team members for collaborative problems.[a]

PLANNING

- Prioritize the problems identified from the assessment data, with the most severe or life-threatening problems addressed first. Other problems are arranged in descending order of importance. (Maslow's hierarchy of needs is frequently used as a basis for prioritizing; other approaches may be equally valid.)
- Develop short- and long-term patient goals and outcomes in measurable statements that are appropriate to the clinical setting and the length of stay.
- Identify the monitoring parameters to be used to detect possible complications of the disease process or the treatments being used.
- Plan nursing approaches to correlate with each identified patient goal or outcome.
- Integrate outcomes and classification systems into critical pathways or standardized care plans to be used in clinical settings.
- Specific planning related to the patient's pharmacologic needs includes examining drug monographs and developing an individualized teaching plan.

IMPLEMENTATION

- Perform the nursing intervention planned to achieve the established goals or outcomes.
- Monitor the patient's response to treatments, and monitor for complications related to existing pathophysiology.
- Provide for patient safety.
- Perform ongoing assessments on a continuum.
- Document the care given and any additional findings on the patient's chart.[b]
- Specific interventions related to the patient's pharmacologic needs include administering the prescribed drug using the seven rights: verifying the right patient, the right drug, the right dose, the right route, the right time, the right indication, and the right documentation. The nurse also will be monitoring the patient using diagnostic parameters; monitoring for adverse effects of medications; and performing and documenting health teaching, which includes having the patient understand the drug name, the dose, the route of administration, the anticipated therapeutic response, the adverse effects, what to do if a dose is missed, and how to fill a prescription.

EVALUATION

- Evaluation is an ongoing process that occurs at every phase of the nursing process. Establish target data to review and analyze at intervals prescribed by guidelines in the practice setting.
- Review and analyze the data regarding the patient, and modify the care plan so that goals and outcomes of care, which are used to return the patient to the highest level of functioning, are attained.
- Evaluate outcomes with the use of the classification systems, critical pathways, or standardized care plans that are used in the clinical setting.
- Follow a systematic approach to recording progress, depending on the setting and charting methodology.
- Continue the nursing process, initiate referral to a community-based health agency, or execute discharge procedures as ordered by the healthcare provider.
- Specific evaluation criteria related to the patient's pharmacologic needs include evaluating the patient's tolerance of drug therapy and their understanding of the treatment regimen.

[a]Because not all patient problems are amenable to resolution by nursing actions, those complications or problems associated with medical diagnosis or that result from treatment-related issues are placed in a category known as "Collaborative Problems," which the nurse monitors.
[b]Integrate the classification system that is currently in use in the clinical setting when charting (e.g., Nursing Minimum Data Set, Omaha System, Home Health Care Classification System).
ALT, Alanine aminotransferase; *AST,* aspartate aminotransferase; *BUN,* blood urea nitrogen; *LDH,* lactate dehydrogenase.

During the assessment, the nurse collects a comprehensive information base about the patient from the physical examination, the nursing history, the medication history, and professional observations. Formats commonly used for data collection, organization, and analysis are the head-to-toe assessment, body systems assessment, and Gordon's Functional Health Patterns Model. The head-to-toe and body systems approaches focus on the patient's physiology, whereas the Gordon's Functional Health Patterns Model (Box 4.2) includes sociocultural, psychological, spiritual, and developmental factors that affect the individual's needs.

NURSING DIAGNOSIS

Nursing diagnosis is the second phase of the five-step nursing process. NANDA International (NANDA-I,

Box 4.2 Gordon's Functional Health Patterns Model

Health Perception–Health Management Pattern
Nutrition-Metabolic Pattern
Elimination Pattern
Activity-Exercise Pattern
Cognitive-Perceptual Pattern
Sleep-Rest Pattern
Self-Perception–Self-Concept Pattern
Role-Relationship Pattern
Sexuality-Reproductive Pattern
Coping–Stress Tolerance Pattern
Value-Belief Pattern

Adapted from Gordon M. *Manual of Nursing Diagnosis.* 11th ed. Sudbury, MA: Jones & Bartlett; 2007.

formerly the North American Nursing Diagnosis Association) approved the following official definition of the term *nursing diagnosis:* "[a] clinical judgment about individual, family, or community responses to actual or potential health problems/life processes."

