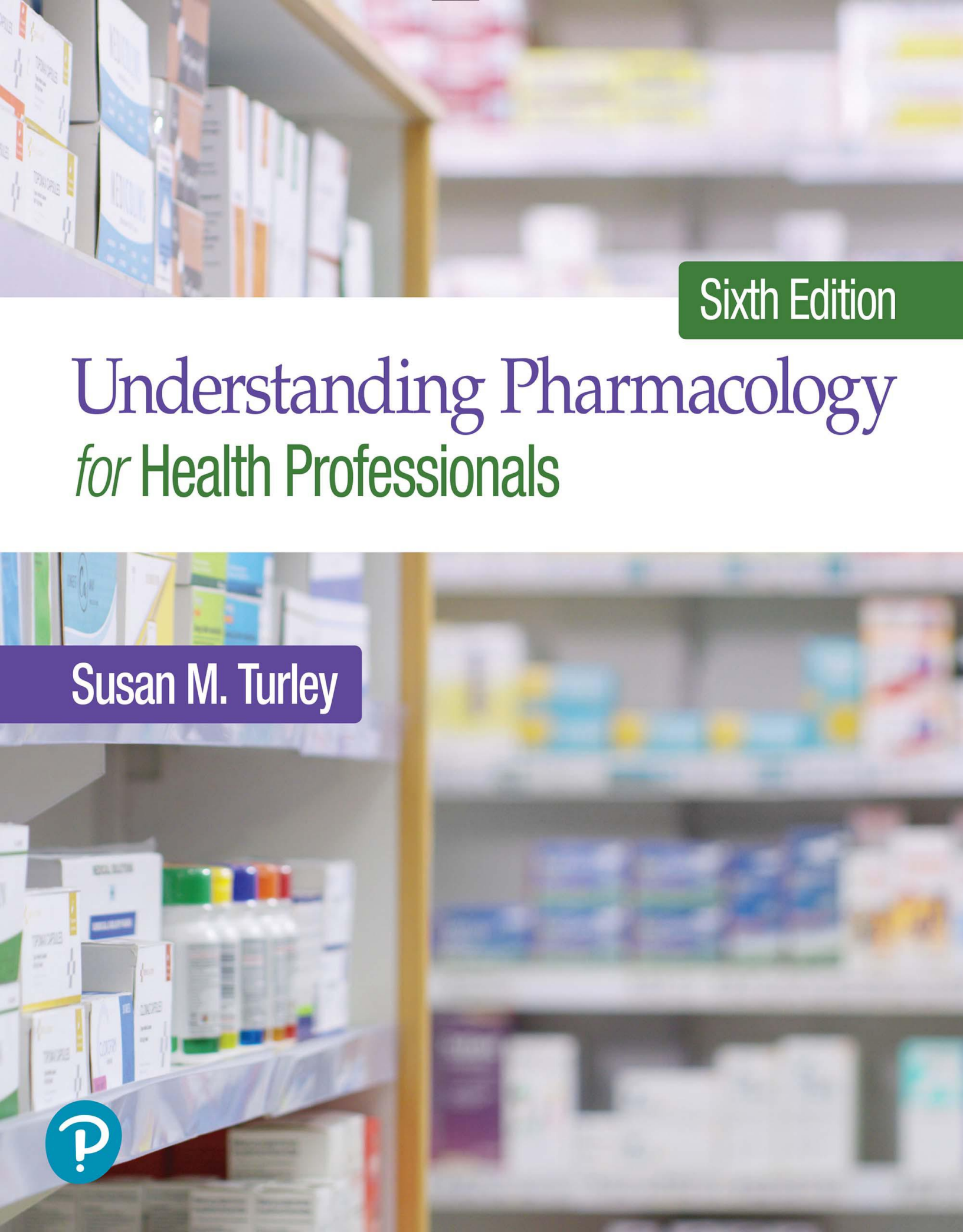

Sixth Edition

Understanding Pharmacology *for* Health Professionals

Susan M. Turley

UNDERSTANDING PHARMACOLOGY
for Health Professionals

Sixth Edition

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Pearson

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Dedication

To my daughters Lien and Minh

COMMENTS ABOUT PREVIOUS EDITIONS OF

Understanding Pharmacology for Health Professionals

I love how the author was able to take a subject like pharmacology and make it understandable to someone like me who knew nothing about the subject. I love the little tidbits of information (historical and just interesting) that are included in each chapter. Furthermore, it has an exceptional glossary and index in the back.

—*Student in an introductory pharmacology course*

I've been wishing I could tell the author that the fear I had of this subject going into this course has been alleviated because of this book! I have retained much more of this information than I thought I could.

—*Student in an introductory pharmacology course*

A clear, well-organized, stimulating textbook that takes the student step-by-step through the whole subject of pharmacology without going into needless complexities or irrelevant details. The facts are accurate and up-to-date, and their logical connections are presented with clarity.

—*Reviewer*

Understanding Pharmacology for Health Professionals is not only a superb introductory textbook but is a reference work that you will consult often and with profit.

—*John H. Dirckx, M.D.* (Foreword to the first edition)

DID YOU KNOW?

As I write this in 2021, I am ever mindful of the many children in this country and around the world who are in need of help, food, and homes.

All of the royalties from this textbook are given to provide ongoing financial support to orphanages and feed-and-read school programs for destitute children in several countries, as well as to help poor and hungry children in the United States.

CONTENTS

FOREWORD

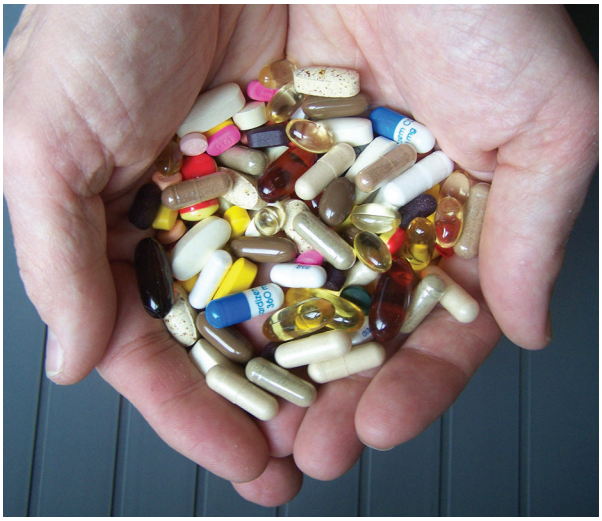
The classical Greek word *pharmakon*, on which the word *pharmacology* is based, has three related meanings: *charm*, *poison*, and *remedy*. These variants of the word spotlight important aspects of the history of pharmacology.

In the prescientific age, issues of cause and effect were frequently assumed in the absence of experimental proof. What we now call superstition and magic were accepted before the introduction of rational modes of thought and action. Primitive healers used natural substances of animal, vegetable, and mineral origins with boundless confidence in their power to cure, even though objective evidence of their efficacy was lacking. And we can be sure that many cures took place through the power of suggestion, a potent force still recognized today as the "placebo effect."

But if some patients recovered after dosing with crude, prehistoric remedies, others were killed outright. It cannot have escaped the early medicine men—or their patients—that some "medicines" were more useful for getting rid of enemies (or inconvenient friends) than for treating the sick; hence, the second meaning of the word *pharmakon*. Even today, the toxicity of drugs is a major problem, for some of our most effective drugs also have the narrowest margins of safety.

Only after centuries of observation and experimentation has medical science achieved an understanding of the way in which drugs work and a sound basis for their safe and effective use. This is the third meaning of *pharmakon*, one that was hedged about with a great deal of wishful thinking in primitive times, but one that has largely been realized today. And yet, in many ways, we have only scratched the surface of understanding pharmacology.

