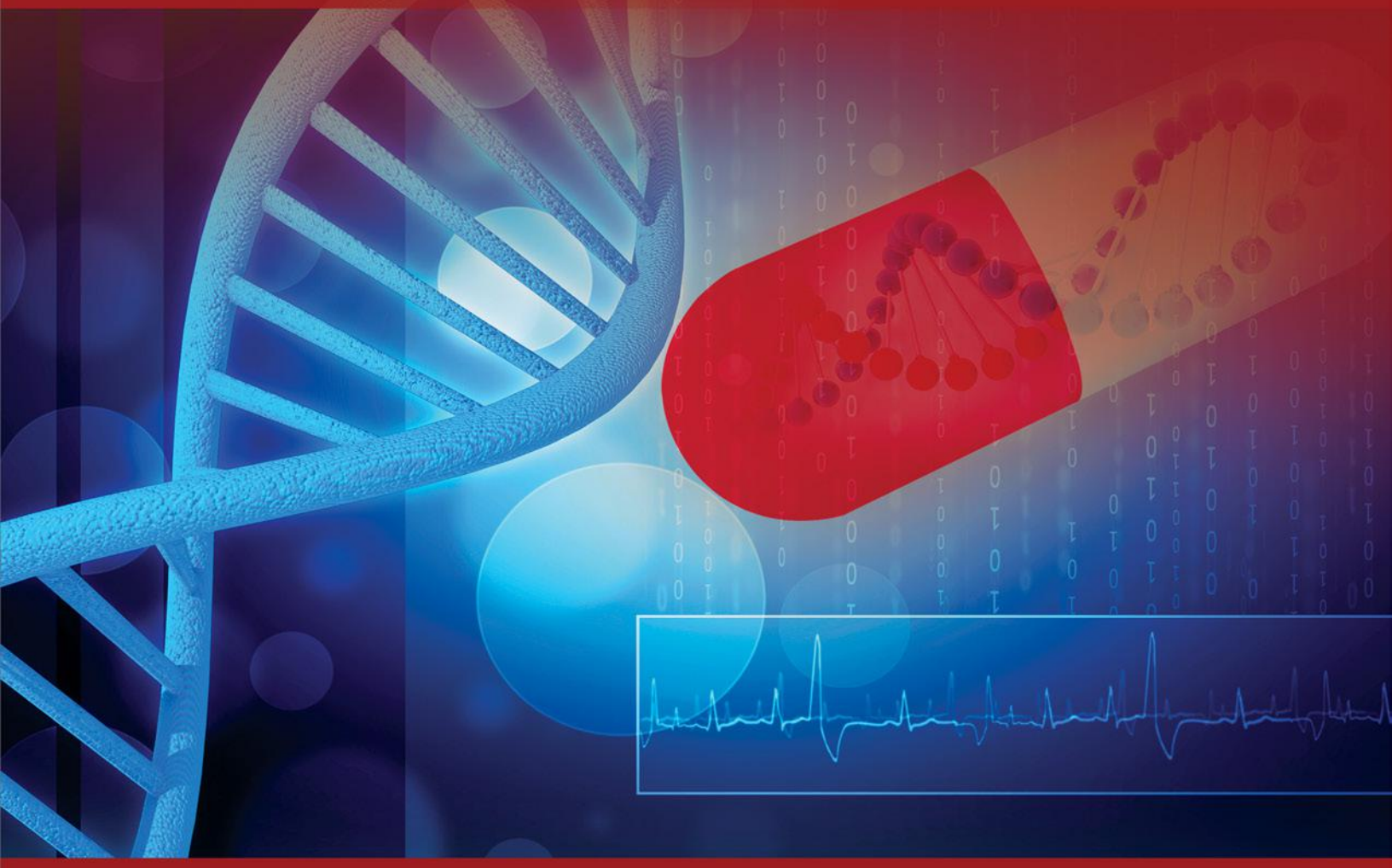
Fourth Edition

Pharmacology

Connections to Nursing Practice



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Brief Contents

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Pharmacology

Connections to Nursing Practice

FOURTH EDITION

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Dr. Adams obtained his master's degree in pharmacology from Michigan State University and his doctorate in education from the University of South Florida. Dr. Adams was on the faculty of Lansing Community College and St. Petersburg College, and was Dean of Health Professions at Pasco-Hernando State College for over 19 years. He is currently Adjunct Professor of Anatomy and Physiology at Hillsborough Community College.

I dedicate this book to nursing educators, who contribute every day to making the world a better and more caring place.

—MPA

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To my daughter, Joy, an extraordinary and resilient woman who continues to change the world for the better, and in memory of my son, Keith, and my husband, Mike.

—CQU

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To my husband, Lee, and my parents, Jane and Ellis, who have given me the foundation to reach for my dreams, and to my amazing children Andrew, Sarah, and Emily, who have made me stronger, better, and more fulfilled than I could have ever imagined. I love you to the moon and back.

—RES

Thank You

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Our heartfelt thanks go out to our colleagues from schools of nursing across the country who have given their time generously to help create this exciting new edition of our pharmacology textbook. These individuals helped us plan and shape our book and resources by reviewing chapters, art, design, and more. *Pharmacology: Connections to Nursing Practice* has reaped the benefit of your collective knowledge and experience as nurses and teachers, and we have improved the materials due to your efforts, suggestions, objections, endorsements, and inspiration. Among those who gave their time generously to help us are the following:

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Preface

Pharmacology is one of the most challenging and dynamic subjects for professional nurses. Each month new drugs are being introduced, and new indications are continually being developed for existing medications. Some medications that were considered preferred drugs only a decade ago are now rarely prescribed. Current knowledge of drug actions, mechanisms, interactions, and legislation is mandatory for nurses to provide safe and effective patient care in all healthcare settings. Pharmacotherapeutics remains a critical and ever-changing component of patient care.

The subtitle of this text, *Connections to Nursing Practice*, has guided its continued development. At a fundamental level, pharmacology is a series of interrelated essential concepts. Some key concepts are shared with the natural and applied sciences. Prediction of drug action requires a thorough knowledge of anatomy, physiology, chemistry, and pathology as well as the social sciences of psychology and sociology. This interdisciplinary nature of pharmacology makes the subject difficult to learn but fascinating to study.

However, the discipline of pharmacology is far more than a collection of isolated facts. To effectively learn this discipline, the student must make connections to nursing practice and, ultimately, connections to patient care. Patients expect to receive effective and safe medication administration from a nurse who is competent in the study of pharmacology. *Pharmacology: Connections to Nursing Practice* identifies key pharmacologic concepts and mechanisms and clearly connects them to current nursing theory and practice for providing optimal patient care.

Pharmacology: Connections to Nursing Practice recognizes that pharmacology is not an academic discipline to be learned for its own sake but is a critical tool to prevent disease and promote healing. This connection to patients, their assessment, diagnoses, and interventions supports basic nursing practice. Like other core nursing subjects, the focus of pharmacology must be to teach and promote wellness for patients.

Structure of the Text

This text is organized according to body systems (units) and diseases (chapters). Unit 1, the first seven chapters, identifies fundamental pharmacologic principles that are applied throughout the text. Although new drugs are constantly being developed, these chapters build the structural framework for understanding the applications of all drugs. The role of complementary and alternative therapies, which are used by many patients, is included in the context of holistic care.

Unit 2 connects pharmacology, the nurse, and the patient, with an emphasis on positive patient outcomes. The four chapters in this unit recognize the essential role of nurse–patient interactions in providing optimal patient care throughout the lifespan. The fact that individuals vary in their responses to drug action is an important theme introduced in this unit.

Units 3 through 11 provide the concepts and connections that are necessary to understand the actions and adverse effects of individual drugs on different body systems. Many of the units begin with a chapter that briefly reviews relevant anatomy and physiology, which is a useful feature for the student when studying drug actions. Each chapter clearly identifies the concepts and connections necessary for safe and effective pharmacotherapy. Pharmacology is intimately related to the study of disease processes. The connections between pharmacology and pathophysiology are clearly established for each drug class in every chapter.

Resources for Faculty and Student Success

Resources for Faculty

Pearson is pleased to offer a suite of resources to support teaching and learning, including:

- **TestGen Test Bank**
- **Lecture Note PowerPoints**
- **Instructor's Resource Manual**

Resources for Students

Online Resources for students that are available include:

- Making the Patient Connection case studies and answers
- Additional Case Studies and answers
- Answers to Patient Safety Questions
- Suggested answers to Connection Checkpoints, and more!

A Practical Approach to Learning Pharmacology

◄ **Disease and Body System Approach.** The organization by body systems (units) and diseases (chapters) places the drugs in context with how they are used therapeutically. This organization connects pharmacology and pathophysiology to nursing care.

► **Updated! Prototype Approach.** The vast number of drugs that the practicing nurse must learn is staggering. To facilitate learning, this text uses a prototype approach in which the most representative medications in each classification are introduced in detail. This edition features 194 prototype drugs that include detailed information on therapeutic effects, mechanism of action, pharmacokinetics, adverse effects, contraindications, drug interactions, pregnancy category, and treatment of overdose.

PROTOTYPE DRUG **Amiodarone (Pacerone)**

Classification **Therapeutic:** Antidysrhythmic, Class III
Pharmacologic: Potassium channel blocker

Therapeutic Effects and Uses: Approved in 1985, amiodarone is the most frequently prescribed Class III antidysrhythmic. It is considered a broad-spectrum antidysrhythmic because it is effective in terminating both atrial and ventricular dysrhythmias. It is approved for the treatment of resistant ventricular tachycardia and recurrent fibrillation that may prove life threatening, and it has become a preferred medication for the treatment of atrial dysrhythmias in patients with HF.

Adverse Effects: Potentially serious adverse effects limit the use of amiodarone. Amiodarone may cause nausea, vomiting, anorexia, fatigue, dizziness, and hypotension. Visual disturbances are common in patients taking this drug for extended periods and include blurred vision due to cornea deposits, photophobia, xerostomia, cataracts, and macular degeneration. Rashes, photosensitivity, and other skin reactions occur in 10% to 15% of patients taking the drug. Certain tissues concentrate this medication; thus, adverse effects may be slow to resolve, persisting long after the drug has been discontinued. **Black Box Warning (oral form only):** Amiodarone causes a pneumonia-like syndrome in the lungs. Because the pulmonary toxicity may be fatal, baseline and periodic assessments of lung function are essential. Amiodarone has prodysrhythmic action and may cause bradycardia, cardiogenic shock, or AV block. Mild liver injury is frequent with amiodarone.

◄ **Updated! Black Box Warnings.** The latest black box warnings issued by the U.S. Food and Drug Administration are clearly identified for all prototype medications.

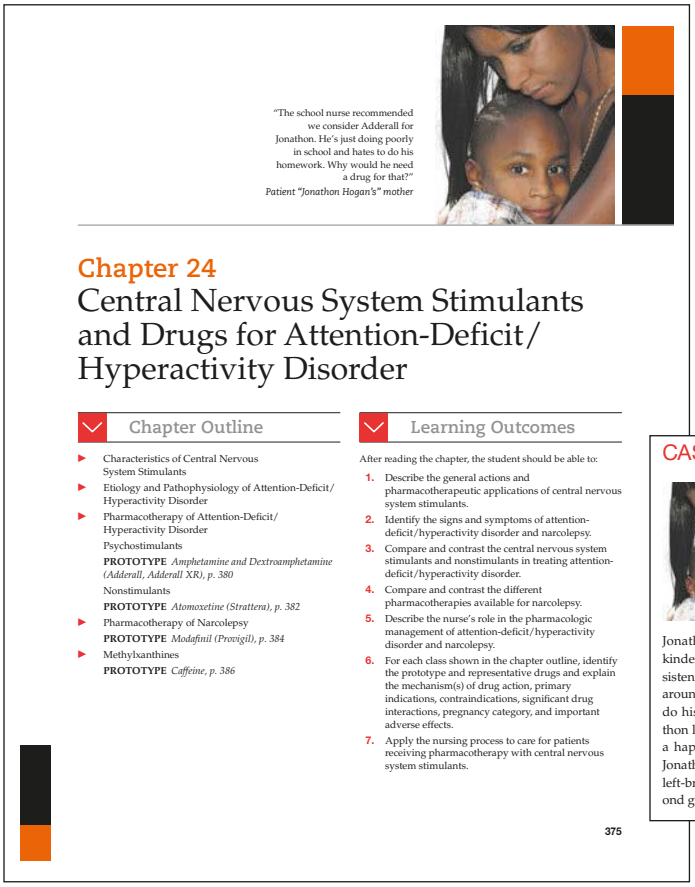
▶ **Updated! Drug Tables.** Easy-to-understand tables reflect the latest FDA-approved drugs and provide average dosages for most medications. Unique to this text is a listing of the most common and the most serious adverse effects for each drug or drug class. This allows the student to immediately recognize important safety information regarding the drug(s) he or she is administering.

Table 38.5 Antiplatelet Drugs

Drug	Route and Adult Dose (Maximum Dose Where Indicated)	Adverse Effects
anagrelide (Agrylin)	PO: 0.5 mg qid or 1 mg bid (max: 10 mg/day)	*Nausea, vomiting, diarrhea, abdominal pain, dizziness, headache*
aspirin (ASA, acetylsalicylic acid)	PO: 80 mg daily to 650 mg bid	
dipyridamole (Persantine)	PO: 75–100 mg qid as adjunct to warfarin therapy	Increased bleeding, central nervous system (CNS) effects (dipyridamole), anaphylaxis (aspirin), interstitial lung disease (anagrelide)
vorapaxar (Zontivity)	PO: 2.08 mg/day	
ADP Receptor Blockers		
clopidogrel (Plavix)	PO: 75 mg/day (max: 300 mg/day for life-threatening cases)	*Minor bleeding, dyspepsia, abdominal pain, headache, rash, diarrhea*
prasugrel (Effient)	PO: 60-mg loading dose followed by 10 mg/day	
ticagrelor (Brilinta)	PO: 180-mg loading dose followed by 90 mg bid	Increased clotting time, GI bleeding, blood dyscrasias, angina
Glycoprotein IIb/IIIa Receptor Antagonists		
abciximab (ReoPro)	IV: 0.25 mg/kg initial bolus over 5 min, then 0.125 mcg/kg/min for 12 h (max: 10 mcg/min)	*Dyspepsia, dizziness, pain at injection site, hypotension, bradycardia, minor bleeding*
eptifibatide (Integrilin)	IV: 180 mcg/kg initial bolus over 1–2 min, then 2 mcg/kg/min for 24–72 h (max: 180 mcg/kg bolus, 2 mcg/kg/min infusion)	Major hemorrhage, thrombocytopenia
tirofiban (Aggrastat)	IV: 0.4 mcg/kg/min for 30 min, then 0.1 mcg/kg/min for 12–24 h	
Drugs for Intermittent Claudication		
cilostazol (Pletal)	PO: 100 mg bid	*Dyspepsia, nausea, vomiting, dizziness, myalgia, headache*
pentoxifylline (Trental)	PO: 400 mg tid (max: 1200 mg/day)	Tachycardia and palpitations (cilostazol), CNS effects (pentoxifylline), heart failure, MI

Note: *Italics* indicate common adverse effects. Underline indicates serious adverse effects.

Connections to Nursing Practice


"The school nurse recommended we consider Adderall for Jonathon. He's just doing poorly in school and hates to do his homework. Why would he need a drug for that?"
Patient "Jonathon Hogan's" mother

Chapter 24
Central Nervous System Stimulants and Drugs for Attention-Deficit/ Hyperactivity Disorder

Chapter Outline

- Characteristics of Central Nervous System Stimulants
- Etiology and Pathophysiology of Attention-Deficit/ Hyperactivity Disorder
- Pharmacotherapy of Attention-Deficit/ Hyperactivity Disorder
  - Psychostimulants
    - **PROTOTYPE** *Amphetamine and Dextroamphetamine (Adderall, Adderall XR), p. 380*
  - Nonstimulants
    - **PROTOTYPE** *Atomoxetine (Strattera), p. 382*
- Pharmacotherapy of Narcolepsy
  - **PROTOTYPE** *Modafinil (Provigil), p. 384*
- Methylxanthines
  - **PROTOTYPE** *Caffeine, p. 386*

Learning Outcomes

After reading the chapter, the student should be able to:

1. Describe the general actions and pharmacotherapeutic applications of central nervous system stimulants.
2. Identify the signs and symptoms of attention-deficit/hyperactivity disorder and narcolepsy.
3. Compare and contrast the central nervous system stimulants and nonstimulants in treating attention-deficit/hyperactivity disorder.
4. Compare and contrast the different pharmacotherapies available for narcolepsy.
5. Describe the nurse's role in the pharmacologic management of attention-deficit/hyperactivity disorder and narcolepsy.
6. For each class shown in the chapter outline, identify the prototype and representative drugs and explain the mechanism(s) of drug action, primary indications, contraindications, significant drug interactions, pregnancy category, and important adverse effects.
7. Apply the nursing process to care for patients receiving pharmacotherapy with central nervous system stimulants.