Using knowledge and skills related to anatomy, physiology, nutrition, psychology, pharmacology, microbiology, nursing practice skills, and communication techniques, the nurse analyzes the data collected during the assessment phase to identify whether certain major and minor **defining characteristics** (i.e., manifestations or signs and symptoms) relate to a particular patient problem. This analysis determines which data is important to act on and which data is to be monitored. The nurse may conclude that certain actual problems are present and identifies them with a nursing diagnosis. Nursing diagnoses provide the basis for the selection of nursing interventions or actions needed to treat the patient. Not all patient problems identified during an assessment are treated by the nurse alone. Many of these problems require a multidisciplinary approach.

A **medical diagnosis** is a statement of the patient's alterations in structure and function, and this results in the diagnosis of a disease or disorder that impairs normal physiologic function. A nursing diagnosis usually refers to the patient's ability to perform activities of daily living (ADLs) in relation to the impairment induced by the medical diagnosis; it identifies the individual's response to the illness. A medical diagnosis also tends to remain unchanged throughout the illness, whereas nursing diagnoses may vary, depending on the patient's state of recovery. Concepts that help distinguish a nursing diagnosis from a medical diagnosis include the following:

1. Conditions described by nursing diagnoses can be accurately identified by nursing assessment methods.
2. Nursing treatments or methods of risk-factor reduction can resolve the condition described by a nursing diagnosis.
3. Nurses assume accountability for outcomes within the scope of nursing practice.
4. Nurses assume responsibility for the research required to clearly identify the defining characteristics and causative factors of conditions described by nursing diagnoses.
5. Nurses engage in improving methods of treatment and treatment outcomes for conditions described by nursing diagnoses.

The wording of an actual nursing diagnosis takes the form of a three-part statement. These statements consist of the following: (1) a patient problem summarizing the issue; (2) the contributing factors or cause, which may include deficits in ADLs or the medical diagnosis; and (3) the defining characteristics (i.e., manifestations or signs and symptoms). An example related to pharmacology would state: *Insufficient knowledge related to polypharmacy as evidenced by inability to state what prescribed medications are used for.*

The risk nursing diagnosis statement consists of two parts: (1) the diagnostic label from the NANDA-I–approved list and (2) the risk factors that make the individual more susceptible to the development of the problem. A risk diagnosis is validated by the presence of risk factors that would contribute to the individual developing the stated problem.

Further discussion of the philosophy and clinical use of nursing diagnoses can be found in other primary texts and references, especially in those developed solely for the purpose of explaining nursing diagnoses.

Not all patient problems identified by the nurse can be resolved by nursing actions; many care plans include multidisciplinary input and planning to maximize patient outcomes. However, the nurse is responsible for monitoring the patient on a continuum for potential complications that are associated with the medical diagnosis, the diagnostic procedures, or the treatments prescribed.

Focused Assessment

A **focused assessment** is the process of collecting additional data specific to a patient or family that validates a suggested problem or nursing diagnosis. The questions asked or the data collected are used to confirm or rule out the defining characteristics associated with a specific nursing diagnosis statement. During the focused assessment, prescriptive orders can be identified that the nurse can implement and that are within the nurse's scope of practice.

PLANNING

Planning is the third phase of the five-step nursing process. After the patient has been assessed and problems have been diagnosed, plans should be formulated to meet the patient's needs. Planning usually encompasses four phases: (1) priority setting, (2) the development of measurable goal and outcome statements, (3) the formulation of nursing interventions, and (4) the formulation of anticipated therapeutic outcomes that can be used to evaluate the patient's status. The written or