Many medicines achieve their effects not by neatly eliminating or neutralizing the source of symptoms but by inducing abnormalities in body chemistry or function that tend to offset the abnormalities caused by the disease. Except for a few naturally occurring enzymes, hormones, vitamins, and minerals, most substances administered as medicines are foreign to the body and are therefore capable of causing annoying side effects and allergic reactions. Clearly, this state of affairs leaves much to be desired and presents a continuing challenge to pharmacologic chemists and clinical researchers.



The fact that we don't have a single perfect drug, much less a panacea or cure-all, accounts for the staggering multitude and diversity of imperfect drugs in current use.

The great number and variety of drugs are apt to prove daunting at first sight to the student who undertakes the study of pharmacology. I, as a physician, am sometimes asked, "How can you possibly remember all those drugs?" The answer is simple: I can't, and neither can anyone else. Typical practicing physicians have a working knowledge of just a

few drugs in each pharmacologic category—perhaps more in categories pertaining to their specialty, perhaps none in categories they never have occasion to prescribe. Once a physician is fully familiar with the characteristics, indications, side effects, and doses of one drug in a pharmacologic category, similar information about all the others in the same category would be excess baggage.

Just as the range of useful information for the practicing physician doesn't include the whole field of pharmacology, students in health care don't need to memorize huge masses of information or endless lists of drugs. What they need is a good understanding of how various kinds of drugs work, their potentials and limitations, some of the reasons for their number and diversity, and the rationale behind their bewildering and often tongue-twisting names.

This is exactly the kind of mental database that *Understanding Pharmacology for Health Professionals* can give students. The author, drawing from her diversified background in nursing, medical transcription, health information management, and healthcare education at the college level, has produced a clear, well-organized, stimulating textbook that takes students step-by-step through the whole subject of pharmacology without going into needless complexities or irrelevant details. The facts are accurate and up-to-date, and their logical connections are presented with clarity. Historical sidelights and pertinent illustrations keep the interest level high. A comprehensive Drug Reference at the end of the textbook gives capsule information about hundreds of current drugs, as well as their pronunciations.

—John H. Dirckx, M.D.

(from the Foreword to the first edition)

PREFACE

Welcome to the study of pharmacology! You have decided to become a medical assistant, a health information manager, a medical coder, a pharmacy technician, a respiratory therapist, a nurse, or some other type of healthcare professional who needs to know about pharmacology and how drugs are used in health care. This textbook is designed for you!

There is an excitement inherent in the study of pharmacology. The field of pharmacology is amazing in its scope, ranging from historical and present-day uses of herbs and plants to day-to-day painstaking research that produces unusable products as well as lifesaving drugs to incredible technology and genetic manipulation.

The road of pharmacology is paved with extensive and often unrecognized research on the part of thousands of doctors and scientists around the world. Pharmacology is built layer by layer upon previous discoveries and consists of equal parts of hard work, astute observations, sudden insights, and divinely appointed coincidences. But more than that, pharmacology is constantly being built anew with each new drug discovery. The future holds a seemingly limitless potential for discovery!

The purpose of this textbook is to provide a framework of knowledge to help you:

1. Recognize drug categories and generic and trade name drugs.
2. Understand therapeutic drug effects and the reasons for using drugs to treat disease.
3. Understand why side effects, allergic reactions, and other effects of drugs occur.
4. Explore the implications of drugs on health care and current controversies surrounding drugs.

This new sixth edition of *Understanding Pharmacology for Health Professionals* will help you gain the knowledge of pharmacology that you need to succeed in a healthcare-related job. You will understand drugs that are currently on the market and also be prepared for the many new drugs that are approved each year.

With the help of *Understanding Pharmacology for Health Professionals, Sixth Edition*, the road of pharmacology that stretches ahead of you will become both familiar and nonthreatening—one that you can travel frequently and confidently in the future.

Susan Turley

Author, *Understanding Pharmacology for Health Professionals*, 6th edition

A Note to Students

THE BEGINNINGS OF THIS TEXTBOOK

A number of years ago, I began to teach a course in pharmacology (lecture and clinical lab) at a local community college. By the third semester of teaching, I had selected, used, and subsequently discarded three different pharmacology textbooks from three different publishers. Some of my objections to these textbooks were that they were

- Dry and uninteresting
- Lacking in drug photographs or connections to the real world
- Inconsistent in the depth of content presented
- Unclear in their explanation of drug actions
- Out of date
- Visually uninviting
- Lacking in humor and anecdotal information.

By the fourth semester of teaching pharmacology, I made the decision to begin writing student handouts for each chapter to supplement my weekly lecture. I tried to make the explanations of drug actions and other in-depth topics as clear and straightforward as possible. This often necessitated prolonged research on certain topics until I was certain I could convey a complicated concept in a concise and understandable way.

After many revisions, additions, and much research, this material became the basis for the first edition of *Understanding Pharmacology for Health Professionals*.

Just prior to completing the first edition, I received a master's degree in adult education. Having thoroughly studied the techniques of the best educators, I was more convinced than ever that these techniques—the techniques I had used in the first edition—could be applied to the teaching of pharmacology, and that pharmacology could be presented in an interesting, stimulating, challenging, and even humorous way to enhance the total learning experience. So I included interesting anecdotal and historical material, as well as humorous material/cartoons/quotes, to enliven the first-edition text.

Abundant positive feedback from students, instructors, and healthcare professionals from across the country overwhelmingly validated this combination of clear explanations and attention-holding techniques as a successful educational and professional tool.

HOW TO USE THIS TEXTBOOK

As you begin, do these things first before reading the chapter text.

- Review the Chapter Contents list. This alerts you to all of the topics that are presented in the chapter.
- Review the Learning Objectives. This gives you an overview of areas of information in the chapter that you will be asked to describe, explain, differentiate, or demonstrate.
- Review the Key Words and Phrases box to familiarize yourself with important chapter vocabulary.
- Browse/skim through the pages of the chapter. This gives you an idea of the length of the chapter and more specific information about its contents.
- Look at some of the illustrations, photographs, and feature boxes in the chapter. These entice you to begin reading the chapter material!

After you have finished reading and studying the chapter, answer the Chapter Review Exercises at the end of the chapter. This helps you assess your level of learning and apply what you have learned.

PRACTICAL APPLICATIONS OF KNOWLEDGE

It is important that you be able to relate the information you are learning to your own life experiences, whether personal or professional. Everyone has at least some familiarity with drugs. In addition, most people have a family member or friend who is taking one or more drugs. As you begin your study of a particular chapter, your instructor may ask you to document in writing conversations with family members or friends about drugs they are taking, the symptoms that prompted the prescription of those drugs, and whether or not their symptoms improved—all while keeping the person's identity confidential, of course! You may also include drugs you are taking and why, but this is optional (to preserve your privacy).

In this way, you become an active participant in the information-gathering process and begin to see yourself as a researcher. The facts you gather will form a mental framework upon which to place the information you learn in the textbook. You will remember that your sister takes Flovent for her asthma, that you use Claritin for your seasonal allergies, and that your elderly aunt takes Celebrex for her arthritis and hydrochlorothiazide for her high blood pressure.

Besides having a knowledge of drug uses and actions, it is important for you to know how to communicate your knowledge through speaking and writing. This means mastering the pronunciation and spelling of drug names and recognizing common generic drugs and their trade name equivalents.

While I was teaching pharmacology at the community college, a student in the Emergency Medical Technician (EMT) Program approached me and asked for assistance in learning to pronounce drug names. This student stated that he was being ridiculed when he called ahead to alert the emergency room about an ambulance patient's current drugs and couldn't correctly pronounce the drug names. I made a recording of the pronunciations of the most common generic and trade name drugs for him. He studied it and later reported that he was successfully pronouncing the drug names and that the healthcare professionals he dealt with had noticed his improvement in this area.