375

◀ **Making the Patient Connection** is a feature that opens each chapter with a quote and a photo of a patient. It reinforces to the student that the focus of pharmacology must always be on the patient. To drive this important message home, the patient who is introduced at the start of the chapter is revisited at the end with critical thinking exercises. These questions assist the student to apply the content learned in the chapter to a realistic patient scenario. An additional case study is also included for further application of knowledge learned.

CASE STUDY: Making the Patient Connection

Remember the patient "Jonathon Hogan" at the beginning of the chapter? Now read the remainder of the case study. Based on the information presented within this chapter, respond to the critical thinking questions that follow.

Jonathon Hogan has had trouble at school beginning in kindergarten and for the past year. His teachers have consistently reported that he is easily distracted and wanders around the classroom even during a lesson. Getting him to do his homework after school has been a struggle. Jonathon loves art and does well at video games. Because he is a happy-go-lucky child, his parents have assumed that Jonathon's right-brain dominance has created trouble with left-brain logical work. With more homework now in second grade, Jonathon is struggling to keep up in school. The school nurse suspects he may have ADHD. She has recommended an appointment with Jonathon's healthcare provider and told his parents that Adderall may help Jonathon focus on his schoolwork.

Critical Thinking Questions

1. What is ADHD and why would Jonathon be experiencing more difficulty as he becomes older?
2. How might amphetamine sulfate and dextroamphetamine (Adderall) help Jonathon with his ADHD?
3. What caregiver education would be appropriate regarding dextroamphetamine and amphetamine sulfate (Adderall)?
4. What are other nonpharmacologic treatments for ADHD?

Answers to Critical Thinking Questions are available on the faculty resources site. Please consult with your instructor.

► **New! Connections: Preparing for Advanced Practice.** Dramatic changes in the delivery of healthcare have placed an increased emphasis on developing the critical thinking skills and clinical decision-making abilities of nurses at both the undergraduate and graduate levels. Through case studies, the authors use strategies that promote the clinical decision-making skills of advanced practice nurses. Particular attention is paid to advanced practice nurses who are preparing to work within specialty practice settings and with vulnerable populations.

CONNECTIONS: Preparing for Advanced Practice

Chronic Kidney Disease and Prescribing Considerations

Case

Nolan is a 71-year-old African American man who was admitted to the hospital for altered mental status. His daughter Renee reported that her father had become progressively confused and had been having visual and auditory hallucinations, seeing and hearing people and animals that were not really there. In the past 24 hours, Nolan's symptoms had become more persistent and she became more and more concerned. Nolan has a 9-year history of HF and type 2 diabetes, and was diagnosed 10 months ago with stage V CKD, thought to be primarily due to his diabetic nephropathy.

On admission, the nurse practitioner hospitalist, his bedside nurse, and the unit's Pharm D. reviewed his medications with Renee. Nolan was taking 81 mg of aspirin, atenolol, atorvastatin, calcium acetate, insulin, and had recently started 300 mg of gabapentin 3 times daily for the diabetic neuropathy. On physical examination, he was sleepy but arousable. His blood pressure was 136/86 mmHg; pulse was 72 beats/min (regular); respiratory rate was 14 breaths/min; and oxygen saturation 96%. What pharmacologic factors should the team be considering for Nolan?

Discussion

Kidney disease, both acute kidney injury (AKI) and CKD, affects every organ system in the body. The number of patients with AKI and CKD has increased due to the aging populations and medical advancements. Prescribing considerations for patients with CKD and AKI therefore require more thought, especially for medications that are renally excreted. For prescribing purposes, CKD is divided into three grades:

- Mild: GFR 20–50 mL/min; serum creatinine 150–300 µmol/L
- Moderate: GFR 10–20 mL/min; serum creatinine 300–700 µmol/L
- Severe: GFR less than 10 mL/min; serum creatinine more than 700 µmol/L (GFR above 50 mL/min does not usually require any dosage adjustment.)

Drugs to which particular attention should be given include histamine H_2-receptor antagonists, specific antibiotics, anticonvulsants, digoxin, and NSAIDs. Prescribing any medication that increases potassium levels, such as potassium supplements and potassium-sparing diuretics, is potentially very dangerous. Additionally, methotrexate, enoxaparin, and metformin should no longer be prescribed even with a mild grade of CKD. With cardiovascular (e.g., atenolol), antidiabetic (e.g., glibenclamide), or anticonvulsive (e.g., gabapentin) drugs, the recommendation is to use alternative medications, such as metoprolol, gliquidone, or carbamazepine, that are not renally excreted or are independent of kidney function. Drug dose adjustments should be considered with antimicrobial (e.g., ampicillin), antiviral (e.g., acyclovir), and some chemotherapeutic and cytotoxic drugs (e.g., cisplatin). Products with a high sodium content (e.g., antacids) should be avoided because they may cause sodium and water retention in patients with CKD (Carville, Wonderling, & Stevens, 2014).

CONNECTIONS: Treating the Diverse Patient

Improved Kidney Function from Thyroid Hormone Replacement

Because thyroid hormones affect nearly all body systems, even slight changes in the amount of circulating hormones may have profound effects, especially in the very young and the older adult populations. Recent research suggests that thyroid hormone therapy may help preserve renal function in older patients (Lu, Guo, Liu, & Zhao, 2016). Subclinical hypothyroidism may have significant effects on chronic kidney disease. Several theories exist as to why thyroid replacement improves renal function, including improvement in cardiac status, improvement in dyslipidemias, or the effect on vascular endothelium (Hataya, Igarashi, Yamashita, & Komatsu, 2013; Rhee et al., 2015; Shin et al., 2013). Individualized treatment for subclinical hypothyroidism should be considered in older patients.

◄ **Connections: Treating the Diverse Patient** features identify gender, cultural, and ethical influences that are important modifiers of drug action.

► **Connections: Complementary and Alternative Therapies** features present herbal therapies and dietary supplements that may be considered as alternatives to conventional drugs. These features include a description of the herb or supplement, history of use, standardization of dose, and brief description of the scientific evidence supporting (or not supporting) the use of the product.

CONNECTIONS: Complementary and Alternative Therapies

Probiotics for Diarrhea

Description

Probiotics are live microorganisms that are taken in specified amounts to confer a health benefit on the host. Most commercial probiotics are bacteria from the genera *Lactobacillus* and *Bifidobacterium*; however, the yeast *Saccharomyces* is sometimes also used.

History and Claims

Although probiotics have been used for thousands of years, only in the past 20 years has research begun to confirm their health benefits. Probiotics are claimed to improve immune function, decrease cancer risk, lower blood cholesterol, reduce blood pressure, and prevent vaginal infections. Probiotic supplements are available in certain drinks, yogurts, and tablets. Although probiotics are safe, care must be taken not to exceed recommended doses.

Standardization

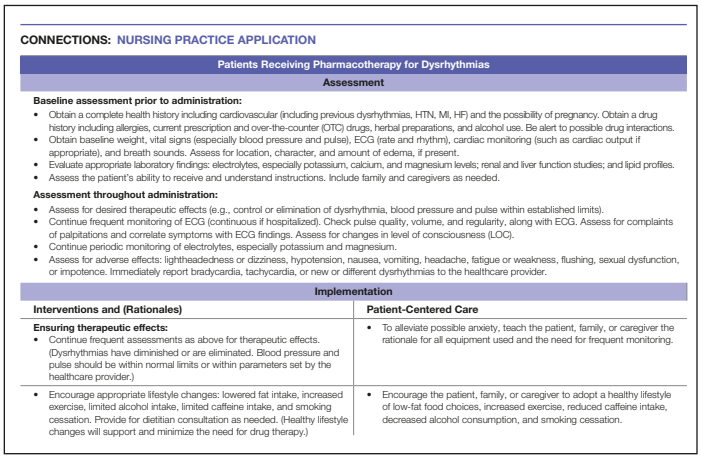
Supplements include capsules, tablets, and granules, as well as cultured dairy products that contain the probiotic bacteria. Doses are not standardized. Tablet doses range from 50 to 500 mg, and not all dairy products contain active cultures.

Evidence

Most of the evidence supporting the efficacy of probiotics is related to their effects on the intestinal tract. Both *Lactobacillus* and *Bifidobacterium* are normal nonpathogenic inhabitants of a healthy digestive tract. These are considered to be protective flora, inhibiting the growth of potentially pathogenic species such as *E. coli*, *Candida albicans*, *Helicobacter pylori*, and *Gardnerella vaginalis*. Probiotics restore the normal flora of the intestine following diarrhea, particularly diarrhea resulting from antibiotic therapy (National Center for Complementary and Integrative Health, 2016). A 2015 systematic review indicated that probiotics do in fact reduce symptoms of IBS in patients (Didari, Mozaffari, Nikfar, & Abdollahi, 2015). Probiotics have also been shown to be effective at shortening episodes of acute infectious diarrhea and may be considered an option for increasing eradication rates for those with *H. pylori* (Dang, Reinhardt, Zhou, & Zhang, 2014).

Although probiotics have been used for many years, they are not without risk. Infections (including sepsis), lactic acidosis, and other serious adverse effects have been noted (Doron & Snydman, 2015). Because of these, probiotic supplements should be used with caution in critically ill patients.

► **Connections: Nursing Practice Applications** features concisely connect the nursing process to the major drug class(es) in each drug chapter and incorporate outcomes from the Quality and Safety Education for Nurses (QSEN) competencies of patient-centered care, teamwork and collaboration, patient safety, and evidence-based practice. Each nursing intervention is patient centered and includes the rationale and associated patient and family teaching. Collaboration with other disciplines, such as social support services or dietary services, is also included in the interventions. Important lifespan and diverse patient considerations are noted throughout. The Nursing Practice Applications are organized to help students learn to think like a nurse as they take students through the processes of drug administration, nursing care, and teaching that are necessary in pharmacotherapy.



CONNECTIONS: NURSING PRACTICE APPLICATION

Patients Receiving Pharmacotherapy for Dysrhythmias

Assessment

Baseline assessment prior to administration:

- Obtain a complete health history including cardiovascular (including previous dysrhythmias, HTN, MI, HF) and the possibility of pregnancy. Obtain a drug history including allergies, current prescription and over-the-counter (OTC) drugs, herbal preparations, and alcohol use. Be alert to possible drug interactions.
- Obtain baseline weight, vital signs (especially blood pressure and pulse), ECG (rate and rhythm), cardiac monitoring (such as cardiac output if appropriate), and breath sounds. Assess for location, character, and amount of edema, if present.
- Evaluate appropriate laboratory findings: electrolytes, especially potassium, calcium, and magnesium levels; renal and liver function studies; and lipid profiles.
- Assess the patient's ability to receive and understand instructions. Include family and caregivers as needed.

Assessment throughout administration:

- Assess for desired therapeutic effects (e.g., control or elimination of dysrhythmia, blood pressure and pulse within established limits).
- Continue frequent monitoring of ECG (continuous if hospitalized). Check pulse quality, volume, and regularity, along with ECG. Assess for complaints of palpitations and correlate symptoms with ECG findings. Assess for changes in level of consciousness (LOC).
- Continue periodic monitoring of electrolytes, especially potassium and magnesium.
- Assess for adverse effects: lightheadedness or dizziness, hypotension, nausea, vomiting, headache, fatigue or weakness, flushing, sexual dysfunction, or impotence. Immediately report bradycardia, tachycardia, or new or different dysrhythmias to the healthcare provider.

Implementation

Interventions and (Rationales)	Patient-Centered Care
Ensuring therapeutic effects: • Continue frequent assessments as above for therapeutic effects. (Dysrhythmias have diminished or are eliminated. Blood pressure and pulse should be within normal limits or within parameters set by the healthcare provider.)	• To alleviate possible anxiety, teach the patient, family, or caregiver the rationale for all equipment used and the need for frequent monitoring.
• Encourage appropriate lifestyle changes: lowered fat intake, increased exercise, limited alcohol intake, limited caffeine intake, and smoking cessation. Provide for dietitian consultation as needed. (Healthy lifestyle changes will support and minimize the need for drug therapy.)	• Encourage the patient, family, or caregiver to adopt a healthy lifestyle of low-fat food choices, increased exercise, reduced caffeine intake, decreased alcohol consumption, and smoking cessation.

CONNECTIONS: Patient Safety

Incorrect Insulin Dose

A patient with diabetes has 30 units of Humulin R (regular) insulin ordered for the morning dose. There are several patients with diabetes on the unit and the nurse has given many doses of insulin that morning. The nurse prepares the insulin but draws up Humalog 30 units instead. The patient begins experiencing symptoms of hypoglycemia within 15 minutes and is treated successfully.

What errors occurred and how could they be prevented in the future?

Answers to Patient Safety questions are available on the faculty resources site. Please consult with your instructor.

◄ **Connections: Patient Safety,** a QSEN competency, is a feature that presents a brief patient–nurse scenario that illustrates potential pitfalls encountered by nurses that can lead to medication errors. Most scenarios end with a question asking the student to identify what went wrong, what the nurse should do in the situation, what the nurse should question about the order, or what the nurse should do differently in order to prevent medication administration errors.

► **New! Connections: Using Research in Practice** features illustrate connections to nursing or pharmacology research and discuss the short- and long-term directions of pharmacotherapeutics. A critical thinking question is presented at the end of each feature to challenge the student to connect scientific evidence to nursing practice.

CONNECTIONS: Using Research in Practice

Early Exposure to Allergens May Reduce Asthma Risk

Allergen exposure has been noted to increase the risk for and severity of asthma in both children and adults (Custovic, 2015; Sheehan & Phipatanakul, 2016). What is not as clear is what roles the timing of initial exposure, ongoing exposure, types of allergens, or amount of exposure play in the development of protection from conditions such as asthma and anaphylaxis (Sheehan & Phipatanakul, 2016).

Lynch et al. (2014) noted that cumulative exposure to allergens in the first 3 years of life seemed to decrease the risk of recurrent wheezing and allergies and that such early exposure may be beneficial. A subsequent study also noted that

CONNECTIONS: Lifespan Considerations

Miscarriage Prevention with Anticoagulants

Miscarriage in pregnancy is devastating, and recurrent miscarriage even more so. Autoimmune diseases are related to poorer obstetric outcomes than that of the general population, especially in mothers with undiagnosed thrombophilias (genetic hypercoagulability disorders) such as antiphospholipid syndrome (APS). Antiphospholipid antibodies are present in 15% of women with recurrent miscarriage, and there is a potential 90% risk of future fetal loss in those women if left untreated (Chetty & Duncan, 2015). Other obstetric and neonatal complications related to APS include preeclampsia; eclampsia; hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome; early delivery and subsequent prematurity; intrauterine growth restriction (IUGR); and placental insufficiency (Begum, Ganguly, & Islam, 2015; de Jesús, Rodrigues, de Jesús, & Levy, 2014).

Due to discrepancies in the research on treatment recommendations for the use of heparin, LMWH, or aspirin for recurrent spontaneous abortion before 10 weeks of pregnancy, it is recommended that a woman experiencing such loss discuss the situation with her provider and whether genetic testing should be conducted. If genetic coagulation abnormalities are found, heparin or LMWH may be considered as an option (Andreoli et al., 2013).

◄ **Connections: Lifespan Considerations** features clearly identify important considerations to ensure safe and effective pharmacotherapy in the older adult and pediatric populations.

CONNECTION Checkpoint 38.1

Coagulation occurs by intrinsic and extrinsic pathways. From what you learned in Chapter 28, which pathway is activated when blood leaks from a vessel? Which is more complex and takes several minutes? Which results in the formation of fibrin? *Answers to Connection Checkpoint questions are available on the faculty resources site. Please consult with your instructor.*

▲ **Connection Checkpoints** ask the student to recall past concepts from previous chapters that are related to current study. Unique to this text, these reinforce material learned in previous chapters that has direct application to the current chapter.

► **PharmFacts** connect relevant statistics to the presented material. They add interest to the subject and place it in perspective with other nursing concepts.

PharmFACT

In the United States, over 13 million units of whole blood and red blood cells are donated each year. About 36,000 units of red blood cells are needed every day (American Red Cross, n.d.).