The pronunciation of drug names should be practiced during the study of each chapter. Many drug names, particularly the generic names, have multiple syllables, and correct pronunciation requires some practice. Hearing your instructor pronounce the drug name is just the first step. You need to practice pronouncing drug names for yourself. An easy-to-use, see-and-say pronunciation guide is located right next to the generic name drug in each chapter. A pronunciation guide for each trade name drug is found in the A–Z Drug Reference at the end of the textbook.

While studying pharmacology, it is easy to become buried by the sheer volume of drug names, drug facts, and other details. It is important to recognize the common suffix for generic drugs that belong to a specific drug category. Going forward, it is critical that you retain the ability to research and find information about new drugs as they come on the market. You need to know how to locate new drugs on the Internet, how to interpret printed drug information, how to formulate questions to obtain additional information, and how to contact appropriate individuals (pharmacists, doctors, etc.) to obtain information.

On a personal note, I would encourage you to constantly increase your knowledge of pharmacology during your study of this textbook and in the future. I hope this textbook will make your study of pharmacology relevant and interesting. Blessings to you as you study and learn about pharmacology!

Susan Turley

Author, *Understanding Pharmacology for Health Professionals*, 6th edition

A Guide to the Sixth Edition

Thanks to valuable input from students, instructors, and reviewers, the sixth edition includes an abundance of new features. In the pages that follow, please explore what makes this new edition an ideal teaching and learning tool.

NEW STRUCTURE AND ORGANIZATION

In order to better accommodate the 16-week semester schedule used by our community college customers, we have combined the material in some chapters for a total of 15 chapters. There are two units—Unit I: Introduction to Pharmacology, which contains Chapters 1, 2, and 3, and Unit II: Drugs Related to a Body System, which contains Chapters 4–15. The remaining chapter materials have been placed in an expanded list of Appendices. The decrease in the number of chapters from 25 to 15 makes it easier for students to concentrate on just one chapter per week, with week 16 reserved for the final examination.

Unit I Introduction to Pharmacology

Unit I consists of three chapters that introduce the field of pharmacology. These chapters build a strong foundation of basic knowledge that facilitates learning about specific drugs and drug categories that are presented in later chapters.

Unit II Drugs Related to Body Systems

Unit II consists of 12 chapters (Chapters 4 through 15, each of which is related to a body system. The body system approach is the most efficient way to learn anatomy and physiology, human diseases . . . and pharmacology.

Unit III Appendices

Unit III consists of eight appendices (Appendices A through H) related to drug information not covered in the textbook chapters.

MOST CURRENT DRUG INFORMATION

Every chapter and each appendix has been updated to include the most current generic and trade name drugs, drug categories, and drug information available—right up to the date of publication. Each drug category includes a description of how its drugs work in the body and their therapeutic effects. Side effects, adverse effects, and drug interactions are also discussed.

These updates are also reflected in the A–Z Drug Reference section at the end of the textbook.

RANKL Inhibitor Drugs for Osteoporosis

RANKL (receptor activator of nuclear factor kappa beta ligand) is a cytokine that is secreted by osteoblasts. It then activates osteoclasts to begin the process of bone breakdown. RANKL inhibitor drugs prevent RANKL from activating receptors on the osteoclasts, thus preventing bone breakdown and loss of bone. These drugs are monoclonal antibody drugs. *Note*: The suffix *-mab* is common to generic monoclonal antibody drugs.

Drug Name	Pronunciation
denosumab (Prolia)	[deh-NOH-soo-mab]
romosozumab (Evenity)	[roh-moh-soh-zyoo-mab]

NEW DRUG PRONUNCIATIONS

Drug pronunciations are now included after every generic drug in the chapters and appendices. These are the author's own see-and-say pronunciation guides that make it easy to pronounce difficult, multisyllable generic drug names. This enhances the learning experience by immediately linking the drug name with its pronunciation. The A–Z Drug Reference at the end of the textbook includes both the generic drug and trade name drug pronunciations.

Drug Name	Pronunciation
cimetidine (Tagamet HB) (see ■ Figure 4-2)	[sy-MEH-tih-deen]
famotidine (Pepcid) (see ■ Figure 4-3)	[fah-MOH-tih-deen]
nizatidine	[ny-ZAH-tih-deen]

UPDATED KEY WORDS AND PHRASES

This overview feature at the beginning of each chapter and appendix now includes new drug words and phrases that reflect the changing nature of pharmacology: biologic drugs, COVID-19 vaccines, prescription drug monitoring programs, recombinant DNA technology, etc.

NEW WORD PART AND MEANING BOXES

This language tool helps students see how a complex word can be broken down into its word parts and meanings.

Word Part	Meaning
anti-	(against)
tuss/o-	(cough)

UPDATED VISUAL ENHANCEMENTS

- This edition has more illustrations and photographs of real drugs than ever before. The quantity and quality of photographs throughout the sixth edition have been greatly increased to include a variety of drug forms, drug packages, drug labels, and drugs being administered to patients. This variety and realism provide an unparalleled learning experience for students, as they are immersed in the visual aspects of pharmacology.
- Vibrant new colors for the chapter opener pages and feature box headers enhance the visual appeal and learning experience. The feature boxes—Drug Alert!, Did You Know?, Historical Notes, Focus on Health Care, and Look Closer—so popular with students and instructors—have been retained and updated with fresh header colors and a distinctive design.
- Touches of humor in the form of cartoons—one of this textbook's best-known and most-appreciated features—have been retained.

DID YOU KNOW?

Ziconotide (Prialt) is derived from the venom of a cone snail that lives in the coral reefs around the Philippines. This was the first drug approved by the FDA that was an exact chemical duplicate of a substance found in the ocean. Any substance secreted by a sea creature must be very concentrated because it is immediately diluted with sea water. The drug ziconotide is many times stronger than morphine.

Figure 2-1 ***This drug was tested on 2000 white mice, and they had a ball.***

Source: David W. Harbaugh

EXPANDED CHAPTER REVIEW EXERCISES

This end-of-chapter feature has been expanded to included additional types of questions (Matching, True or False, Fill in the Blank), as well as updated material in the existing sections of Quiz Yourself, Clinical Applications, and Critical-Thinking Questions.

True or False

1. The drug capsaicin to treat osteoarthritis was derived from the opium poppy. _____
2. "Biologic drugs" refer to monoclonal antibodies that are used to treat rheumatoid arthritis. _____
3. Endorphins are the body's own natural pain relievers. _____
4. Acetaminophen can be given intravenously in a hospital setting. _____
5. Tylenol can be used as an anticoagulant drug to prevent a stroke or heart attack. _____
6. COX-1 and COX-2 enzymes produce prostaglandins that cause pain. _____
7. Lyrica and Cymbalta are trade name drugs used to treat rheumatic arthritis. _____
8. Prescription-strength drugs of calcium and vitamins D and K are used to treat osteoporosis. _____

About the Author

Susan M. Turley, MA (Educ), BSN, RN, RHIT, is an experienced educator and practitioner in many areas of health care. She has a Master of Arts degree in adult education, a Bachelor of Science degree in nursing, and national certification in the field of health information management.

As a nurse, Susan has worked and administered drugs in neonatal and pediatric intensive care units, physician office settings, and a plasmapheresis center. She has also worked in an administrative capacity in managed care and long-term care, as a quality manager, health information manager, physician office auditor, and infection control officer and has created physician credentialing databases.

As an educator, Susan has been an adjunct professor, teaching an introductory pharmacology course for students in the pharmacy technician, medical assisting, and respiratory therapy programs at a community college. She also taught medical terminology and medical transcription courses there for many years. Susan has developed the bachelor's and master's curricula for the International Institute of Original Medicine. She was the co-leader for many medical transcription instructor training sessions, sponsored by Health Professions Institute. She was also a guest speaker at several annual seminars sponsored by Stevens College to prepare students to take the health information management national certification examination.

As an author, Susan is known for clarity in presenting technically difficult material and for a special blend that includes humor and interesting anecdotes to stimulate learning and keep interest high. Students and colleagues alike have enthusiastically endorsed the accuracy and clarity of her textbooks.

Susan is also the author of *Medical Language, Fifth Edition* (Pearson, 2020), as well as numerous medical and educational articles for national medical transcription journals. She has also been employed by physicians as an editor for articles submitted to peer-reviewed physician journals and for a chapter in an otolaryngology textbook for physicians.

To stay abreast of pharmacy trends and new drugs on the market, Susan subscribes to *Drug Facts and Comparisons* (Wolters Kluwer, 2021) and Drugs.com, and she participates in continuing education courses offered by *Pharmacy Times*. She is also a pharmacology consultant/editor for *Nursing: A Concept-Based Approach to Learning, Fourth Edition* (Pearson, 2023).

ACKNOWLEDGMENTS

To my colleagues at Pearson, I wish to thank:

- Kevin Wilson, Content Manager for Health Sciences and my editor, who gave a most-welcome go-ahead to begin the process of revising and updating the new sixth edition, and then enthusiastically supported it each step of the way from conception to finished product.
- Melissa Bashe, Managing Producer, Health Sciences, my long-term colleague and friend who has worked on nearly every edition of my two textbooks. Her enthusiasm and encyclopedic knowledge of publishing made her an essential partner for answering each and every question, big and small.

To my colleagues at Straive, I also thank:

- Patty Donovan, Senior Project Manager, Health Sciences, my long-term colleague and friend who has been a part of nearly every edition of my two textbooks. Her positive attitude helped overcome obstacles, encourage me, and push the production of the sixth edition over the finish line.
- Meghan DeMaio, Project Management Team Lead, who collected and coordinated the myriad details involved in this project.

I also wish to thank the many instructors who have used the various editions of this textbook since it was first published in 1991. I also acknowledge the many students who have studied from this textbook. The insightful comments of all of these individuals have helped to continuously improve this textbook from its first edition to the latest sixth edition.

For the early editions, I wish to acknowledge Mark Cohen, then Executive Editor for Health Professions at Pearson for his expertise, creative insights, and enthusiasm for *Understanding Pharmacology for Health Professionals* through the years. I thank Sally C. Pitman and Health Professions Institute for publishing the first edition of this textbook and John H. Dirckx, M.D., an expert reviewer and author of the Foreword for the first edition.

I thank the late David W. Harbaugh, his wife G. Joanne Harbaugh, and son Blake Harbaugh for continuing to allow publication of his medical cartoons in this edition.

I would also like to express my appreciation to the following people for their valuable contributions to the textbook or supplements program:

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Patricia McLane, RHIA, BS
Adjunct Instructor
Health Information Technology
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Livonia, Michigan

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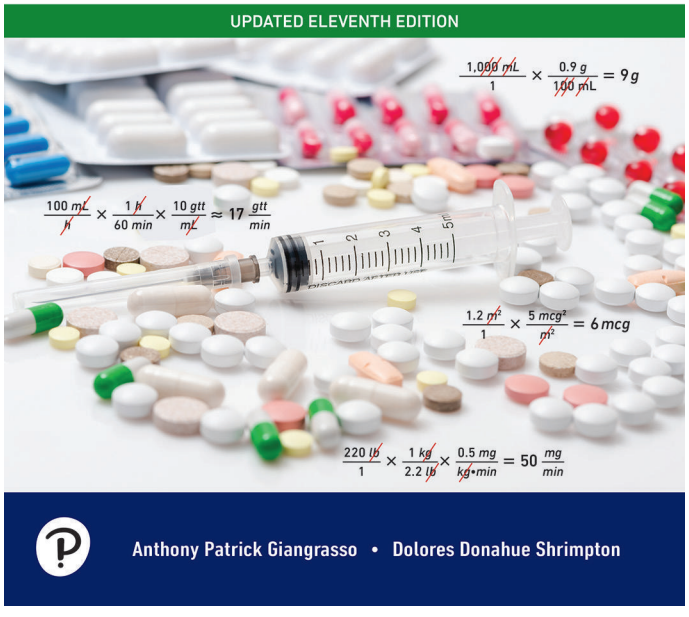
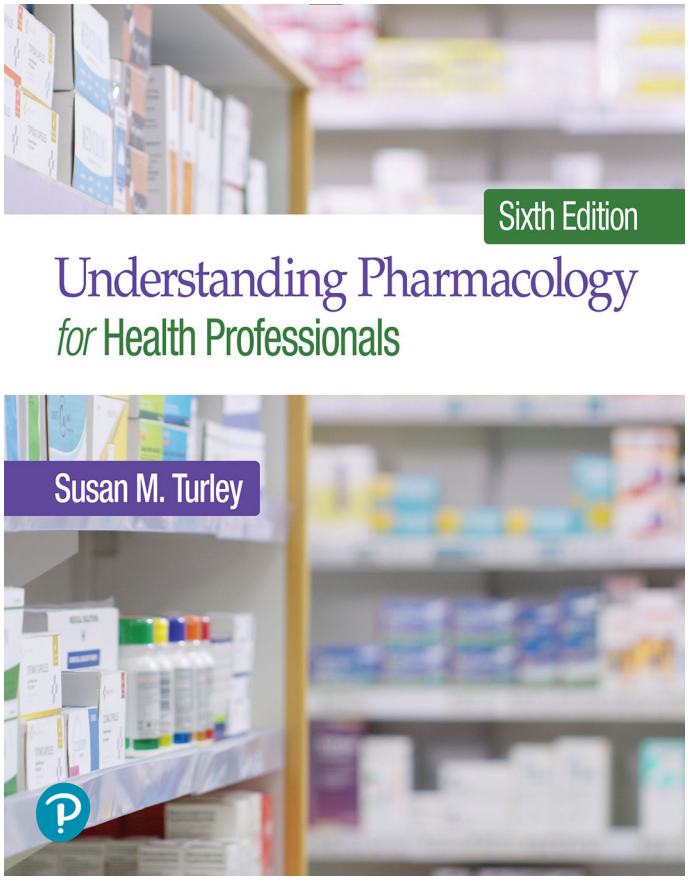
A Note about Drug Doses and Calculations

It is not the purpose of this textbook to instruct in the actual prescribing or administration of drugs. Calculation of drug doses and administration of drugs are entirely different topics of study. For those students seeking a resource dedicated to this aspect of pharmacology, *Medical Dosage Calculations* by Giangrasso and Shrimpton (Pearson, 2022) is an ideal companion textbook. Instructors and bookstores may wish to contact their Pearson representative to arrange a value-priced bundle package of these two texts.





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1

Introduction to Pharmacology

Chapter Contents

Learning Objectives

After you study this chapter, you should be able to:

1. Describe the origin and meaning of *pharmacology*, *drug*, *medicine*, and *Rx*.
2. Describe the medical uses of drugs.
3. Describe types of pharmacies and roles of the pharmacist and pharmacy technician.
4. Describe how drugs are discovered or created.
5. Differentiate between the chemical, generic, and trade names of a drug.
6. Differentiate between prescription drugs, Schedule drugs, over-the-counter drugs, and dietary supplements and give examples of each.
7. Describe the categories of controlled substances and give examples.
8. Describe the use of orphan drugs and designer drugs.
9. Define each key word and phrase.
10. Demonstrate mastery of the chapter by completing the Chapter Review Exercises.