CONNECTIONS: Community-Oriented Practice

Calcium Channel Blockers and Effects on Minerals

Patients may be concerned about taking calcium supplements for osteoporosis prevention while taking CCBs. Calcium and magnesium supplements may actually help maintain a normal blood pressure or a lower high blood pressure, and as long as normal doses are taken, do not appear to affect the antihypertensive effects of CCBs. More recent research suggests that CCBs may affect the body's mineral content (Suliburska, Bogdanski, Szulinska, & Pupek-Musialik, 2014). CCBs, along with other antihypertensive drugs such as beta blockers and angiotensin-converting enzyme (ACE) inhibitors, were found to decrease serum zinc levels. Because depletion of some minerals such as zinc may have long-term effects on glucose and lipid metabolism, adequate mineral intake through diet or supplementation should be considered when a patient is taking CCBs or other antihypertensives.

◄ **Connections: Community-Oriented Practice** features provide important information that nurses need to convey to their patients to ensure that they receive effective pharmacotherapy after leaving the hospital or clinical setting.

Nursing Responsibilities:

- Notify the prescriber prior to administration if the patient has a history of leukemia, multiple myeloma, or other myeloid malignancies.
- Monitor for and immediately report signs and symptoms of fluid overload, hypokalemia, and cardiac dysrhythmias.
- Monitor patients with preexisting fluid retention conditions carefully, such as HF, pleural effusion, or ascites, for worsening of symptoms.
- This drug has a black box warning for possible anaphylaxis. Promptly report any signs and symptoms of allergic reaction to the provider and discontinue the drug.

Lifespan and Diversity Considerations:

- Tachycardia, cardiomegaly, papilledema, conjunctival redness, and bone changes may occur more frequently in children taking oprelvekin than in adults. Carefully monitor heart rate and heart sounds, changes in visual acuity or eye pain, and for complaints of bone pain or changes in gait. Further cardiac testing (e.g., echocardiography) and frequent eye exams may be warranted.

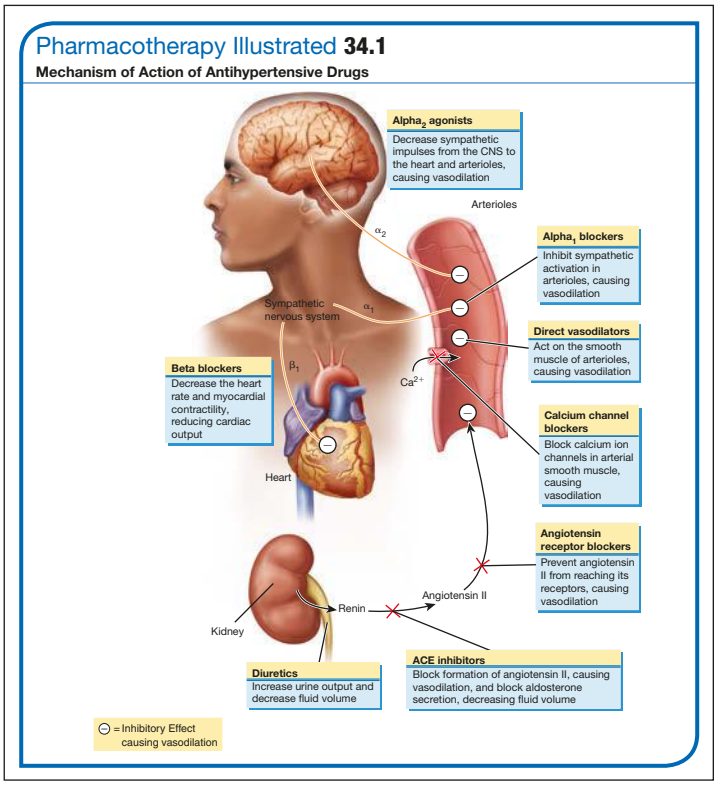
Patient and Family Education:

- Do not take any other prescription or nonprescription drugs, dietary supplements, or herbal products without the approval of the healthcare provider.

◀ **Nursing Responsibilities** specific to some prototype drugs are provided in a bulleted list format. Nursing Responsibilities include important lifespan and diversity considerations and patient and family education needs. When a prototype drug does not have a correlating Nursing Practice Application, a more complete Nursing Responsibilities section follows the prototype drug section.

Learning Through Visuals

▶ **Updated and Expanded! Pharmacotherapy Illustrated** features visually present the mechanism of action for many of the prototype drugs, showing students specifically how drugs counteract the effects of disease.



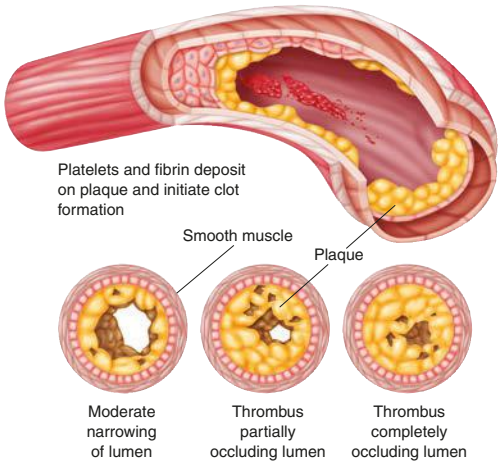


Figure 35.1 Atherosclerosis in the coronary arteries.

◄ **Vivid, Colorful, and Effective Illustrations** help students review the anatomy, physiology, and pathophysiology of a body system to better understand the impact of disease on that system.

Understanding the Chapter

The most comprehensive chapter review in its class! **Understanding the Chapter** begins with a **Key Concepts Summary**, which quickly identifies the numbered key concepts from the chapter.

► **Making the Patient Connection** reconnects the student to the patient presented in the scenario at the chapter opening. The student learns additional details about the patient's health history and participates in critical thinking questions about the scenario. This allows application of knowledge obtained in the chapter.

CASE STUDY: Making the Patient Connection

Remember the patient "Jonathon Hogan" at the beginning of the chapter? Now read the remainder of the case study. Based on the information presented within this chapter, respond to the critical thinking questions that follow.

Jonathon Hogan has had trouble at school beginning in kindergarten and for the past year. His teachers have consistently reported that he is easily distracted and wanders around the classroom even during a lesson. Getting him to do his homework after school has been a struggle. Jonathon loves art and does well at video games. Because he is a happy-go-lucky child, his parents have assumed that Jonathon's right-brain dominance has created trouble with left-brain logical work. With more homework now in second grade, Jonathon is struggling to keep up in school. The school nurse suspects he may have ADHD. She has recommended an appointment with Jonathon's healthcare provider and told his parents that Adderall may help Jonathon focus on his schoolwork.

Critical Thinking Questions

1. What is ADHD and why would Jonathon be experiencing more difficulty as he becomes older?
2. How might amphetamine sulfate and dextroamphetamine (Adderall) help Jonathon with his ADHD?
3. What caregiver education would be appropriate regarding dextroamphetamine and amphetamine sulfate (Adderall)?
4. What are other nonpharmacologic treatments for ADHD?

Answers to Critical Thinking Questions are available on the faculty resources site. Please consult with your instructor.

Additional Case Study

Anna Steinmetz has graduated from nursing school and is working nights. She is having difficulty adjusting to her night schedule. Her healthcare provider suggested she utilize a medication to assist with her adjustment to shift work. She has been prescribed modafinil (Provigil).

1. What effect does modafinil (Provigil) have on the patient's ability to maintain alertness during shift work?
2. What teaching will you provide to the patient regarding this medication?
3. The patient reports feelings of lightheadedness with position changes. What interventions will assist in maintaining patient safety?

Answers to Additional Case Study questions are available on the faculty resources site. Please consult with your instructor.

◄ An **Additional Case Study** gives students another opportunity to apply their knowledge to patient care.

► **Chapter Review** prepares students for course exams on chapter content and gives exposure to NCLEX-RN®-style questions. Answers and rationales are provided in Appendix A.

Chapter Review

1. An elementary school nurse is providing education to the faculty on the use of central nervous system stimulants to treat attention-deficit/hyperactivity disorder. Of the following, which is most important for the nurse to convey to the faculty?
   1. Have the child bring the drug dose in a lunch bag and come to the office to take it to avoid being teased.
   2. Request that the parents leave an extra copy of the prescription at the school in case the dose runs out.
2. The nurse is caring for a patient who has been prescribed atomoxetine (Strattera). The patient tells the nurse, "The world would be better off without me." Which action would the nurse take for this patient?
   1. Tell the patient to stop taking atomoxetine immediately and not to take it until checking with the provider.
   2. Assure the patient that these are normal symptoms because the drug may take 3 or 4 weeks to work.
   3. Alert the family or caregiver that immediate attention and treatment are needed for these symptoms.

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◀ Detailed **References** and a **Selected Bibliography** provide the foundation for evidence-based nursing practice and support the currency and accuracy of the textbook content.

New to the Fourth Edition

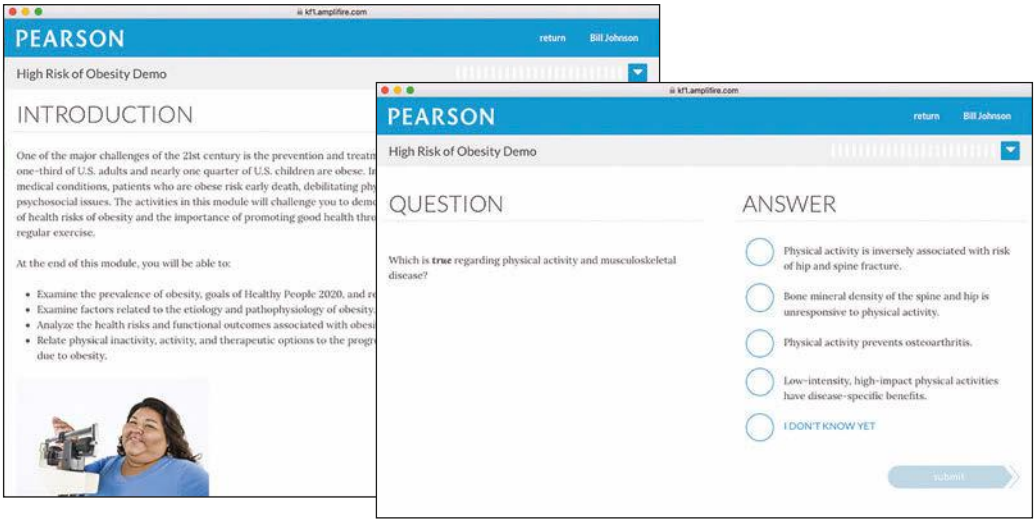
- Updated Connections features cover current topics that nurses will face in practice.
- **New** Connections: Preparing for Advanced Practice features help students develop critical thinking and clinical decision-making skills.
- **New** Connections: Using Research in Practice features illustrate connections to nursing or pharmacology research.
- More than 30 new drugs have been added to update medications approved by the FDA since the previous edition.
- Revised art program: More than 10 figures have been added or revised in this edition to enhance the clarity of difficult pharmacologic concepts.

MyLab Nursing

MyLab Nursing is an online learning and practice environment that works with the text to help students master key concepts, prepare for the NCLEX-RN exam, and develop clinical reasoning skills. Through a new mobile experience, students can study *Pharmacology: Connections to Nursing Practice* anytime, anywhere. New adaptive technology with remediation personalizes learning, moving students beyond memorization to true understanding and application of the content. MyLab Nursing contains the following features:

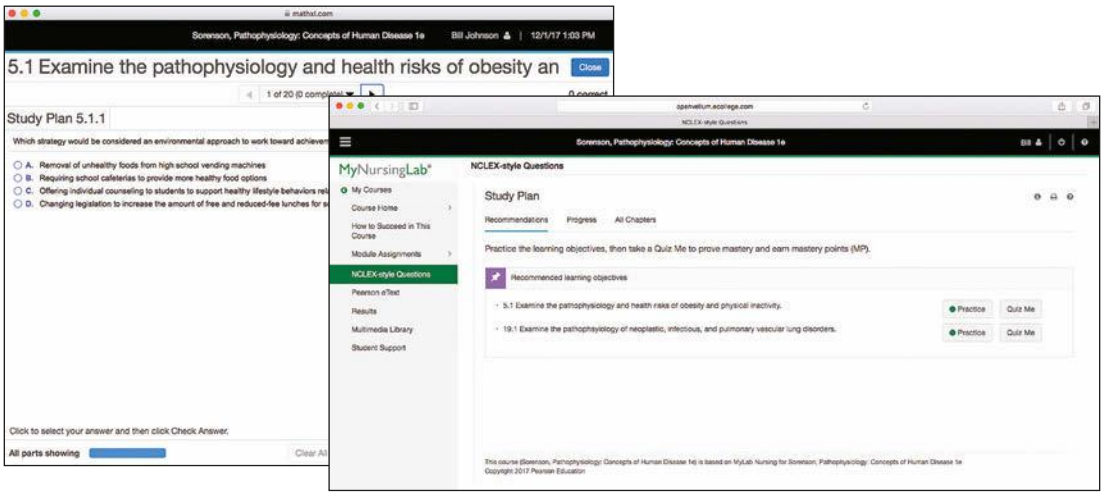
Dynamic Study Modules

New adaptive learning modules with remediation that personalize the learning experience by allowing students to increase both their confidence and their performance while being assessed in real time.



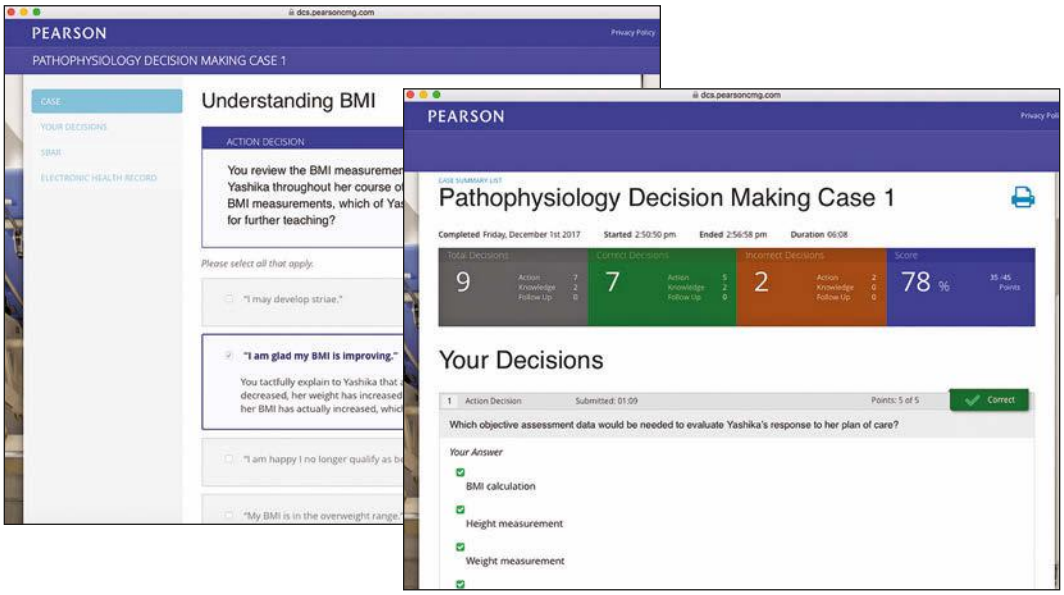
NCLEX-Style Questions

Practice tests with more than 1000 NCLEX-style questions of various types build student confidence and prepare them for success on the NCLEX-RN exam. Questions are organized by Chapter.



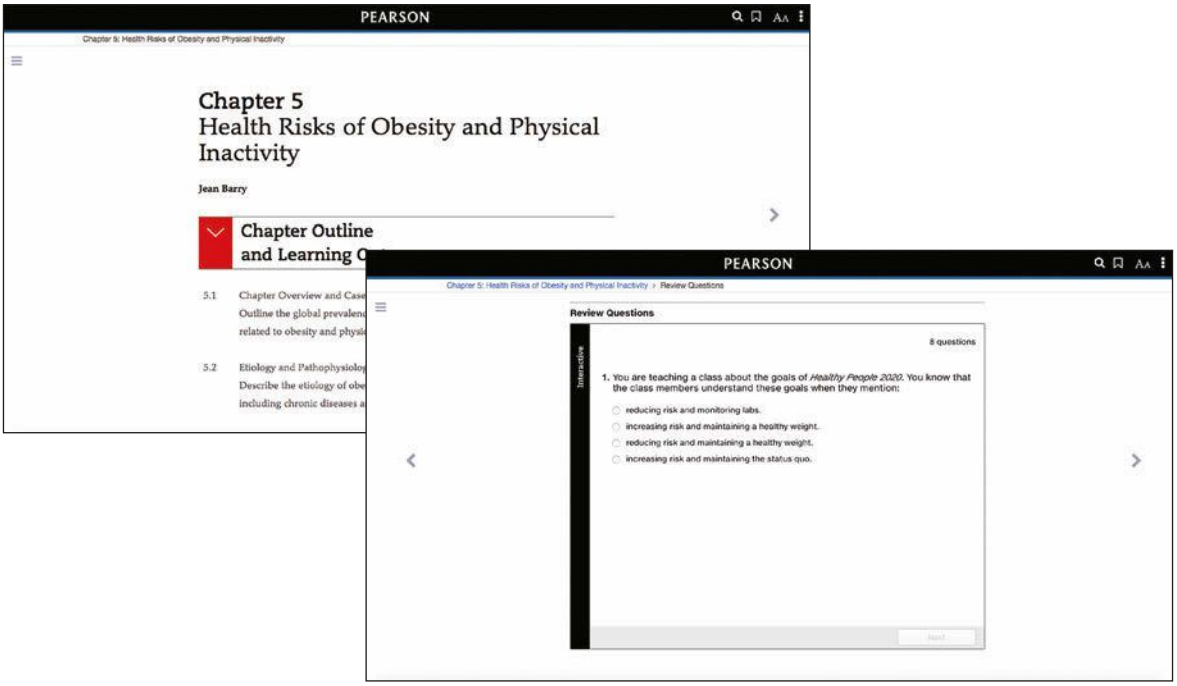
Decision Making Cases

Clinical case studies that provide opportunities for students to practice analyzing information and making important decisions at key moments in patient care scenarios. These 10 unfolding case studies are designed to help prepare students for clinical practice.



Pearson eText

Enhances student learning both in and outside the classroom. Students can take notes, highlight, and bookmark important content, or engage with interactive and rich media to achieve greater conceptual understanding of the text content. Interactive features include audio clips, pop-up definitions, figures, questions and answers, the nursing process, hotspots, and video animations.

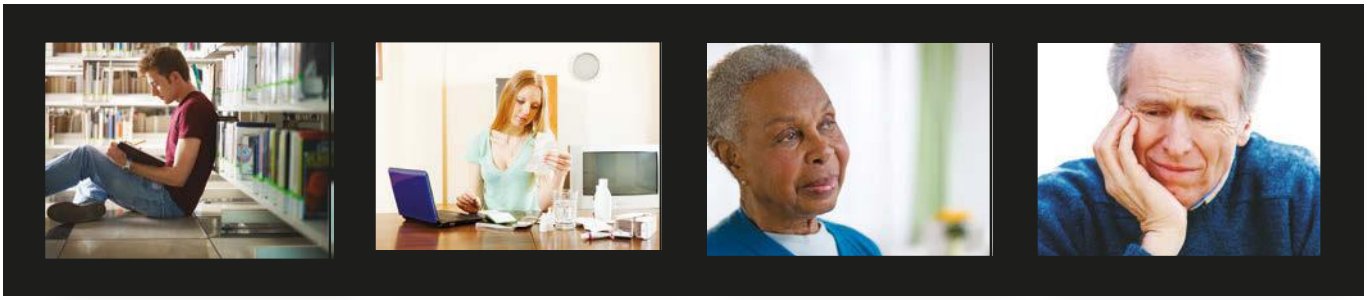


Contents

Unit 8 Pharmacology of Infectious and Neoplastic Diseases

Unit 1

Fundamental Principles of Pharmacology



"Wow, I just left my first pharmacology class and my head is swirling. How will I ever remember all this?"
Student "Josh Remming"

Chapter 1
Introduction to Pharmacology: Concepts and Connections

Chapter Outline

- Brief History of Pharmacology
- Pharmacology: The Study of Medicines
- Characteristics of an Ideal Drug
- Classification of Drugs
- Prototype Drugs
- Naming Drugs
- Connecting Pharmacology to Clinical Nursing Practice

Learning Outcomes

After reading this chapter, the student should be able to:

1. Identify key events in the history of pharmacology.
2. Compare and contrast the terms *drug*, *pharmacology*, and *pharmacotherapy*.
3. Explain the importance of pharmacotherapy to clinical nursing practice.
4. Using specific examples, explain the difference between the pharmacologic and therapeutic methods of classifying drugs.
5. Identify the advantages of using prototype drugs to study pharmacology.
6. Classify drugs by their chemical, generic, and trade names.
7. Discuss the rationale for a pharmaceutical company receiving exclusivity for the marketing of a new drug.
8. Analyze possible differences between generic drugs and their trade-name equivalents.
9. Explain how a biosimilar drug differs from its reference product.
10. Identify the responsibilities of the nurse in drug administration as part of an interprofessional team.

Key Terms

bioavailability, 8
biosimilar drug, 9
chemical names, 7
combination drugs, 8
drug, 4
exclusivity, 7
generic name, 7
indications, 5
pharmacologic classification, 6
pharmacology, 4
pharmacotherapy, 4
prototype drug, 7
therapeutic classification, 6
trade name, 7

More drugs are being administered to consumers than ever before. Over 3.6 billion prescriptions are dispensed each year in the United States, and the number is rapidly approaching 4 billion. Sales of prescription medications at retail pharmacies in the United States exceeded $286 billion in 2015 (Kaiser Family Foundation, 2016). The applications of pharmacology to medicine have expanded over the centuries and the nurse serves a key role in ensuring the success of pharmacotherapy. The purpose of this chapter is to introduce fundamental concepts of pharmacology and to emphasize the connections between drug therapy and clinical nursing practice.

PharmFACT

From 1999 to 2014, deaths from prescription opioids such as methadone and oxycodone quadrupled. More than 165,000 Americans died from overdoses from these prescription drugs during this period (Centers for Disease Control and Prevention, 2016).

Brief History of Pharmacology

1.1 The practice of applying products to relieve suffering has been recorded throughout history by virtually every culture.

The story of pharmacology is rich and exciting, filled with accidental discoveries and landmark events. Its history likely began when a human first used a plant to relieve symptoms of disease. One of the oldest forms of healthcare, herbal medicine has been practiced in virtually every culture dating to antiquity. The Babylonians recorded the earliest surviving "prescriptions" on clay tablets in 3000 BC, although magic and the art of reading omens were probably considered just as legitimate to healing as the use of herbal remedies. At about the same time, the Chinese recorded the *Pen Tsao* (Great Herbal), a 40-volume compendium of plant remedies dating to 2700 BC. The Egyptians followed in 1500 BC by archiving their remedies on a document known as the Eber's papyrus, which contains over 700 magical formulas and remedies. Galen, the famous Greek physician, described over 1000 healing preparations using plant products before his death in AD 201.

Little is known about pharmacology during the Dark Ages. Although it is likely that herbal medicine continued to be practiced, especially in monasteries and in centers of Arabic culture, few historical events related to drug therapy were recorded. Pharmacology, and indeed medicine, could not advance until the discipline of science was eventually viewed differently than magic and superstition.

The first recorded reference to the word *pharmacology* was found in a text titled "Pharmacologia sen Manuductio and Materiam Medicum" by Samuel Dale in 1693. Before this date, the study of herbal remedies was called "Materia Medica." The term *Materia Medica* likely originated from a Latin term meaning "medical matters," although use of this term continued into the early 20th century.

Although the exact starting date is obscure, modern pharmacology is thought to have begun in the early 1800s. At that time, chemists were making remarkable progress in separating specific substances from complex mixtures. This enabled chemists to isolate the active agents morphine, colchicine, curare, cocaine, and other early drugs from their natural plant products. Pharmacologists could then study their effects in animals more precisely, using standardized amounts. Some of the early researchers even used themselves as test subjects. Friedrich Sertürner, who first isolated morphine from opium in 1805, injected himself and three of his friends with a huge dose of 100 mg of his new product. He and his cohorts experienced acute morphine intoxication for several days afterward.

Pharmacology as a distinct discipline was officially recognized when the first Department of Pharmacology was established in Estonia in 1847. John Jacob Abel, who is considered the father of American pharmacology due to his many contributions to the field, founded the first pharmacology department in the United States at the University of Michigan in 1890.

In the 20th century, the pace of change in all areas of medicine became exponential. Pharmacologists no longer needed to rely on the slow, laborious process of isolating active agents from scarce natural products. They could synthesize drugs "from scratch" in the laboratory. Hundreds of new drugs could be synthesized and tested in a relatively short time span. More importantly, it became

possible to understand how drugs produced their effects, right down to their molecular mechanism of action.

The current practice of pharmacology is extremely complex and has progressed far beyond its early, primitive history. The nurses and other health professionals who administer medications, however, must never forget the early roots of pharmacology: the application of products to relieve or prevent human suffering. Whether a substance is extracted from the Pacific yew tree, isolated from a fungus, or created in a laboratory, the central purpose of pharmacology is focused on the patient and improving the quality of life.

CONNECTION Checkpoint 1.1

Some modern drugs used in the treatment of diabetes, cardiovascular disorders, and other conditions have unique sources. Using an online dictionary or search engine, what are the natural sources for exenatide (Byetta), captopril (Capoten), and hyaluronic acid? What conditions are they used to treat? *Answers to Connection Checkpoint questions are available on the faculty resources site. Please consult with your instructor.*

Pharmacology: The Study of Medicines

1.2 Pharmacology is the study of medicines.

The word *drug* has already been used numerous times in this text. What exactly is a drug? Is everything a drug, including water, vitamin C, or perhaps a can of cola? What about substances naturally found in the body, such as estrogen or testosterone? Is it even possible to define a drug?

The definition of a drug is indeed difficult but is nevertheless important to the healthcare profession. There are many definitions, but perhaps the clearest is that a **drug** is any substance that is taken to prevent, cure, or reduce symptoms of a medical condition. Considering the substances listed earlier, which, then, are drugs? Although it may seem vague, the correct answer is "it depends."

- The caffeine consumed in a cup of coffee is not considered a drug. Yet caffeine is included in several therapies for headache pain, including Excedrin and Fioricet. For the patient trying to get pain relief, caffeine is a drug.
- Vitamin C, if ingested as part of an orange or tomato, is food. Food is not a drug. However, someone with a vitamin C deficiency may be administered vitamin C to cure scurvy. For this patient, vitamin C is then considered a drug.
- A can of cola is certainly not listed in any drug guide. However, if a patient with diabetes is experiencing a hypoglycemic reaction, the glucose in a can of soda may raise the patient's blood sugar and prevent a coma; thus, the glucose in the cola may be considered a drug in this example.
- Substances normally found in the body are not considered drugs unless they are administered to treat a condition. For example, the hormone estrogen circulating in the blood is not a drug. However, when it is taken as an oral contraceptive to prevent a condition (pregnancy), estrogen is considered a drug.

Once the meaning of the term *drug* is understood, the next essential term is *pharmacology*. The word *pharmacology* is derived from two Greek words, *pharmakon*, which means "medicine" or "drug," and *logos*, which means "study." Thus, **pharmacology** is most simply defined as the study of medicines. Pharmacology is an expansive subject, ranging from understanding how drugs are administered, to where they travel in the body, to the actual responses they produce. **Pharmacotherapy**, or pharmacotherapeutics, is the application of drugs for the purpose of disease prevention and treatment of suffering.

Drugs are a form of medical intervention given to improve a patient's condition or to prevent harm. Pharmacotherapy often begins when the patient experiences signs or symptoms that cause dissatisfaction with current or future health status. A major role of the nurse is to design interventions that meet the desired health goals of the patient. Pharmacotherapy is a critical intervention for many conditions. The rationale for pharmacotherapy is illustrated in Figure 1.1.

Over 11,000 trade-name and generic drugs and combination agents are currently available for pharmacotherapy. Each has its own characteristic set of therapeutic applications, interactions, adverse effects, and mechanism of action. Many drugs are prescribed for more than one disease and most produce multiple effects on the body. Further complicating the study of pharmacology is the fact that drugs may elicit different responses depending on individual patient factors such as age, gender, race, body mass, health status, and genetics. Indeed, learning the applications of existing medications and staying current with new drugs introduced every year can be an enormous challenge for the nurse. The task, however, is a critical one for both the patient and the healthcare provider. When applied properly, drugs can dramatically improve patients' quality of life. If applied improperly, the consequences of drug action can cause permanent disability and even death.

There are important exceptions to the drug definition mentioned earlier. What about crack cocaine, ecstasy, LSD, or the fumes in glues and paint thinners? These are certainly drugs, but they are not taken "to prevent, cure, or reduce symptoms of a medical condition." In fact, they are taken to produce a biologic effect viewed as desirable or pleasurable by the user (see Chapter 27). Other exceptions to this definition of the term *drug* will become apparent as the student studies pharmacology.

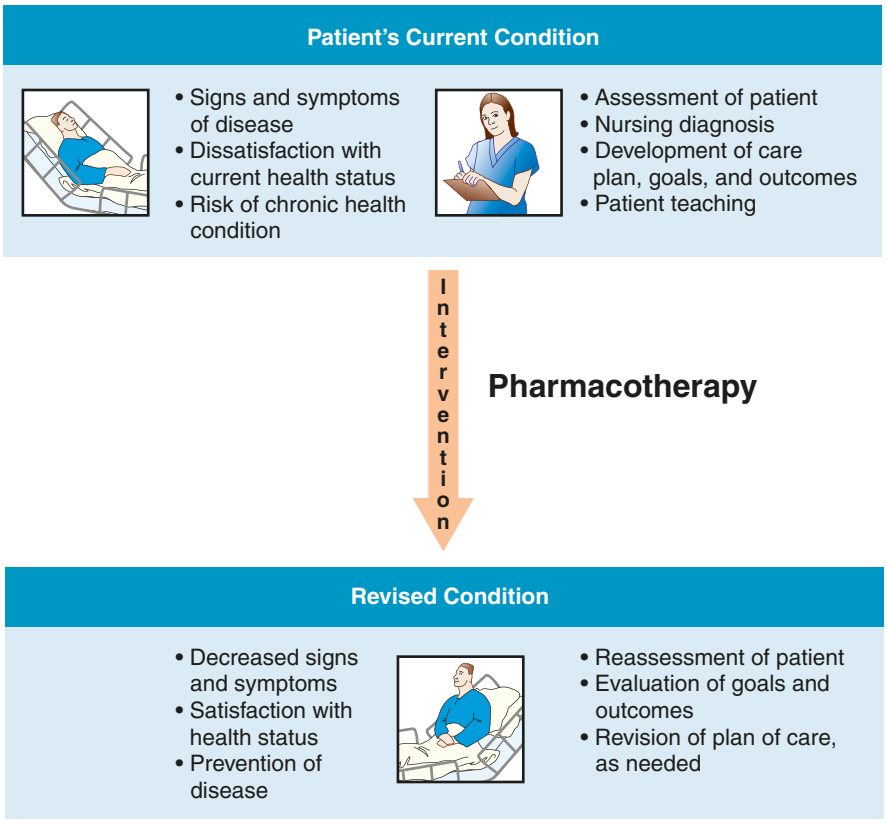


Figure 1.1 Rationale for pharmacotherapy: a partnership between the patient and the healthcare provider.

Characteristics of an Ideal Drug

1.3 The perfect drug is safe and effective.

As they begin their journey in mastering pharmacology, nursing students should start with a notion of the ideal or "perfect drug." Learning the characteristics of an ideal drug gives a basis for comparison to "real drugs." It is always the goal of pharmacotherapy to select the perfect or ideal drug for the patient. Just what is a perfect drug? It is one that:

- Effectively treats, prevents, or cures the patient's condition.
- Produces a rapid, predictable response at relatively low doses.
- Produces no adverse effects.
- Can be taken conveniently, usually by mouth.
- Can be taken infrequently, usually once a day, and for a short length of time.
- Is inexpensive and easily accessible.
- Is quickly eliminated by the body after it produces its beneficial effect.
- Does not interact with other medications or food.

After reading this description, it should appear clear to the student that there is really no such thing as a perfect drug. Some drugs meet most of the criteria, whereas others meet very few. At the very least, all prescription drugs are expected to have some degree of effectiveness at treating or preventing a health condition. The conditions for which a drug is approved are its **indications**. Every medication has at least one indication, and most have multiple indications. Some drugs are used for conditions for which they have not been approved; these are called unlabeled or off-label indications.