KEY WORDS and PHRASES

analog *19*
apothecary *4*
chemical name *12*
compounding *4*
controlled substance *15*
designer drug *19*
dietary supplement *18*
drug *2*
e-prescribing *6*
gene replacement therapy *11*
generic name *12*
Food and Drug Administration *15*
isomer *10*
medication, medicine *2*
monoclonal antibody drug *11*
orphan drug *19*
over-the-counter drug *18*
pharmacology *2*
pharmacy *5*
pharmacist *6*
pharmacy technician *6*
prescription drug *15*
prophylaxis *2*
recombinant DNA technology *11*
Rx *15*
Schedule drug *15*
trade name *13*

Word Part	Meaning
pharmac/o-	(drug; medicine)

INTRODUCTION TO PHARMACOLOGY

Pharmacology is a fascinating, exciting, and multifaceted field that will impact not only your professional career as a member of the healthcare team but also your personal life as a consumer.

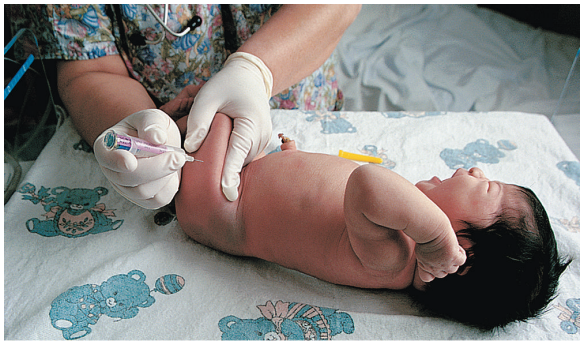
Pharmacology is the study of drugs and their interaction with living organisms. The word *pharmacology* comes from the Greek word *pharmakon*, which means "drug" or "medicine." Pharmacology also relates to other fields, such as botany, chemistry, genetics, toxicology, addiction, legislation, technology, and patient education—to name a few.

The word ***drug*** is derived from the Dutch word *droog*, which means "dry" and refers to the use of dried herbs and plants as the first medicines. A drug can be thought of as any nonfood chemical substance that affects the mind or the body. The Latin word *medicina* means "remedy or cure," and it is where the words ***medicine*** and ***medication*** come from. *Medicine* refers to a drug that is administered for its value as a preventive, diagnostic, or therapeutic agent. In common use, the word *drug* is interchangeable with the word *medicine* or *medication*, but the word *drug* can also refer to a chemical substance that does not have any legitimate use (e.g., an illegal drug or street drug).

Medical Uses for Drugs

Drugs have three medical uses. They are used to prevent disease, diagnose disease, and treat disease.

1. **Prevent disease.** Drugs are used to prevent the occurrence of diseases. The administration of a preventive drug is known as ***prophylaxis***. This is from a Greek word that means "to keep guard before." Examples include:
   - A drug taken before traveling to prevent motion sickness.
   - A vaccine to prevent a certain disease, such as tetanus, herpes, or influenza (see ■ Figure 1-1).
   - A contraceptive drug to prevent pregnancy.



■ Figure 1-1 Preventive use.
This newborn infant is receiving an injection of a vaccine to prevent a childhood disease.
Source: Elena Dorfman/Pearson Education

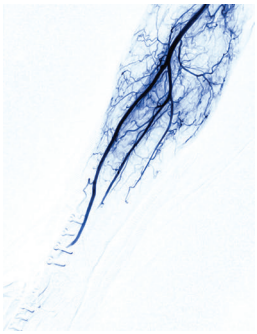


Figure 1-2 Diagnostic use.
This contrast dye is a drug that outlines the arteries when an x-ray is taken.
Source: samunella/Shutterstock

Figure 1-3 Therapeutic use.
This drug is given orally to treat a patient with a high level of cholesterol in the blood.
Source: Susan Turley

2. **Diagnose disease.** Drugs are used by themselves or in conjunction with x-ray or laboratory tests to diagnose the presence of disease. Examples include:
   - A contrast dye used during an x-ray procedure (Figure 1-2).
   - A drug that increases the heart rate to mimic exercise in a cardiac patient who cannot do a treadmill exercise stress test.
3. **Treat disease.** The majority of drugs are used to treat and control, improve, or cure the symptoms and signs of disease. Examples include:
   - An analgesic drug to control the pain and inflammation of arthritis.
   - A drug to lower the level of cholesterol in the blood (see Figure 1-3).
   - An antibiotic drug to cure an infection by killing bacteria.

FOCUS ON HEALTH CARE

The American Academy of Pediatrics issues an annual immunization schedule to prevent childhood diseases. All children must be current with their vaccinations before they are permitted to enroll in school. (Vaccines and vaccination are discussed in Appendix B.)

DRUGS THROUGH HISTORY

So how did it all begin? Pharmacology is one of the oldest branches of medicine. Cultures around the world have used drugs for thousands of years.

- Ancient people in 5000 BC in Mesopotamia ("the cradle of civilization") used clay tablets to record their use of drugs.
- The ancient Chinese emphasized the use of herbs and minerals (see Figure 1-4), along with acupuncture, massage, and exercise. The first book of Chinese herbal medicine in 3494 BC included over 300 different herbal remedies.

Figure 1-4 Chinese herbal medicines.
This Chinese pharmacist is preparing herbal medicines in much the same way that his ancestors did, using dried herbs crushed into powder. In 1970, the Chinese Academy of Medical Science found that 45 percent of Chinese traditional herbal remedies were therapeutic, according to the standards of Western medicine.
Source: Maron/Fotolia

- In Japan, the position of pharmacist was ranked even higher than that of personal physician to the Emperor.
- In King Tutankhamun's tomb, archeologists found hundreds of jars of plant oils. The Ebers Papyrus, an Egyptian medicinal scroll from 1500 BC, contained the names of 800 herbal formulas. The Egyptians also applied moldy bread to abrasions, a practice that actually had some therapeutic basis as, many centuries later, the antibiotic drug penicillin was extracted from a mold. The Egyptians also used garlic to treat heart disease and tumors. However, they also used substances that are not used today as drugs: frogs' bile, sour milk, lizards' blood, pigs' teeth, sugar cakes, dirt, spiders' webs, hippopotamus' oil, and toads' eyelids!
- The Aztec Indians of Mexico maintained royal gardens of medicinal plants.
- The Native Americans of North America used wild ginger for a cold or stomachache and cascara for constipation, a drug that is still in use today.

During the Middle Ages, the healer in a village or the tribal chief prescribed substances as drugs. These ranged from addictive substances such as opium from the poppy plant to a toxic substance such as mercury to cure worms. At that time, little was known about the anatomy and physiology of the human body. The use of ingredients was often based on lore and superstition. Some ingredients had therapeutic value, while others did not or were actually harmful.

Drugs from 1700 to 1900

During the 1700s and 1800s, the drugs being sold often contained addictive ingredients that were not mentioned on the label, such as opium, heroin, or cocaine. One newspaper advertisement in 1885 said, "Cocaine Toothache Drops. Instantaneous Cure! Price 15 cents." It was not known at that time that cocaine was highly addictive. Children as well as adults became addicted because consumer warnings against this and other addictive or lethal drugs did not yet exist.

Apothecary comes from a Greek word that means "storehouse (of dried plants and herbs)." The first apothecary shop was established in the United States in 1729, the first hospital-based pharmacy in 1751, and the first drug store with a registered pharmacist in 1823. Apothecaries offered a broad range of drugs that were prepared according to standard recipes that involved drying, crushing, and combining substances from plants, animals, and minerals—a process known as ***compounding*** (see Figure 1-5). As drug knowledge increased, there was a need for a comprehensive list of all drugs and their ingredients. This list was known as a *pharmacopeia*. *The United States Pharmacopeia* was first published in 1820.