As a general rule, the more a medicine strays from the perfect drug profile, the less commonly it is used. This is because whenever possible, healthcare providers strive to prescribe the most effective, safest, and most convenient medication for the patient. In the home care setting, drugs that cause annoying adverse effects, have inconvenient dosing schedules, or are expensive are often not taken by patients, potentially worsening their condition and causing failure of treatment outcomes. Of course, some essential drugs do produce serious adverse effects or must be given by invasive routes, such as intravenously. In these cases, the drug is either administered in a clinical setting by a nurse, or the patient receives careful instructions and regular monitoring on an outpatient basis.

CONNECTIONS: Patient Safety

Preventing Interactions

A patient has tried to manage symptoms of depression naturally with St. John's wort, an herbal over-the-counter product. This has not been successful and the patient has decided to visit the healthcare provider. After a thorough assessment, the provider gives the patient a prescription for the antidepressant paroxetine (Paxil). Before teaching this patient about the new prescription, the nurse consults a drug reference guide. Based on that content, what will this patient need to know about St. John's wort and paroxetine to ensure safe and effective medication therapy? (Refer to this textbook or a drug reference guide for information about paroxetine [Paxil] and potential interactions.)

Answers to Patient Safety questions are available on the faculty resources site. Please consult with your instructor.

Classification of Drugs

1.4 Drugs may be organized by their therapeutic classification or pharmacologic classification.

The U.S. Food and Drug Administration (FDA, 2016) document *Approved Drug Products with Therapeutic Equivalence Evaluations*, informally called the "Orange Book," lists over 11,000 approved drugs. With the vast number of drugs available, it is essential that methods be used to group similar agents to aid in their study and understanding. The two basic classifications of drugs are therapeutic and pharmacologic. Both categories are widely used in classifying prescription and nonprescription drugs. The key difference is that the **therapeutic classification** describes what is being treated by the drug, whereas the **pharmacologic classification** describes how the drug acts.

Drugs are placed into therapeutic classes based on their usefulness in treating a specific disease. Table 1.1 shows the method of therapeutic classification, using cardiovascular drugs as an example. Many different types of drugs affect cardiovascular function. Some drugs influence blood coagulation, whereas others lower cholesterol levels or prevent the onset of stroke. Drugs may be used to treat hypertension, heart failure, abnormal cardiac rhythm, chest pain, myocardial infarction (MI), or circulatory shock. Thus, drugs that treat cardiovascular disorders may be placed in several therapeutic classes, for example, anticoagulants, antihyperlipidemics, and antihypertensives. The key to therapeutic classification is to simply state what condition is being treated by the particular drug. Other examples of therapeutic classifications include antidepressants, antipsychotics, drugs for erectile dysfunction, and antineoplastics. Notice how the prefix *anti-* often refers to a therapeutic classification.

The pharmacologic classification addresses a drug's mechanism of action or how a drug produces its effect in the body. Table 1.2 illustrates the use of pharmacologic classification, using hypertension as an example. A diuretic treats hypertension by lowering plasma volume. Calcium channel blockers treat this disorder by decreasing the force of cardiac contractions. Other drugs block components of the renin-angiotensin system. Notice that each example describes how hypertension might be controlled. A drug's pharmacologic classification is more specific than its therapeutic classification and requires an understanding of biochemistry and physiology. Pharmacologic classifications may use a drug's chemical name.

Table 1.1 Organizing Drug Information by Therapeutic Classification

THERAPEUTIC FOCUS: DRUGS AFFECTING CARDIOVASCULAR DISEASE

Therapeutic Usefulness	Therapeutic Classification
Influence blood clotting	Anticoagulants
Lower blood cholesterol	Antihyperlipidemics
Lower blood pressure	Antihypertensives
Restore normal cardiac rhythm	Antidysrhythmics
Treat angina	Antianginals

Table 1.2 Organizing Drug Information by Pharmacologic Classification

FOCUS ON HOW A DRUG WORKS: PHARMACOTHERAPY OF HYPERTENSION

Mechanism of Action	Pharmacologic Classification
Lowers plasma volume	Diuretic
Blocks heart calcium channels	Calcium channel blocker
Blocks hormonal activity	Angiotensin-converting enzyme inhibitor
Blocks physiologic reactions to stress	Adrenergic antagonist (or blocker)
Dilates peripheral blood vessels	Vasodilator

Although classifications help to organize drugs, the process is by no means easy or standardized. Most drugs have multiple classifications. For example, the drug epinephrine is classified as a vasoconstrictor, an autonomic nervous system agent, an adrenergic agonist, a sympathomimetic, a bronchodilator, an agent for anaphylaxis, an ocular mydriatic, an antiglaucoma agent, a catecholamine, and a topical hemostatic. This is clearly a mix of therapeutic (e.g., antiglaucoma) and pharmacologic (e.g., catecholamine) classifications. Which one(s) should the student remember? Unfortunately for nursing students, the answer is all of them. The classification chosen primarily depends on the specific clinical use of the drug (What condition is being treated?). Sometimes the classification of choice is simply a preference of the healthcare provider. Although challenging, remembering the different classifications will pay dividends as the student's pharmacology course progresses.

CONNECTION Checkpoint 1.2

State whether each of the following classifications for aspirin is therapeutic or pharmacologic: anticoagulant, salicylate, central nervous system agent, analgesic, antipyretic. Use a drug guide, if needed. *Answers to Connection Checkpoint questions are available on the faculty resources site. Please consult with your instructor.*

Prototype Drugs

1.5 A prototype drug is the agent to which all other medications in a class are compared.

As discussed in Section 1.4 learning thousands of drugs is simplified, at least somewhat, by grouping similar drugs together into broad classifications. Just knowing its therapeutic or pharmacologic classification can reveal important information about a drug. An additional strategy is helpful when learning pharmacology. One common and useful

Figure 1.2 Obtained from the deadly nightshade plant *Atropa belladonna*, atropine remains a traditional prototype drug.
Courtesy of Heike Falkenberg/Fotolia.

practice is to select a single drug from a class and compare all other medications in the class to this representative medication. This is called a **prototype drug**. By learning about the prototype drug in depth, the actions and adverse effects of other drugs in the same class can be predicted. For example, by learning the actions and effects of penicillin V, students can extend this knowledge to all other drugs in the penicillin class of antibiotics. In this textbook, the drug prototypes are clearly identified, and detailed information regarding their therapeutic effects, mechanism of action, adverse effects, contraindications, precautions, and nursing responsibilities, including patient and family education, is presented.

Selecting a drug to serve as the prototype for a class is not always a simple matter; healthcare providers and textbooks sometimes disagree. The traditional prototype approach uses the oldest and best understood drug in the class. For example, atropine has been used for thousands of years and still remains a prototype drug for certain indications (see Figure 1.2). Sometimes, however, newer drugs are developed in the same class that are more effective or have a more favorable safety profile. Over time, an older prototype drug may be infrequently prescribed and a different, more clinically useful prototype may be chosen for the class. This textbook uses a practical approach to prototype drugs, selecting a combination of traditional drugs and those most widely used. Regardless of the approach, the student must remember that the prototype is the drug to which all others in a class are compared.

Naming Drugs

1.6 Drugs have chemical, generic, and trade names.

Despite the utility of using drug classes and prototypes when studying pharmacology, learning thousands of drug names remains a challenge. Adding to this difficulty is that most drugs have multiple names. The three basic types of drug names are chemical, generic, and trade names.

Chemical names are assigned using standard nomenclature established by the International Union of Pure and Applied Chemistry (IUPAC). A drug has only one chemical name. This chemical name is sometimes helpful in predicting a drug's physical and chemical properties. Although chemical names convey a clear and concise meaning about the nature of a drug to the chemist, these names are often complicated and difficult to remember or pronounce. For example, it is unlikely that the nurse would remember that the chemical name for alprazolam (Xanax) is 8-chloro-1-methyl-6-phenyl-4H-s-triazolo[4,3-α][1,4]-benzodiazepine. In only a few cases, usually when the name is brief and easily remembered, will nurses use chemical names. Examples of easy to remember chemical names of common drugs include lithium carbonate, calcium gluconate, and sodium chloride.

Drugs are sometimes named and classified by a portion of their chemical structure, known as the chemical group name. In the Xanax example, a portion of the chemical name, benzodiazepine, is used as a drug class. Other examples include the fluoroquinolones, aminoglycosides, phenothiazines, and thiazides. Although these names may seem complicated when first encountered, knowledge of chemical group names will become invaluable as the nursing student begins to learn and understand the actions of the drugs in the major drug classes.

The **generic name** of a drug is assigned by the United States Adopted Names Council. With few exceptions, generic names are less complicated and easier to remember than chemical names. Many organizations, including the FDA, the United States Pharmacopeial Convention, and the World Health Organization, routinely describe a medication by its generic name. Because each drug has only one generic name, healthcare providers often use this name, and students must memorize it. Fortunately, sometimes components of a generic name can help a student recognize other drugs in that same class. For example, the ending *-lol* is used in the generic name of beta-adrenergic blockers, and the ending *-statin* denotes a lipid-lowering drug.

A drug's **trade name**, sometimes called the proprietary, product, or brand name, is assigned by the pharmaceutical company marketing the drug. The trade name is intentionally selected to be short and easy to remember so that patients will remember it (and ask for it by name). The term *proprietary* suggests ownership. In the United States, the FDA grants the pharmaceutical company exclusive rights to name and market a drug for a certain number of years after it approves a new drug application. During the period of **exclusivity**, competing companies are not allowed to market generic versions of the product. The rationale for exclusivity is that the developing pharmaceutical company needs sufficient time to recoup the millions of dollars in research and development costs involved in designing and testing a new drug. Without the guarantee of exclusivity, pharmaceutical companies have little incentive to develop new and unique drugs. When

exclusivity expires, competing companies may sell a generic equivalent drug, sometimes using a different name, which the FDA must approve. The typical length of exclusivity for a new drug is 5 years; however, this may be extended by 3 additional years if the drug is determined to have a new indication, can be delivered by a different route, or is made available in a different dosage form. If, for example, a pharmaceutical company completes pediatric studies and determines the dosage and safety of a drug in this population, the FDA adds 6 months of exclusivity. Orphan drugs (see Chapter 2) have 7 years of exclusivity. Pharmaceutical companies can make millions of dollars in sales from exclusivity; thus, they usually make great efforts to receive extensions from the FDA. Expiration dates for the exclusivity of specific drugs are listed by the FDA in its *Approved Drug Products with Therapeutic Equivalence Evaluations* publication.

Trade names are a challenge for students to learn because there may be dozens of products that contain the same drug. In addition, many products contain more than one active ingredient. Drugs with more than one active generic ingredient are called **combination drugs**. This poses a problem when trying to match one generic name with one product name. As an example, refer to Table 1.3 and consider the drug diphenhydramine (generic name), also called Benadryl (one of many trade names). Low doses of diphenhydramine may be purchased over the counter (OTC). Higher doses require a prescription. If the nurse is looking for diphenhydramine, it may be listed under many trade names such as Benadryl, Nytol QuickCaps, Sominex, and Unisom, formulated alone or in combination with other active ingredients. Acetaminophen and aspirin are additional examples of agents that appear in many combination drugs with dozens of different trade names. To avoid this confusion, generic names should be used when naming the active ingredients in a combination drug. When referring to a drug, it is conventional to write the generic name in lowercase first, followed by the trade name in parentheses with the first letter capitalized. Examples include alprazolam (Xanax) and acetaminophen (Tylenol).

Table 1.3 Examples of Generic Drugs Contained in Trade-Name Products

Generic Drugs	Trade Names
Aspirin	Acetylsalicylic Acid, Acuprin, Anacin, Aspergum, Bayer, Bufferin, Ecotrin, Empirin, Excedrin, Maprin, Norgesic, Salatin, Salocol, Salsprin, Supac, Talwin, Traphen-10, Vanquish, Verin, ZORprin
Diphenhydramine	Allerdryl, Benadryl, Benahist, Bendylate, Caladryl, Compoz, Diahist, Diphenadril, Eldadryl, Fenylhist, Fynex, Hydramine, Hydril, Insomnal, Noradryl, Nordryl, Nytol, Tusstat, Wehdryl
Ibuprofen	Advil, Amersol, Apsifen, Brufen, Haltran, Medipren, Midol 200, Motrin, Nuprin, Pamprin-IB, Rufen, Trendar

1.7 Generic drugs are less expensive than trade-name drugs, but they may differ in bioavailability.

During the years of exclusivity for a new drug, the pharmaceutical company determines the price of the medication. Because there is no competition, the price is relatively high. Once the exclusive rights end, competing companies market the generic equivalent drug for less money, and consumer savings may be considerable. In many states, pharmacists may routinely substitute a generic drug when the prescription calls for a trade name. In other states, the pharmacist must dispense drugs directly as written by a healthcare provider or obtain approval before providing a generic substitute.

PharmFACT

Nine out of every 10 prescriptions dispensed in the United States are for generic drugs. The greatest cost savings are for generic drugs prescribed for mental health indications and for hypertension (Generic Pharmaceutical Association, 2015).

Pharmaceutical companies marketing trade-name drugs often lobby aggressively against laws that might restrict the routine use of certain trade-name drugs. The lobbyists claim that there are significant differences between a trade-name drug and its generic equivalent and that switching to the generic drug may be harmful to the patient. Consumer advocates on the other hand argue that generic substitutions should always be permitted because of the cost savings to patients.

Are there really significant differences between a trade-name drug and its generic equivalent? The answer is unclear. Despite the fact that the dosages may be identical, drug formulations are not always the same. The two drugs may have different inert ingredients. If in tablet form, the active ingredients may be more tightly compressed in one of the preparations. Liquid drugs may use different solvents such as water or alcohol.

The key to comparing trade-name drugs and their generic equivalents lies in measuring the **bioavailability** of the two agents. Bioavailability is defined by the Federal Food, Drug, and Cosmetic Act (see Chapter 2) as the rate and extent to which the active ingredient is absorbed from a drug product and becomes available at the site of drug action to produce its effect. Bioavailability may be affected by many factors, including inert ingredients and tablet compression. Anything that affects the absorption of a drug or its travel to the target cells can certainly affect drug action. Measuring how long a drug takes to exert its effect (onset time) gives pharmacologists a crude measure of bioavailability. If the trade and generic products have the same rate of absorption and have the same onset of therapeutic action, they are said to be *bioequivalent*.

The importance of bioavailability differences between a trade-name drug and its generic equivalent depends on the specific circumstances of pharmacotherapy. For example, if a patient is in circulatory shock and the generic equivalent drug takes 5 minutes longer to produce its effect, that may indeed be significant. However, if a generic medication for arthritis pain relief takes 45 minutes to act, compared to the trade-name drug, which takes 40 minutes, it probably does not matter which drug is used, and the inexpensive product should be prescribed to provide cost savings to the consumer. As a general rule, bioavailability is of most concern when using critical care drugs and those with a narrow safety margin. In these cases, the patient should continue taking the trade-name drug and *not* switch to a generic equivalent, unless approved by the healthcare provider. For most other drugs, the generic equivalent may be safely substituted for the trade-name drug.

In the age of internet pharmacies, the issue of exclusive marketing rights has drastically changed. Other countries are not bound by U.S. drug laws, and it is easy for patients to obtain medications through the mail at a fraction of the cost in the United States. For example, a pharmaceutical company may have exclusivity for selling Cialis in the United States, but companies in India and China can sell the identical drug through internet pharmacies and ship it to customers in the United States. In some cases, they may sell the drug to consumers without a prescription. Some countries do not have the same high quality control standards as the United States, and the patient may be purchasing a useless or even harmful product. Furthermore, although some internet sites may appear to be based in the United States, they may instead be obtaining their medications from sources outside the United States. Nurses must urge their patients not to purchase drugs from overseas pharmacies because there is no assurance that the drugs are safe or effective.

1.8 Biosimilar drugs are very closely related to biologic medications that have already received FDA approval.

Biologic drugs are medicines made by living cells, such as bacteria or yeast. Because of their natural origin, biologics are often complex molecules that require many years of research to develop and gain status as FDA-approved drugs. In recent years, biologics have become important treatments for rheumatoid arthritis, multiple sclerosis, and cancer. They are effective medications, but are usually very expensive. For example, some of the newer biologics for hepatitis C cost thousands of dollars per dose.