Figure 1-5 Compounding.
A mortar and pestle were used to crush several dried substances to create a drug.
Source: Nataliia Melnychuk/Shutterstock

It was not until the 1800s that chemists developed techniques to extract and isolate pure substances. The isolation of the drug morphine from opium marked the beginning of modern drug therapy using chemically pure ingredients. In the early 1900s, the extraction and preparation of drugs was still a time-consuming process that utilized test tubes, filters, and Bunsen burners. Pharmacists at that time actually prepared the drugs they dispensed. Daily, they made milk of magnesia, paregoric, syrup bases for liquid medicines, and hand-rolled suppositories. Much has changed since then! Most drugs are now completely synthetic, but some natural substances have undergone chemical modification in order to create new drugs with improved therapeutic effects. In addition, pharmacists usually do not prepare drugs, but instead dispense them and provide patient information and education.

TODAY'S PHARMACY

Today, for the most part, the word *apothecary* has been replaced by the word *pharmacy*. ***Pharmacy*** comes from a Greek word that means "preparer of drugs." Today, a pharmacy is a site where drugs are received from a drug company, stored as inventory, and then dispensed to patients or consumers to fill an order or a prescription.

- A hospital pharmacy (also known as an *inpatient pharmacy*) is located within a hospital. This is a central pharmacy, but large hospitals can also have smaller *satellite pharmacies* in different locations throughout the hospital to provide quick access to drugs. A hospital only dispenses drugs to patients who are being treated in the hospital, not to the general public. A hospital pharmacy provides all the drugs a patient needs while in the hospital, as well as a small supply at the time of discharge.
- An outpatient pharmacy (also known as an *ambulatory pharmacy*) is located in an ambulatory clinic or in a group of physicians' offices within the hospital complex.
- Skilled nursing facilities and long-term care facilities do not have in-house pharmacies; instead, a pharmacy supply company delivers their drugs, which are kept at each nurses' station or patient care unit.
- A community pharmacy is a retail drug store or area in a grocery store that dispenses drugs to persons who have a prescription. These pharmacies also sell over-the-counter drugs, medical supplies, medical equipment, and nonmedical items. Some pharmacies still do compounding of drugs (see ■ Figure 1-6).
- An online pharmacy provides a convenient service to patients who want to fill a prescription over the Internet and have the medication shipped to them. The National Association of Boards of Pharmacy (NABP) accredits online pharmacies. Amazon's Pill Pack is a full-service online pharmacy that ships a two-week supply of prescription drugs packaged in small Pill Packs preprinted with the day and time when the medications should be taken.

Figure 1-6 Compounding pharmacy.

These pharmacists are using mortars and pestles to crush ingredients that will be mixed together, formed into a drug, and packaged for the patient. Compounding is done, for example, to flavor a medication for administration to a child; create drugs for patients who may be allergic to the ingredients of gluten, lactose, or dyes; or change the form of a drug for patients who cannot swallow tablets.

Source: Terry Vine/Getty Images

Technology in the Pharmacy

Technology plays a prominent role in a pharmacy today. **E-prescribing** is the computerized creation and transmission of a prescription from a healthcare provider to the pharmacy; this process no longer involves a handwritten prescription or faxing. Pharmacy informatics is the use of a computerized database to store drug information and automate its retrieval. Barcode technology is used to make sure the right drug is being given to the patient. Robots are used to fill prescriptions. An automated dispensing system in a hospital can dispense hundreds of drugs from different drug manufacturers. Outpatient pharmacies that are part of a corporate pharmacy chain are linked together through a common computer system so that a patient can have a prescription refilled quickly at any of the many pharmacies in that chain. Many pharmacies have a drive-through window for pickup. Pharmacists have also become involved in monitoring and communicating with patients after a prescription has been filled. Medication dispensers in the patient's home let the pharmacy know if the patient is taking the prescribed medication at the right time.

THE PHARMACIST AND PHARMACY TECHNICIAN

A **pharmacist** is a healthcare professional who manages a pharmacy and dispenses medications. Pharmacists work in all types of pharmacies. Pharmacists who work in a community pharmacy often provide advice and information about diseases and drugs and personal assistance to customers (see Figure 1-7). Many pharmacies have a room for consultation and counseling. Medication therapy management is a service provided by pharmacists to help patients understand the drugs being used to treat their conditions. This service is a patient-centered approach that helps prevent medication errors and improves patient compliance.

A **pharmacy technician** is an assistant who performs pharmacy-related tasks under the direction of a pharmacist. These include filling prescriptions, labeling prescription bottles, stocking shelves, and giving instructions to customers (see Figure 1-8). Each pharmacy is required to be licensed by the state. A pharmacist must have a Doctor of Pharmacy degree (PharmD) as well as state licensure; in most states, a pharmacy technician must pass a national certification examination and be licensed by that state.

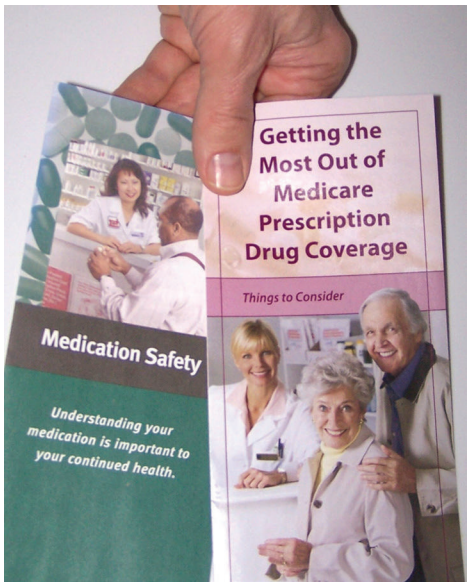


Figure 1-7 Drug information.
Pharmacists provide free pamphlets to customers and explain how to take drugs safely.
Source: Susan Turley

Figure 1-8 The pharmacy technician.
The pharmacy technician works under the direction of the pharmacist and directs all drug-related questions to the pharmacist. The pharmacist is responsible for checking the accuracy of the pharmacy technician's work.
Source: Dragon Images/Shutterstock

HISTORICAL NOTES

Benjamin Franklin founded the first hospital pharmacy. The infamous traitor Benedict Arnold worked as a pharmacist. Author Agatha Christie once worked as a hospital pharmacist. Vice President Hubert Humphrey had a pharmacy license and worked in his father's drug store.

DRUG DISCOVERY AND CREATION

Drugs are discovered or created in several ways. Many drugs in use today were originally from plants, animals, or minerals. Now, drugs are also created by molecular or genetic manipulation.

Drugs Derived from Plants

Plants have been utilized as drugs for centuries. The medicinal use of the foxglove plant was noted in the 13th century (see Figure 1-9). A derivative of this plant is used to make the drug digoxin (Lanoxin), which is still used today to treat congestive heart failure. The juice of berries from the belladonna plant was used in the 16th century by women to enlarge their pupils and brighten their eyes. *Belladonna* means "beautiful lady" in Italian. It is the original source of two drugs that are still used today—atropine and scopolamine. Atropine enlarges the pupils for eye examinations. Scopolamine prevents motion sickness. The poppy plant (see Figure 1-10) has been cultivated for centuries to produce the addicting drug opium; it is the source of the illegal street drug heroin and the legal prescription drug morphine to treat severe pain.

Figure 1-9 Foxglove plant.
This beautiful wild flowering plant is foxglove, but its scientific name is *Digitalis lanata* because its flowers resemble finger-like digits. The drug digitalis from this plant was discovered in 1741 by Dr. William Withering, an English physician, who used it to treat congestive heart failure. The drug digoxin (Lanoxin), which is from the original digitalis drug, still has this same use.
Source: Susan Turley

Figure 1-10 Opium poppy.
Sap from the blue-green seed heads of the pink flower of the opium poppy was first used in 1806 to produce morphine, an opioid drug that is still used to treat severe pain.
Source: Pics-xl/Shutterstock

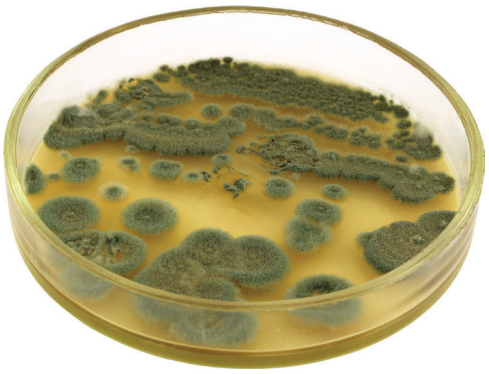


Figure 1-11 Penicillin mold.
The antibiotic drug penicillin was from this type of blue-green mold.
Source: Satirus/Shutterstock

Colchicine was derived from the autumn crocus known as *Colchicum autumnale.* It was used in the 6th century to treat gout and is still used for that today. Bark from the cinchona tree has been used to treat malaria since the 1600s, and the purified drug today is quinine. The antidiabetic drug metformin was originally developed from the French lilac plant. The first antibiotic drug penicillin was derived from the mold *Penicillium chrysogenum* (see Figure 1-11). The fungus from which cephalosporin antibiotic drugs were derived was from a sewer outlet in Sardinia. The anticancer drug vincristine came from the leaves of the periwinkle plant, and the anticancer drug paclitaxel was from the needles of the Pacific yew tree. Aspirin originally came from the bark of the willow tree. Some natural vitamin C dietary supplements are still derived from rose hips, the rounded seed of a rose plant. The drug capsaicin (Zostrix) originated from the capsaicin or hot pepper plant (see Figure 1-12). The drug galantamine (Razadyne), for Alzheimer disease, originated from the bulb of the daffodil flower. Also, many of the gums, oils, and bases in which drugs are dissolved come from plant sources.

Drugs Derived from Animals

Thyroid supplement drugs contain dried (desiccated) thyroid gland tissue from pigs. This is used to treat patients with the endocrine disease of hypothyroidism. The antituberculosis drug streptomycin was developed from the stomach contents of a sick chicken. The drug ziconotide (Prialt) that is used to treat severe, chronic pain is the same chemical substance as the venom of the cone snail that lives on coral reefs in the Philippines. The drug Premarin, an estrogen (female hormone) replacement that is used to relieve the symptoms of menopause, was derived from *pre*gnant *mar*es' ur*in*e, and the trade name is formed from letters from that phrase. In the past, the only source of insulin to treat diabetes mellitus was from ground-up beef or pork pancreas. Today, insulin to treat type 1 diabetes mellitus

Figure 1-12 Capsaicin.
The topical drug capsaicin (Zostrix) is available as a cream, gel, or lotion. It inhibits the transmission of nerve impulses in patients with nerve pain from diabetes mellitus or from the skin infection of shingles.
Source: Susan Turley

Figure 1-13 Gila monster.
This large, poisonous lizard lives in the southwestern United States and Mexico. Its saliva is the source of the drug exenatide (Byetta).
Source: fivespots/Shutterstock

is no longer from animal sources. However, a noninsulin drug used to treat type 2 diabetes mellitus—the drug exenatide (Byetta)—was developed from an unusual animal source—the saliva of the Gila monster (see Figure 1-13). Fish oil that contains omega-3 fatty acids is available as an over-the-counter dietary supplement.

Drugs Derived from Minerals

The mineral gold is used in the gold compound drug auranofin (Ridaura) to treat rheumatoid arthritis. The chemical symbol for gold *Au* is included in both the generic and trade name drugs. Potassium chloride (Klor-Con) is a prescription drug that is used to treat a low level of potassium in the blood (see Figure 1-14). Topical coal tar drugs (Cutar, Neutrogena T/Gel) that treat psoriasis of the skin are a byproduct of coal mining.

Minerals, such as calcium and iron, are available as individual dietary supplements, and trace minerals, such as copper, magnesium, selenium, and zinc, are included in many multivitamin supplements. Centrum multivitamins use the advertising slogan "From A to Zinc" to show that they contain vitamins and minerals alphabetically from vitamin A through the mineral zinc (see Figure 1-15).

Figure 1-14 Klor-Con.
This trade name drug contains the minerals potassium and chloride.
Source: Susan Turley

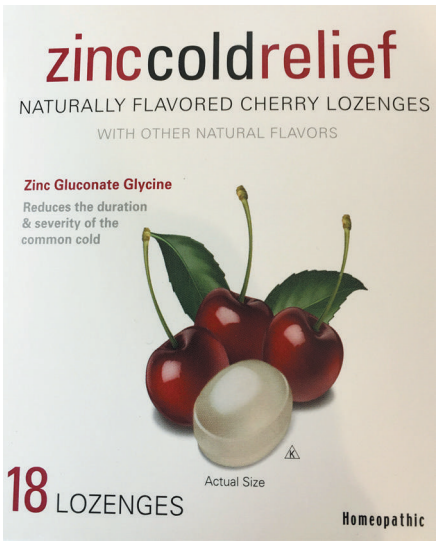


Figure 1-15
Zinc lozenges are available over-the-counter to treat the cough and sore throat of a common cold.
Source: Susan Turley

Drugs Derived from Molecular or Genetic Manipulation

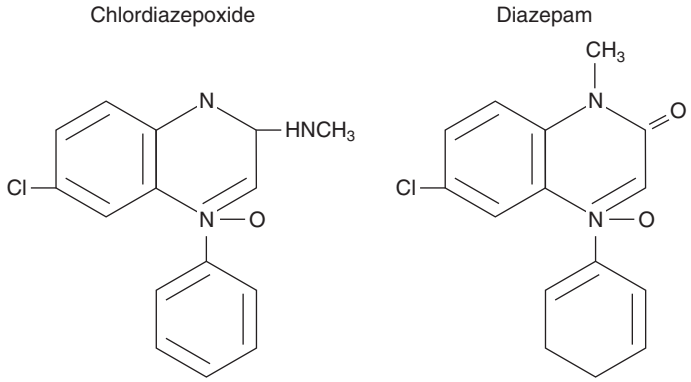
Today, drugs are derived through molecular or genetic modification or manipulation.

Molecular Manipulation

Molecular manipulation involves changing the molecular structure of a drug. In the past, this was a slow process that involved trial and error, using molecular models made of wood and wire. Today, a computer can display the structure of any chemical or drug from thousands in its database. Using computer-aided design, researchers can rotate a molecule in three dimensions to see if its particular arrangement of atoms could be the "key" that can fit into a receptor on a cell membrane and create a drug effect. When researchers want to know why different drugs seem to produce a similar effect, they can view those molecular structures on the computer. An **isomer** is a molecule that is similar to another molecule, with the same number and types of atoms, but differs in the arrangement and position of those atoms and their chemical bonds. Dextrorotary drugs (such as dextromethorphan, which is used to relieve coughing) and levorotary drugs (such as levothyroxine, which is a replacement for thyroid hormone) are examples of mirror-image isomers whose molecular structures were rotated to the right (*dextr/o-* means "right") or to the left (*lev/o-* means "left") as compared to the original molecule. Other types of molecular manipulation create drugs that are similar in structure but are not isomers (see ■ Figure 1-16). With only very slight molecular modifications, a chemical can be changed significantly in ways that influence how it acts as a drug—its absorption, metabolism, half-life, therapeutic effects, or side effects. The computer can help identify possible new drugs but can also identify those chemicals that would probably not be successful in treating a particular disease before time and money are invested in clinical drug trials.