Biosimilar drugs have comparable effectiveness and safety to FDA-approved biologic products. Because a biosimilar is not an exact, duplicate copy of the original medication (known as the *reference product*), it should not be called a generic medication. Biosimilars are not required to undergo the same rigorous preclinical and clinical testing as their reference products; therefore, they are less expensive. To be approved as a biosimilar, the manufacturer must demonstrate to the FDA that the drug differs very little from the approved reference product. This includes having the same route of administration, dosage forms, and mechanism of action. The first biosimilar, Zarxio, was approved by the FDA with the same indications as filgrastim (Neupogen), the original biologic product (FDA, 2015). Inflectra was approved in 2016 as a biosimilar to infliximab (Remicade). Many other biosimilars are expected to reach the market in the coming years.

Connecting Pharmacology to Clinical Nursing Practice

1.9 Effective pharmacotherapy depends on a nurse's understanding of pharmacology as well as interprofessional practice with other members of the healthcare team.

Pharmacotherapy has become a mainstay of modern medical treatment, and a thorough understanding of expected drug effects, the associated monitoring required, and the care and teaching associated with drugs that are prescribed in patient care is crucial to effective nursing practice. As a member of an interprofessional team, nurses, physicians, advanced practice nurses, pharmacists, and, most importantly, the patient work together to achieve optimal therapeutic outcomes from drug therapy. The importance of pharmacology to clinical nursing practice cannot be overstated, and the connection between pharmacology and nursing practice is emphasized throughout this entire textbook.

A major goal of this textbook is to provide a solid foundation in the knowledge of pharmacology and pharmacotherapeutics. Chapters 2 through 4 provide the legal and scientific bases for pharmacotherapeutics. As a member of an interprofessional healthcare team, it is most often the nurse who serves as the connection between a prescription and the patient's safe use of the prescribed drug. Monitoring the patient's condition before and during drug use, evaluating drug effects, teaching the patient about self-administration, and conducting a medication reconciliation are key nursing responsibilities. A medication reconciliation is the process of keeping track of the patient's medications as the patient's care proceeds from one healthcare provider to another. For the advanced practice nurse, an understanding of the pathophysiology underlying the patient's current condition, excellent assessment skills, and clinical decision-making skills aimed at choosing the best treatment options are required.

A major goal in studying pharmacology is to eliminate medication errors and to limit the number and severity of adverse drug events. Many adverse effects are preventable. Nurses can routinely avoid many serious adverse drug

effects in their patients by applying their experience and knowledge of pharmacotherapeutics to clinical practice. Some adverse effects, however, are not preventable. It is vital that the nurse be prepared to recognize and respond to potential adverse effects of medications. The nursing management of adverse effects and medication errors are discussed in Chapters 5 and 6, respectively.

Before any drug is administered, the nurse must obtain and process pertinent information regarding the patient's medical history, physical assessment, disease processes, and learning needs and capabilities. Growth and developmental factors must always be considered. It is important to remember that a large number of variables influence a patient's response to drugs throughout the lifespan. Having a firm understanding of these variables can increase treatment success. Chapters 8 through 11 of this textbook address these aspects of pharmacotherapy.

For a nurse, knowledge of pharmacology is an ongoing, lifelong process that builds as a nurse is in practice and chooses specific clinical areas. Early in practice, learning prototype drugs that represent a specific classification of drugs, recognizing key similarities in generic names, and always looking up unknown or new drugs will help build this knowledge base. As the nurse's experience grows, anticipating drug effects and care and teaching needs becomes integrated into nursing practice. For an advanced practice nurse working as a nurse practitioner, this clinical experience helps to enhance the new information acquired to prepare for prescriptive authority. Chapters 12 through 75 present the foundational knowledge needed for effective pharmacotherapy. Each unit begins with a review of the anatomy and physiology underlying the mechanism of action of drugs discussed in the unit, followed by detailed information about specific classifications of drugs and nursing responsibilities for those classifications.

Despite its essential nature, the study of pharmacology should be viewed in the proper perspective. Drugs are just one of many tools available to the nurse for preventing or treating human suffering. Although pharmacology is a key intervention in many cases, nurses must use all the healing sciences in treating their patients. The effectiveness of a drug in treating disease can never substitute for skilled, compassionate nursing care. Too much reliance on drug therapy can diminish the importance of the nurse–patient relationship.

Understanding Chapter 1

Key Concepts Summary

1.1 The practice of applying products to relieve suffering has been recorded throughout history by virtually every culture.

1.2 Pharmacology is the study of medicines.

1.3 The perfect drug is safe and effective.

1.4 Drugs may be organized by their therapeutic classification or pharmacologic classification.

1.5 A prototype drug is the agent to which all other medications in a class are compared.

1.6 Drugs have chemical, generic, and trade names.

1.7 Generic drugs are less expensive than trade-name drugs, but they may differ in bioavailability.

1.8 Biosimilar drugs are very closely related to biologic medications that have already received FDA approval.

1.9 Effective pharmacotherapy depends on a nurse's understanding of pharmacology as well as interprofessional practice with other members of the healthcare team.

CASE STUDY: Making the Patient Connection

Remember the student "Josh Remming" at the beginning of the chapter? Now read the remainder of the case study. Based on the information presented within this chapter, respond to the critical thinking questions that follow.

Josh Remming, a 23-year-old student, is in his first semester of nursing school. He thought that nursing would provide him with a great career and lots of opportunity. He enjoys helping people and has always been fascinated with healthcare. However, after the first pharmacology class, Josh is worried because there seems to be an overwhelming amount of content to learn in just one semester.

At the end of the class, Josh talks with other students who are concerned and a bit anxious. Much of the

conversation centers around lecture content provided by the professor. Following are some of the questions from Josh's classmates. How would you respond?

Critical Thinking Questions

1. What is the difference between therapeutic classification and pharmacologic classification?
2. What classification is a barbiturate? Macrolide? Birth control pills? Laxatives? Folic acid antagonist? Antianginal agent?
3. What is a prototype drug, and what advantages does a prototype approach to studying pharmacology offer?
4. Why do nurses need to know all this pharmacology?

Answers to Critical Thinking Questions are available on the faculty resources site. Please consult with your instructor.

Additional Case Study

Sarah Hawkins, an older woman who lives on a fixed income, is on multiple medications. She says that all her friends are taking the generic form of their medications. While you are visiting her, she asks, "What do you think of generic medicines? Are they safe? Are they as good? Are they worth it?"

1. How do generic equivalent drugs differ from a proprietary (trade-name) drug?
2. What would you recommend that Sarah do about accepting generic drugs?

Answers to Additional Case Study questions are available on the faculty resources site. Please consult with your instructor.

Chapter Review

1. The nurse is using a drug handbook to determine the indications for the drug furosemide (Lasix). The term *indications* is defined as the:
    1. Way a drug works on the target organs.
    2. Amount of the drug to be administered.
    3. Conditions for which a drug is approved.
    4. Reason that the drug should not be given.
2. The nurse is reviewing the patient's medication record and does not recognize the medication, filgrastim-sndz (Zarxio). Consulting a drug guide, the nurse finds it is listed as a "biosimilar" to filgrastim (Neupogen). Which of the following best describes the definition of a biosimilar drug?
    1. It is another term for a "generic" drug when the two drugs exert similar biologic effects.
    2. It is a drug that has similar effects on the body, but belongs in a different chemical and therapeutic classification.
    3. It is a drug that is derived from living cells, such as yeast, and has comparable effectiveness and safety to the reference product drug.
    4. It is a drug that is identical to the reference product drug and thus, does not require FDA approval.
3. As a member of an interprofessional team, what key responsibilities does the nurse have to ensure effective pharmacotherapy? (Select all that apply.)
    1. Monitoring the patient's condition before and during pharmacotherapy
    2. Teaching the patient about self-administration and any required monitoring of drug effects
    3. Ensuring that all drug and treatment options have been considered before beginning pharmacotherapy
    4. Frequently conducting a medication reconciliation to verify current medications in use
    5. Determining the ideal drug to be prescribed to the patient to treat the current condition
4. Which patient characteristics, if noted in the patient's medical record, would the nurse consider important information that may affect the physiologic response to various types of drug therapy? (Select all that apply.)
    1. 82-year-old and female
    2. Asian and obese
    3. Past medical history of kidney disease
    4. Mother and sister with diabetes
    5. Has no medical insurance
5. The nurse is looking up a drug that has been prescribed and wants to know the therapeutic classification for the drug. Which of the following would indicate a therapeutic classification?
    1. Beta-adrenergic antagonist
    2. Antihypertensive
    3. Diuretic
    4. Calcium channel blocker

6. The nurse is asked by a family member: "They're giving mom Motrin and she takes Advil. Hasn't the wrong drug been ordered?" The nurse will respond, knowing that:
   1. There has been an error in the order and the nurse will contact the healthcare provider.
   2. There may be a reason for the healthcare provider to order a different drug.
   3. Not all healthcare agencies buy the same generic drugs and that may account for the difference.
   4. Motrin and Advil are trade names for the same generic drug, ibuprofen.

See Answers to Chapter Review in Appendix A.

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"This headache medicine I bought at the grocery store must be safe because I didn't need a prescription."
Patient "Gertrude Stone"

Chapter 2
Drug Regulations

Chapter Outline

- Patent Medicines
- Brief History of Drug Legislation
- Drug Standards
- The U.S. Food and Drug Administration
- Drug Approval
- Changes to the Drug Approval Process
- Prescription and Over-the-Counter Drugs
- Drug Schedules
- Prescriptive Authority for Nurses

Learning Outcomes

After reading this chapter, the student should be able to:

1. Explain the role of patent medicines in the history of pharmacology and the legislation of drugs.
2. Outline the key U.S. drug regulations and explain how each has contributed to the safety and effectiveness of medications.
3. Describe how the *United States Pharmacopeia-National Formulary* (USP-NF) controls drug purity and standards.
4. Evaluate the role of the U.S. Food and Drug Administration in the drug approval process.
5. Categorize the four stages of new drug approval.
6. Explain the role of a placebo in new drug testing.
7. Discuss how changes to the approval process have increased the speed at which new drugs reach consumers.
8. Compare and contrast prescription and over-the-counter drugs.
9. Explain how scheduled drugs are classified and regulated.
10. Discuss the requirements and regulations needed for nurses to have the ability to prescribe drugs.

Key Terms

clinical phase trials, 19
controlled substances, 22
dependence, 22
formulary, 17
Investigational New Drug (IND), 19
New Drug Application (NDA), 19
new molecular entities, 19
orphan product, 16
patent medicines, 14
pharmacopeia, 17
placebo, 19
postmarketing surveillance, 20
preclinical research, 19
scheduled drugs, 22
U.S. Food and Drug Administration (FDA), 17

Laws govern all aspects of the drug approval, labeling, marketing, manufacturing, and distribution process. The primary purpose of this legislation is to protect the public from unsafe and ineffective products. This chapter examines standards and legislation regulating drugs in the United States.

Patent Medicines

2.1 Early American history saw the rise of patent medicines and the lack of adequate drug regulations.

People have an expectation that the medication they are taking is effective at treating their condition, whether it is asthma, diabetes, or a headache. They expect the label to contain clear and accurate instructions on how the product should be taken. They expect that the drug will be safe when the instructions are correctly followed. Are these reasonable assumptions? In the United States and Canada, the answer is yes. But Americans have not always had this reassurance. Although drugs have been used for thousands of years, it was not until the 20th century that extensive standards and regulations were developed to protect the public from unsafe and ineffective products.

In early America, there were few attempts to regulate drugs. This period saw the rise of **patent medicines**. Although the term *patent* implies a legal right to manufacture or sell a drug, this was not the case. Patent medicines contained a trade name that clearly identified the product, such as William Radam's Microbe Killer, Stanley's Snake Oil, Dr. Kilmer's Swamp Root, or Dr. Moore's Indian Root Pills. Because there were no laws to the contrary, these products went untested and could claim to cure nearly any symptom or disease. Dr. William's Pink Pills for Pale People, which contained iron oxide and magnesium sulfate, claimed to cure rheumatism, nervous headache, palpitations, grippe, neuralgia, locomotor ataxia, partial paralysis, sallow complexion, and all forms of weakness in men or women. A typical advertisement from this era is shown in Figure 2.1.

Figure 2.1 Patent medicines contained a trade name that clearly identified the product and claimed to cure just about any symptom or disease.
Courtesy of Library of Congress/Corbis/VCG/Getty Images.

Patent medicines were often harmless (and ineffective), containing coloring, flavoring, and an aromatic substance that "smelled like medicine." At their worst, some contained hazardous levels of dangerous or addictive substances. In fact, cocaine, heroin, and morphine were freely distributed in patent medicines; some elixirs contained up to 50% morphine, which indeed caused many painful disorders to "disappear." Addictive ingredients were purposely added to guarantee repeat customers for their products. (Note the similarity with nicotine added to tobacco and caffeine added to soft drinks.) In the late 1800s, the familiar Coca-Cola soft drink was a patented beverage that contained an estimated 9 mg of cocaine per serving and was claimed to cure headache, dyspepsia, hysteria, morphine addiction, and impotence. The need for stricter regulation became more apparent in the 1860s as cocaine was synthesized, and the use of opiates as painkillers during the Civil War caused thousands of soldiers to become addicted.

Although the marketing and use of patent medicines may seem humorous and even unbelievable to modern consumers, a few of these products are still available over the counter (OTC). Examples of patent medicines that survived the drug regulations of the 1900s include Smith Brothers Throat Drops, Fletcher's Castoria, Doan's Pills, Vick's VapoRub, and Phillip's Milk of Magnesia. Of course,

the ingredients of these products have changed over time so that they conform to modern regulations regarding labeling, safety, and effectiveness.

Brief History of Drug Legislation

2.2 In the 1900s, drug legislation was enacted to make drugs safer and more effective.

Although individual states attempted to regulate drugs, the first national law was the Drug Importation Act, passed in 1848, which attempted to stop the entry of unsafe drugs into the United States. In the early 1900s, the United States began to develop and enforce tougher drug legislation to protect the public. This was spurred, in part, by the tragic deaths of 13 children in St. Louis in 1901 who were given diphtheria antitoxin that was contaminated with tetanus. In 1902, the Biologics Control Act was passed to standardize the quality of sera, antitoxins, and other blood-related products. Passed shortly thereafter, the Pure Food and Drug Act (PFDA) of 1906 was a significant and powerful piece of drug legislation that gave the government authority to regulate the labeling of medicines. Essentially, this law required that drug labels accurately reflect the contents. Prior to this date, many labels did not contain any indication of the active ingredient within the bottle or its amount. Although the ingredients had to be accurately labeled, a drug could still be marketed for any disease.

In 1912, the Sherley Amendment to the PFDA prohibited the sale of drugs labeled with false therapeutic claims that were intended to defraud the consumer. A major weakness, as borne out in subsequent legal battles, was the difficulty of proving that the false claim made by the seller was intentional.

It is surprising that up to this point in American history no attempt had been made to legislate the use of addictive drugs. The Harrison Narcotic Act of 1914 was passed to require prescriptions for high doses of narcotic drugs and to mandate that pharmacists and healthcare providers keep narcotic records. Since 1914, hundreds of additional state and federal laws have been passed to regulate drugs with abuse potential, including the landmark Comprehensive Drug Abuse Prevention and Control Act (see Section 2.8). Additional details on the history of the regulation of controlled substances are included in Chapter 27.

Unfortunately, two essential components were still missing from the regulation of drugs in the early 20th century. Although the PFDA and other legislation required that ingredients be listed on the label and prohibited intentional false claims, manufacturers did not have to prove that the drug was effective. Furthermore, product safety did not have to be tested before the drug was marketed. Bringing the issue to the forefront was an incident in 1937 in which an elixir of sulfanilamide containing a poisonous chemical (diethylene glycol) killed 107 people, mostly children.

In 1938, Congress passed the landmark Food, Drug, and Cosmetic Act (FDCA), which corrected certain loopholes in previous laws. This was the first law preventing the sale of newly developed drugs that had not been thoroughly tested for safety. Drug labels were required to contain instructions for safe use. The FDCA was also the first attempt at regulating cosmetics and medical devices. Unfortunately, the FDCA did not clearly define "prescription" or specify which drugs required a prescription. Most drugs, including many addictive and harmful substances, were sold by the corner druggist, sometimes legally, other times illegally. In 1951, the Durham-Humphrey Amendment to the FDCA delineated the difference between safer drugs, which were allowed to be sold OTC, and more dangerous drugs, which required prescriptions.

In the late 1950s, the drug thalidomide was found to produce severe birth defects in the children of women taking the drug as a sleeping pill and to treat morning sickness during pregnancy. Although the drug was not approved in the United States, it is estimated that over 20,000 Americans received the drug, because it was widely distributed to healthcare providers without U.S. Food and Drug Administration (FDA) approval. As with other drug legislation, it took a tragedy to convince Congress to pass tougher regulations. Passage of the Kefauver-Harris Amendment to the FDCA in 1962 mandated that manufacturers prove their drugs were effective for specific purposes, as well as safe, through the conduct of "adequate and well-controlled" studies. This law was applied retroactively to all drugs introduced since the passage of the FDCA. This amendment also required that all significant adverse reactions be reported to the FDA and that complete information about adverse effects be included in literature distributed to healthcare providers. For the first time, informed consent was required from patients participating in experimental drug research.

The emphasis on effectiveness continued as the FDA contracted with the National Academy of Sciences and the National Research Council in 1966 to evaluate the effectiveness of 4000 drugs that were approved between 1938 and 1962 based only on their safety. Approximately 40% of all drugs introduced between 1938 and 1962 were found to be ineffective and were subsequently removed from the market. In 1972, a review of OTC drugs began to examine the safety and effectiveness of these products.

In the 1980s, the public placed considerable political pressure on the FDA to find drugs to treat rare or unusual disorders. Pharmaceutical companies were reluctant to develop drugs for these disorders because there would not

be enough sales to recoup their research and development costs. To encourage development of such drugs, the Orphan Drug Act became law in 1983. An **orphan product** is a drug or biologic for treating rare diseases that affect fewer than 200,000 people in the United States. Drug manufacturers are now offered development grants, tax credits for clinical investigation expenses, and 7 years of exclusivity to market an orphan drug. Over 400 medications have been approved as orphan drugs since the passage of this act.

A major focus in the 1990s was to speed the drug approval process, which was often prolonged for many years. The Prescription Drug User Fee Act (PDUFA) of 1992 assessed fees from drug manufacturers to be used specifically for reducing the review time for new drug applications. From 1992 to 2002, the number of full-time equivalent employees examining new drug applications at the FDA increased from 1277 to 2337. The PDUFA was reauthorized in 1997 with the passage of the Food and Drug Administration Modernization Act, which also included provisions to accelerate the review of medical devices, regulate the advertising of unapproved uses of drugs, and regulate health claims for foods. The PDUFA has been reauthorized with the added goal of improving communication between the FDA and new drug sponsors. PDUFA fees collected in 2015 amounted to over $855 million, which supported 4133 full-time positions to support the drug application process at the FDA (FDA, 2016a).

In reaction to the rising popularity of dietary supplements, Congress passed the Dietary Supplement Health and Education Act of 1994 to control misleading industry

Table 2.1 Historical Timeline of Regulatory Acts, Standards, and Organizations

Year	Regulatory Acts, Standards, and Organizations
1820	Physicians establish the first comprehensive publication of drug standards, the *United States Pharmacopeia* (USP).
1848	The Drug Importation Act requires that all drugs (as defined by the newly established pharmacopeia) entering the United States be inspected and analyzed for "quality, purity, and fitness for medical purposes."
1852	Pharmacists found the American Pharmaceutical Association (APhA). The APhA establishes the *National Formulary* (NF), a standardized publication focusing on pharmaceutical ingredients. The USP continues to catalog all drug-related substances and products.
1862	The Federal Bureau of Chemistry, established under the administration of President Lincoln, eventually becomes the Food and Drug Administration (FDA).
1902	The Biologics Control Act controls the quality of sera and other blood-related products.
1906	The Pure Food and Drug Act prohibits the manufacture and sale of adulterated or misbranded foods, drugs, and medications.
1912	The Sherley Amendment makes medicines safer by prohibiting the sale of drugs labeled with false therapeutic claims.
1914	The Harrison Narcotics Act requires those who dispense opium, cocaine, and related substances to keep records of the drugs they dispense and makes it illegal to possess narcotics without a prescription. This act allows physicians to prescribe narcotics only for treatment, not to addicts.
1938	The Food, Drug, and Cosmetic Act is the first law preventing the marketing of drugs not thoroughly tested.
1944	The Public Health Service Act is enacted and covers many health issues, including biologic products and the control of communicable diseases.
1970	The Comprehensive Drug Abuse Prevention and Control Act (also known as the Controlled Substances Act) organizes regulated drugs (including opiates, cocaine, cannabis, stimulants, depressants, and hallucinogens) into five schedules and imposes restrictions and penalties.
1975	The *United States Pharmacopeia* and *National Formulary* become a single standardized publication, the USP-NF.
1986	The Anti-Drug Abuse Act increases sentences and imposes mandatory minimum sentences for those convicted of illegal drug activity based on the type and quantity of drug involved.
1986	The Childhood Vaccine Act authorizes the FDA to acquire information about patients taking vaccines, to recall biologics, and to recommend civil penalties if guidelines regarding biologic use were not followed.
1988	The FDA is officially established as an agency of the U.S. Department of Health and Human Services.
1992	The Prescription Drug User Fee Act requires that nongeneric drug and biologic manufacturers pay fees to be used for improvements in the drug review process.
1994	The Dietary Supplement Health and Education Act requires clear labeling of dietary supplements and gives the FDA the power to remove supplements that cause a significant public risk.
1997	The FDA Modernization Act reauthorizes the Prescription Drug User Fee Act, representing the largest reform effort of the drug review process since 1938.
2002	The Best Pharmaceuticals for Children Act improves the safety and efficacy of medicines for children and continues the exclusivity provisions for pediatric drugs as mandated under the Food and Drug Administration Modernization Act of 1997.
2003	The Medicare Prescription Drug, Improvement, and Modernization Act provides older adults and those with disabilities a prescription drug benefit and better benefits under Medicare.
2007	The FDA Amendments Act (FDAAA) of 2007 reauthorizes and expands the Prescription Drug User Fee Act, the Modernization Act, the Best Pharmaceuticals for Children Act, and the Pediatric Research Equity Act.
2012	The FDA Safety and Innovation Act (FDASIA) of 2012 reauthorizes the Prescription Drug User Fee Act. This requires the FDA to implement a structured benefit-risk framework in the new drug approval process.

claims. Due in part to intense lobbying from the dietary supplement industry, the regulation of these products remains less stringent than that for prescription or OTC drugs. The regulation of herbal products and dietary supplements is discussed in detail in Chapter 7.

In early 2000, the focus of drug regulation turned to access. Advocacy groups claimed that the high cost of drugs caused unequal access to adequate healthcare for the poor, the uninsured, the underinsured, and older adults. In 2003, the Medicare Prescription Drug, Improvement, and Modernization Act was passed. The benefits are adjusted periodically. In 2016, the act provided a benefit that pays 75% of prescription drug spending up to the first $3310 (after a $360 deductible). Those qualifying for the low-income criteria may have their premiums and cost subsidized by the government. Participants pay a maximum out-of-pocket threshold of $7062.50 per year, after which Medicare will pay 95% of the prescription costs. A brief timeline of major events in U.S. drug regulation is shown in Table 2.1.

Drug Standards

2.3 The standardization of drug purity and strength is specified by the *United States Pharmacopeia-National Formulary*.

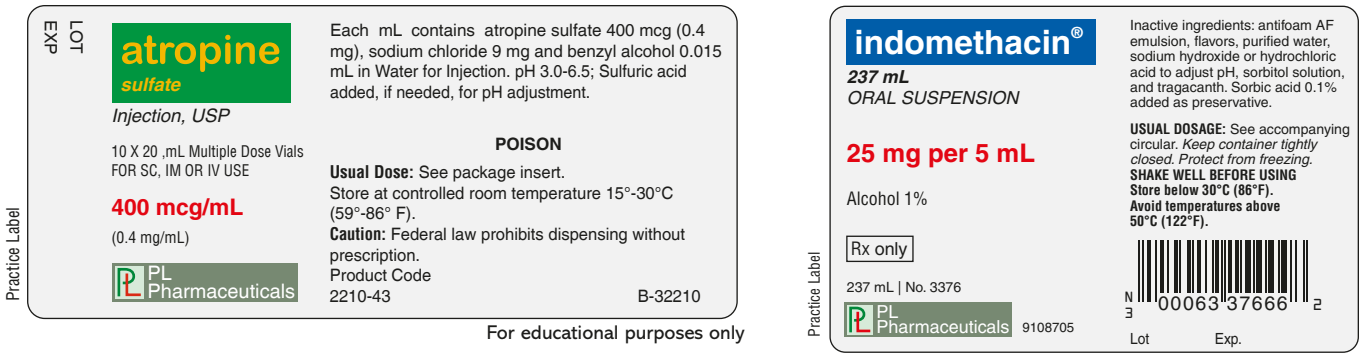
Until the 1800s, drugs were prepared from plants that were available in the natural environment. The strength and purity of the products varied considerably because they were entirely dependent on the experience (and integrity) of the druggist preparing the product and the quality of the local ingredients. Potency and safety varied from region to region and, indeed, from batch to batch. Consider the simple analogy of baking. If 100 people across the world were asked to bake a loaf of bread, the final products would vary considerably in size, taste, and nutritional value. It is likely that no two loaves would be the same. It is obvious that a standard recipe must be followed. Similarly, to obtain consistency in the preparation and potency of drugs, standards (recipes) are needed.

Among the first standards used by pharmacists was the **formulary**, or list of pharmaceutical products and drug recipes. In the United States, the first comprehensive publication of drug standards, the *United States Pharmacopeia* (USP), was established in 1820. A **pharmacopeia** is a medical reference summarizing standards of drug purity, strength, and directions for synthesis. From 1852 until 1975, two major compendia maintained drug standards in the United States, the USP and the *National Formulary* (NF), which were established by the American Pharmaceutical Association (APhA). All drug products were covered in the USP, whereas the NF focused on nondrug ingredients. In 1975, the two were merged into a single publication named the *United States Pharmacopeia-National Formulary* (USP-NF). The current document consists of more than 300 chapters and 4900 drug monographs. The USP-NF is published annually, with two supplements being issued throughout the year. Today, the USP label can be found on many medications verifying the purity and exact amounts of ingredients found within the container. Drugs marketed in the United States must conform to USP-NF standards to avoid possible charges of adulteration and misbranding. Sample labels are illustrated in Figure 2.2. The USP also provides a voluntary program for verifying the label accuracy of dietary supplements (see Chapter 7).

The U.S. Food and Drug Administration

2.4 The regulatory agency responsible for ensuring that drugs and medical devices are safe and effective is the U.S. Food and Drug Administration.

The establishment of a regulatory agency for food and drugs in the United States began with a single chemist appointed by President Lincoln in 1862. The **U.S. Food and Drug Administration (FDA)** was established by the PFDA of 1906 and later expanded to carry out the provisions of the FDCA of 1938. It is one of the oldest drug regulatory



For educational purposes only

Figure 2.2 Medication with the USP label (left) and without USP label (right). Practice labels "for educational purposes only."

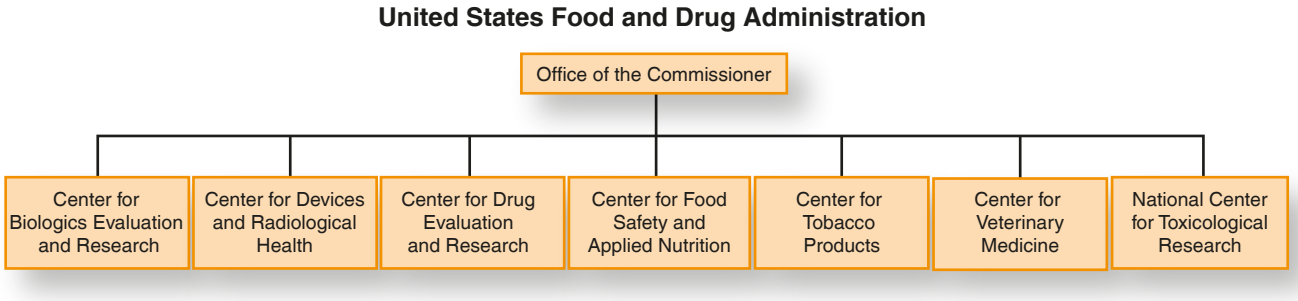


Figure 2.3 Organization of the Food and Drug Administration showing the seven centers that regulate human and veterinary drugs, biologic products, medical devices, the nation's food supply, cosmetics, tobacco, and products that emit radiation.

agencies in the world. The FDA states its mission as follows:

- Protecting the public health by ensuring the safety, efficacy, and security of human and veterinary drugs, biologic products, medical devices, the nation's food supply, cosmetics, and products that emit radiation
- Advancing the public health by helping to speed innovations that make medicines and foods more effective, safer, and more affordable
- Helping the public get the accurate, science-based information they need to use medicines and foods to improve their health.

With such an important and vast mission, the FDA is organized around seven branches, as shown in Figure 2.3. The Center for Drug Evaluation and Research (CDER) states its mission as facilitating the availability of safe, effective drugs; keeping unsafe or ineffective drugs off the market; improving the health of Americans; and providing clear, easily understandable drug information for safe and effective use. All new drugs must be approved by the CDER before they can be marketed. This includes prescription drugs, OTC drugs, and all generic equivalents. After marketing, the CDER is responsible for continued monitoring of safety and may issue additional warnings to healthcare providers or consumers as additional information becomes available.

The Center for Biologics Evaluation and Research (CBER) regulates the use of biologics (drugs derived from living sources), including sera, vaccines, and blood products. One historical achievement involving biologics is the 1986 Childhood Vaccine Act. This act authorizes the FDA to acquire information about patients taking vaccines, to recall biologics, and to recommend civil penalties if guidelines regarding biologics are not followed. The mission of the CBER was recently expanded to include the regulation of gene therapy and treatment with human cells or tissue-based products.

The FDA also oversees the administration of herbal products, dietary supplements, and cosmetics through the Center for Food Safety and Applied Nutrition (CFSAN). Although it does not require testing of herbal or dietary supplements prior to marketing, the CFSAN is responsible for taking action against any supplement that is deemed to be unsafe.

The CFSAN also regulates cosmetics, which are legally defined by the FDCA of 1938 as "articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body . . . for cleansing, beautifying, promoting attractiveness, or altering the appearance." Examples of products considered cosmetics are skin moisturizers, perfumes, lipsticks, fingernail polishes, eye and facial makeup preparations, shampoos, toothpastes, and deodorants. Can a product be both a cosmetic and a drug? In most cases, cosmetics are not drugs; however, it depends on a product's intended use. For example, if a shampoo is marketed to treat a condition such as dandruff, the active ingredient is considered a drug. If a skin cream claims to provide sunscreen protection, it may be considered a drug. Cosmetics do not require approval by the CFSAN prior to marketing, and regulations are much less restrictive compared to drug approval. Manufacturers of cosmetics are generally careful not to promote unwarranted therapeutic claims, such as that a product prevents or treats a condition or disease. This would cause the product to be considered a drug by the FDA, and it would be subject to tighter regulations.

In 2009, the FDA was given the authority to regulate the manufacture, marketing, and distribution of tobacco products. To carry out this legislative mandate, the FDA created a seventh branch, the Center for Tobacco Products.

Drug Approval

2.5 The drug approval process established by the U.S. Food and Drug Administration ensures that drugs sold in the United States are safe and effective.

Drugs are discovered in any number of ways. Penicillin was discovered purely by accident while the scientist was studying an unrelated topic. Many drugs have been isolated from natural substances, including plants and bacteria. Some medications are "me too" drugs, whereby the pharmacologist simply took a well-known drug and slightly modified

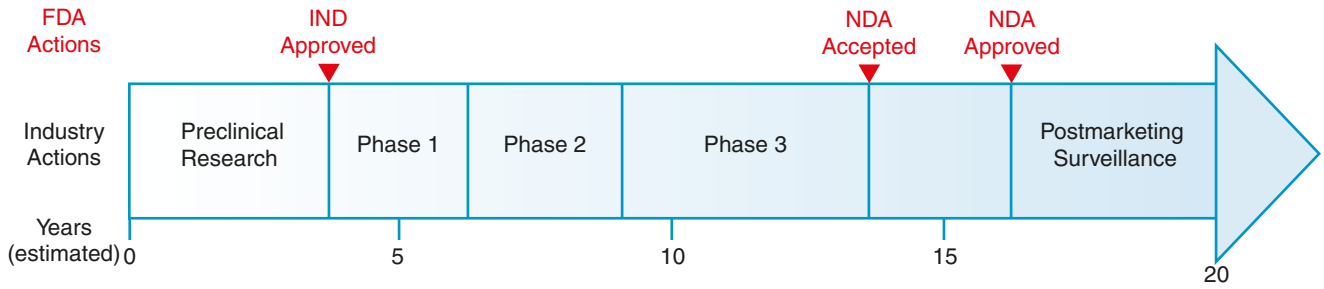


Figure 2.4 Drug development timeline.

the chemical structure to produce a very similar agent. As molecular biology and genetics have progressed into the modern era, drugs have been purposefully designed to fit into specific receptor sites on enzymes or cells.

Regardless of the path to discovery, all drugs must be approved by the FDA before they can be sold in the United States. (Medical marijuana, discussed in Chapter 27, has become an exception to this approval process.) The FDA drug review and approval process follows a well-developed and organized plan, as summarized in Figure 2.4.

The first stage of drug development is **preclinical research**, which involves extensive laboratory testing by the pharmaceutical company. Scientists perform testing on human and microbial cells cultured in the laboratory. Studies are performed in several species of animals to examine the drug's effectiveness at different doses and to look for adverse effects. The goals of this extensive testing on cultured cells and in animals are to determine drug action and to predict whether the drug will cause harm to humans. Because laboratory tests do not accurately reflect the precise way the human body will respond to the drug, preclinical research results are always inconclusive. Most drugs do not proceed past the preclinical research stage because they are either too toxic or simply not effective. The FDA does not regulate preclinical testing.

If a drug appears promising, the pharmaceutical company submits an **Investigational New Drug (IND)** application to the FDA that contains all the animal and cell testing data. Scientists at the FDA study the data and must be convinced that the drug is safe enough to allow human testing. Approval from the FDA is necessary before the next stage can begin.

Clinical investigation, the second stage of drug testing, takes place in three different stages termed **clinical phase trials**. These clinical trials are the longest part of the drug approval process and occur in sequential stages.

- **Phase 1.** Testing is conducted on 20 to 80 healthy volunteers for several months to determine proper dosage and to assess for adverse effects. The focus of the phase 1 trial is on safety. If unacceptable levels of toxicity are noted, the clinical trials are stopped.
- **Phase 2.** Several hundred patients with the disease to be treated are given the drug. The primary focus of the phase 2 trial is on effectiveness, although safety data continue to be recorded. In most cases, the effectiveness of the new drug is compared to an inert substance, or **placebo**, which serves as a control "nontreatment" group. In other cases the new drug is compared to a standard drug used for the same condition. For example, a new drug for reducing fever may be compared to acetaminophen (Tylenol). If the new drug is found to have the same (or less) effectiveness and safety profile compared to the standard drug, the pharmaceutical company may stop the clinical trials. This phase may take several years.
- **Phase 3.** Large numbers of patients with the disease are given the drug to determine patient variability. Potential drug–drug interactions are examined. Patients with chronic conditions such as cardiac, renal, or hepatic impairment are given the drug to determine safety in these important populations. Assessment of effectiveness and safety continues for several years, and thousands of patients may be given the new drug during phase 3.

If the drug continues to show promise through the clinical phase trials, a **New Drug Application (NDA)** is submitted to the FDA. The NDA signals that the pharmaceutical company is ready to sell the new drug. During the NDA review, the FDA examines all preclinical and clinical data to assess whether the proposed new drug is safe and effective. By law, the CDER is obligated to act on at least 90% of the NDAs for standard drugs within 10 months of submission. For priority drugs, the benchmark is 6 months. If the NDA is approved, the manufacturer may begin selling the new drug. If the NDA is rejected, the FDA indicates whether the drug is "approvable" or "not approvable." "Approvable" means that the drug will likely be approved if the pharmaceutical company conducts additional testing or addresses specific issues identified by the FDA. A designation of "not approvable" indicates that the drug has significant barriers to approval.

The number of new drugs approved each year during the past decade has ranged from 78 to 101. Many of the new drugs, however, closely resembled existing medications. A better way to track advances in drug therapy is to monitor how many of the approved drugs are **new molecular entities**, those medications that are truly unique and

structurally different from existing drugs. The number of new molecular entities has ranged from 20 to 30 per year.

Postmarketing surveillance, stage 4 of the drug approval process, begins after the NDA review has been completed. The purpose of stage 4 testing is to survey for harmful drug effects in a larger population. Some adverse effects are very subtle, take longer to appear, and are not identified until a drug is prescribed for large numbers of people. Adverse drug reactions are reported by the manufacturers, healthcare providers, and patients to the FDA Adverse Event Reporting System (FAERS), a computerized database designed to support the FDA's postmarketing surveillance program.

The FDA holds public meetings annually to receive comments from patients, professional organizations, and pharmaceutical companies regarding the effectiveness and safety of new drug therapies. If the FDA discovers a serious problem, it will mandate that a drug be withdrawn from the market. Examples of successful postmarketing surveillance include the removal of two cholesterol-lowering drugs in 2016. Advicor (approved in 2001) and Simcor (approved in 2008) were withdrawn because long-term clinical trials revealed that the medications were ineffective at reducing adverse cardiovascular events. In these cases, the withdrawals were not prompted by serious safety concerns. The benefits of the drugs were found to no longer outweigh their risks.

The drug approval process has several important limitations. Historically, drug trials have used Caucasian men as their test population. Because gender and racial differences may affect how drugs are handled by the body, data obtained during clinical trials may not be representative of the population as a whole. Pharmaceutical companies are now including a more diverse population in their clinical trials. Most drugs have not been tested in children: Pediatric doses and responses are often based on experience rather than research data. Although clinical trials test drugs in pregnant laboratory animals and examine for possible birth defects, these data may not be representative of how drugs affect pregnant women or their fetuses. Finally, adverse effects may occur at such a low level that they are statistically insignificant in clinical trials using a few thousand patients. Several million patients may need to take the drug before these effects can be identified.

Another limitation of the drug approval process relates to off-label uses. A new drug is developed by a pharmaceutical company for a specific indication and patient population at doses that are demonstrated to be safe and effective. FDA approval is based on this indication, based on strong scientific data. After several years of clinical experience, however, healthcare providers may find that the drug is also useful for indications not approved by the FDA. Or, the prescriber may find that the drug works better at a different dosage level or by a different route of administration. Once initially approved by the FDA for any indication, healthcare providers may legally prescribe the drug for other indications they feel are appropriate, despite the fact that the drug was never tested or approved for these additional conditions. How widespread is off-label prescribing? It is estimated that over 20% of prescriptions are for indications not approved by the FDA. The use of off-label drugs is particularly prevalent in cancer treatment and in pediatric patients. Although the FDA does not regulate off-label uses of drugs, laws prohibit pharmaceutical companies from advertising or promoting their drugs for off-label uses. It has not been clearly established whether or not off-label prescriptions increase risks to patients.

PharmFACT

It takes about 12 years of research and development, costing about $350 million, for a new drug to move from initial laboratory testing to the pharmacy shelf (Drugs.com, n.d.).

CONNECTION Checkpoint 2.1

In 2016, granisetron (Sustol), an antiemetic drug, and daclizumab (Zinbryta), an interleukin-2 blocking monoclonal antibody for treating relapsing multiple sclerosis, were approved. Are these considered therapeutic or pharmacologic classifications? *Answers to Connection Checkpoint questions are available on the faculty resources site. Please consult with your instructor.*

Changes to the Drug Approval Process

2.6 The U.S. Food and Drug Administration has sped up the process of drug review.

The process of synthesizing a new drug and testing it in cells, experimental animals, and humans takes many years. The NDA can include dozens of volumes of experimental and clinical data that must be examined during the FDA drug review process. Some NDAs contain over 100,000 pages of data. Even after all experiments have been concluded and clinical data have been gathered, the FDA review process can take several years.

Expenses associated with development of a new drug can cost the drug developer millions of dollars. Pharmaceutical companies are often critical of the regulatory process and are anxious to get the drug marketed to recoup their high research and development expenses. The public is also anxious to receive new medications, particularly for diseases that have a high mortality rate. Although the criticisms of government regulatory agencies are certainly understandable, and sometimes justified, the fundamental priority of the FDA is to ensure the safety of medications. Without an exhaustive review of scientific data, the public could be exposed to dangerous or ineffective drugs.

In the early 1990s, due to pressures from consumer groups and various drug manufacturers, government

officials began to plan how to speed up the drug review process. Reasons identified for the delay in the FDA drug approval process included outdated guidelines, poor communication, and not enough staff to handle the workload.

In 1992, the PDUFA was passed, requiring drug and biologic manufacturers to provide yearly product user fees. This added revenue allowed the FDA to hire more employees and to restructure its organization to more efficiently handle the processing of a greater number of drug applications. As part of the FDA modernization, priority drugs now receive accelerated approval. These are drugs intended to treat serious and life-threatening conditions, such as cancer and AIDS, that lack effective treatments. In some cases, the FDA may grant accelerated approval before the drug has completed phase 3 trials. The FDA usually requires the pharmaceutical company to file subsequent reports confirming the effectiveness of the drug.

PharmFACT

The number of new molecular entities approved in 2015 was 45. Thirty-six percent of these approvals were for first-in-class drugs that have mechanisms that differ from those of existing therapies (FDA, 2016b).

Prescription and Over-the-Counter Drugs

2.7 Over-the-counter drugs are usually safe and effective when used according to label instructions.

The 1951 Durham-Humphrey Amendment to the FDCA clearly established the difference between prescription and OTC drugs. To obtain a prescription drug, an order must be given authorizing the patient to receive the medication. Prescription medications are judged by the FDA to be potentially addictive or too harmful for self-administration. In some cases, they are used to treat conditions too complex for self-diagnosis by the consumer or the drug may require a skilled nurse or healthcare provider to administer it.

The advantages of requiring a prescription are numerous. The healthcare provider has an opportunity to examine the patient and determine a specific diagnosis. The prescriber can maximize therapy by ordering the proper drug for the patient's condition and by controlling the amount and frequency of the drug to be dispensed. In addition, the healthcare provider has an opportunity to teach the patient proper use of the drug and its expected adverse effects.

In contrast to prescription drugs, OTC drugs do not require an order from a healthcare provider. In most cases, patients may treat themselves safely if they carefully follow instructions included with the medication. A key point to remember is that no drug is without risk; if patients do not follow the guidelines on the label, serious adverse effects may result.

Patients prefer to take OTC medications for many reasons. OTC drugs are obtained more easily than prescription drugs. No appointment with a healthcare provider is required, thus saving time and money. Without the assistance of a healthcare provider, however, choosing the proper medication for a specific problem can be challenging for a patient. OTC drugs may interact with foods, herbal products, prescription drugs, or other OTC drugs. Patients may not be aware that some OTC medications can impair their ability to function safely. Self-treatment is sometimes ineffective, and the potential for harm may increase if the disease is allowed to progress.

During the past decade, consumer groups have pushed for the reclassification of certain drugs from prescription to OTC in cases whereby a high margin of safety exists with the medicines. For example, prior to 1996, substances that were used to assist in smoking cessation, such as nicotine patches and gum, were available by prescription only but are now available OTC. Other switches from prescription

CONNECTIONS: Lifespan Considerations

The Association of Cost-Related Medication Nonadherence and Food Insecurity in Older Adults

It is known that the cost of prescription drugs may be a major cause for medication nonadherence in the older adult, but are there other factors that impact nonadherence? Studies suggest that food insecurity, that is, the lack of access to sufficient, nutritious, and affordable food, may also predict nonadherence (Afulani, Herman, Coleman-Jensen, & Harrison, 2015; Herman, Afulani, Coleman-Jensen, & Harrison, 2015). Afulani et al. (2015) found that as the severity of food insecurity increased, nonadherence also increased. Older adult women and older adults with chronic conditions were more likely to report nonadherence. However, having insurance coverage, particularly Medicare and Medicaid, decreased nonadherence. Food security-related nonadherence is not just a problem for the older adult. Herman et al. (2015) found a similar relationship in the nonelderly adult population. In that study, female adults and adults with chronic conditions, low income, no or insufficient health insurance, severe mental illness, or functional limitations had an increased risk of cost-related medication nonadherence.

When assessing a patient's adherence to the prescribed medication regimen, nurses should assess factors other than cost that may increase the risk of nonadherence, particularly food insecurity. Recognizing that patients who are unable to afford or access adequate and nutritious food places them at risk for medication nonadherence may help the healthcare team improve health.

Table 2.2 U.S. Drug Schedules and Examples

Drug Schedule	Abuse Potential	Examples	Therapeutic Use
I	Highest	Heroin, GHB, LSD, marijuana, MDMA, mescaline, methaqualone, methcathinone, peyote, and psilocybin	No currently acceptable medical use; no prescriptions may be written
II	High	Potent opioids (such as codeine in high doses, fentanyl, methadone, morphine, oxycodone, meperidine), amphetamine, cocaine, methamphetamine, methylphenidate, PCP, and short-acting barbiturates	Have currently accepted medical use but use may be severely restricted; normally no refills are permitted (but there are exceptions)
III	Moderate	Anabolic steroids, buprenorphine ketamine, codeine (lower doses compounded with aspirin or acetaminophen), hydrocodone (lower doses compounded with aspirin or acetaminophen), and intermediate-acting barbiturates	Have currently accepted medical use; less stringent controls than Schedule II drugs; five refills allowed in a 6-month period
IV	Low	Benzodiazepines (such as alprazolam, diazepam, midazolam, temazepam), long-acting barbiturates, meprobamate, pentazocine, tramadol, and zolpidem	Have currently accepted medical use; similar controls to Schedule III drugs; five refills allowed in a 6-month period
V	Lowest	Cough medicines with codeine, antidiarrheal medicines with small amounts of opioids	Have currently accepted medical use; similar controls to Schedule III and IV drugs

From *Controlled Substance Schedules*, U.S. Department of Justice, n.d. Retrieved from http://www.deadiversion.usdoj.gov/schedules

to OTC include famotidine (Pepcid AC), cimetidine (Tagamet HB), omeprazole (Prilosec), cetirizine (Zyrtec), budesonide (Rhinocort), fluticasone (Flonase), and loratadine (Claritin). Over the past 25 years, 700 products have been changed from prescription to OTC. The decision to reclassify a drug may be initiated by the manufacturer or mandated by the FDA during its review process.

Herbal products and dietary supplements are also widely available OTC. Herbal products and dietary supplements are not considered drugs; they are not marketed to treat any disease, and they are not subject to the same regulatory process as medications. Yet some of these products can cause adverse effects and interact with medications. Nurses should always inquire about their patients' use of herbal products and dietary supplements and caution them that the FDA has not tested these products for effectiveness or safety. In some cases, herbal products are contraindicated. For example, St. John's wort should not be taken concurrently with antidepressant medications.

PharmFACT

An estimated 23,000-plus emergency department visits each year are attributed to adverse events related to dietary supplements. The two largest categories of supplements are energy drinks and weight loss supplements (Geller et al., 2015).

Drug Schedules

2.8 Drugs with a potential for abuse are categorized into schedules.

Dependence is a powerful physiologic or psychologic need for a substance. Some drugs are frequently abused or have a high potential for dependence; thus, the selling and distribution of these drugs are highly restricted. Drugs that have a significant potential for abuse are placed into five categories called *schedules*. These **scheduled drugs** are classified and regulated according to their potential for abuse, as shown in Table 2.2. Concepts of dependence and drug schedules are discussed in detail in Chapter 27.

In the United States, **controlled substances** are drugs whose use is restricted by the Comprehensive Drug Abuse Prevention and Control Act of 1970 and its later revisions. Hospitals and pharmacies must register with the Drug Enforcement Administration (DEA) and use their registration numbers to purchase scheduled drugs. They must maintain complete records of all quantities purchased and sold. Drugs with the highest abuse potential have additional restrictions. For example, providers must use a special order form to obtain Schedule II drugs, and orders must be written and signed by the provider. Telephone orders to a pharmacy are not permitted. Refills for Schedule II drugs are not permitted; patients must visit their healthcare provider to receive a new prescription. Healthcare providers convicted of unlawful manufacturing, distributing, and dispensing of controlled substances face severe penalties.

CONNECTION Checkpoint 2.2

Once a new drug is approved, it is assigned names. What are the two basic types of drug names and who assigns them? *Answers to Connection Checkpoint questions are available on the faculty resources site. Please consult with your instructor.*

Prescriptive Authority for Nurses

2.9 Advanced practice nurses are allowed to prescribe drugs under state regulations.

Historically, prescribing drugs was the responsibility of the physician or dentist. With the growth of advanced nursing degrees at the master's and doctoral levels, nurses began to specialize and to obtain certification as certified nurse midwives (CNMs), certified registered nurse anesthetists