Here are some other examples of drugs created by molecular manipulation.

- When the antibiotic drug penicillin was derived from mold, one of its drawbacks was that it could not be taken orally because it was destroyed by stomach acid. Researchers added molecules to its chemical structure and created the semi-synthetic antibiotic drug ampicillin, which can be taken orally.
- A popular antihistamine drug that caused a side effect of heart problems was taken off the market. Its molecular structure was then modified to produce the antihistamine fexofenadine (Allegra), which did not affect the heart.



■ **Figure 1-16 Manipulation of the molecular structure.**

The drug chlordiazepoxide, created in 1957, was used to treat anxiety. Its molecular structure was then manipulated to create a second antianxiety drug—diazepam (Valium). These drugs are still in use today.

Source: Pearson Education

- The drug transplatin, a trans-isomer drug, was originally created to treat cancer, but it was not effective. Trans-isomer drugs have the functional part of the drug on one side of a carbon chain; cis-isomer drugs have the functional part on the other side of the carbon chain. Molecular manipulation of the original trans-isomer drug created the cis-isomer drug cisplatin, which is still used to treat bladder, ovarian, and testicular cancer.

Genetic Manipulation

HISTORICAL NOTES

In 1962, researchers Watson and Crick identified the double-helix structure of DNA in the cell's nucleus. In 2000, the deciphering of the human genome opened up the possibility of using cells and genes as drug therapy.

Pharmacogenetics is the knowledge of how the genetic makeup of different people affects their responses to drugs. Pharmacogenomics uses information from the patient's personal human genome (see ■ Figure 1-17) to customize a drug treatment that matches the patient's genetic profile. The Connectivity Map is a computer database that shows connections between a person's genes, diseases, and drugs.

Recombinant DNA (rDNA) technology is a process that uses enzymes to cut apart segments of DNA. Gene cloning produces a large supply of DNA segments. These segments are then transferred from the host organism into a recipient organism. For example, if the DNA segment from the host produces insulin, then the recipient organism will produce insulin as well. Human insulin (Humulin) became the first rDNA drug approved by the FDA (see ■ Figure 1-18). Other drugs created through rDNA technology include erythropoietin, human growth factor, and clotting factors.

Monoclonal antibody drugs are used to treat a variety of diseases. This technology, which was created in 1986, identifies a specific antigen produced by a cancer cell. That antigen is injected into a mouse. The mouse's B lymphocytes then begin to produce antibodies against that antigen. Then the cancer cell and the mouse's B lymphocyte are fused, producing a hybrid cell that grows rapidly (like a cancer cell) but also produces antibodies against that particular type of cancer. The hybrid cells are then grown in enough quantity to make a drug. This same technology is also used to produce a monoclonal antibody drug that is effective against a substance in a person's body that is being produced in excess and is causing disease. This category of generic drugs has a common suffix of *-mab*, for *monoclonal antibody*.

Gene replacement therapy involves creating a person's missing or nonfunctional gene in a laboratory. The created gene is then inserted into a virus that does not cause disease in humans. As a drug, that virus is administered intravenously, carrying the new gene into the nucleus of the cells, where it directs the cells to make the substance that the person's nonfunctioning gene normally produced.

■ **Figure 1-17 DNA molecule.**
Each DNA molecule contains 30,000 genes in the shape of a double helix. In 2000, researchers for the Human Genome Project mapped all 3.2 billion parts of the human genome.
Source: jijomathaidesigners/Shutterstock

Figure 1-18 Humulin insulin.

Humulin (human insulin) was the first drug created by recombinant DNA technology. In 1982, researchers spliced a segment of human DNA into the chromosome of a bacterium. When the bacterium divided, it replicated the human DNA, including the human insulin gene. This resulted in bacteria making human insulin. Note that the insulin drug box indicates that rDNA (recombinant DNA) is the origin of this drug.

Source: Susan Turley

DRUG NAMES

From the moment of its discovery or creation, every drug has a **chemical name** that is assigned by the International Union of Pure and Applied Chemistry (IUPAC). The chemical name accurately describes its molecular structure and distinguishes it from all other chemicals. The chemical name is commonly used by drug companies and researchers but is too lengthy and complicated for everyday use by healthcare professionals and the public.

DID YOU KNOW?

Drug names are more complicated than medical words.

Source: Susan Turley

Aspirin has the trade name or brand name of Bayer, a generic name of acetylsalicylic acid (ASA), but a chemical name of 2-acetoxybenzoic acid, and a molecular formula of $CH_9H_8O_4$.

The drug company, together with the United States Adopted Names (USAN) Council, determines what the drug's **generic name** will be. A chemical name only has one generic drug name related to it. The generic name may consist of two

words, but this text only mentions the first word, which is recognized by all health-care providers. Examples:

- The generic name diltiazem has a full name of diltiazem hydrochloride.
- The generic name zolpidem has a full name of zolpidem tartrate.
- The generic name phenytoin has a full generic name of phenytoin sodium.

When the FDA gives the final approval to a generic drug, the drug company creates a **trade name** (which is the drug's brand name or proprietary name). The word *proprietary* is a business and legal concept that shows ownership. On the drug package and in drug advertisements, the trade name often has the trademark symbol (™) after it or the registered trademark symbol (®). The drug's trade name is a marketing strategy that is promoted in drug advertisements in magazines and on television and the Internet. The trade name is designed to be easy for patients to pronounce and remember. If possible, it may even suggest how the drug is used.

LOOK CLOSER

Throughout this text, lists of drugs will include the generic name, related trade names, and a see-and-say pronunciation of the generic name. This pronunciation guide is straightforward and easy to use. The syllables are separated by hyphens, and the accented syllable is in all capital letters—as seen in this example.

Drug Name	Pronunciation
atenolol (Tenormin)	[ah-TEN-oh-lawl]
metoprolol (Kapspargo Sprinkle, Lopressor, Toprol XL)	[meh-TOH-proh-lawl]
nadolol (Corgard)	[NAD-oh-lawl]
propranolol (Inderal LA, Inderal XL, InnoPran XL)	[proh-PRAN-oh-lawl]

A drug's generic name begins with a lowercase letter. The trade name is capitalized. All of these drugs belong to the drug category of beta-blockers. The suffix *-olol* is common to generic drugs in the beta-blocker category, and their generic drug pronunciations are similar.

This is true for many other categories of generic drugs. For example, generic drugs that belong to the penicillin category of antibiotic drugs have a common suffix of *–cillin*: amoxicillin, ampicillin, nafcillin, oxacillin, penicillin.

FOCUS ON HEALTH CARE

The accurate spelling of generic and trade name drugs is critical to providing quality health care. Generic drug names tend to be long and have many syllables that require careful attention to spelling. Trade name drugs can be difficult to spell because drug companies are not required to follow any standard spellings. For example, the trade name drug Rythmol is used to treat an abnormal rhythm of the heart. The trade name drug Azmacort is used to treat asthma. Notice the differences in spellings.

However, in some cases, the trade name drug can provide some important information.

1. The trade name indicates what disease or symptom the drug is used to treat.

Mucinex	removes mucus from the lungs
Pepcid	treats peptic ulcers

2. The trade name indicates what part of the body is being treated.

Boniva	strengthens the bones
Bronkaid	dilates the bronchi in the lungs
NasalCrom	treats nasal allergies

3. The trade name simplifies but keeps some recognizable parts of the generic drug name.

Cipro	ciprofloxacin (see ■ Figure 1-19)
Haldol	haloperidol
Humulin	human recombinant DNA insulin
Sudafed	pseudoephedrine

4. The trade name indicates the ingredients or source of the drug.

Ferro-Sequels	iron (Fe)
Premarin	from pregnant mares' urine

5. The trade name indicates the therapeutic effect of the drug.

Elimite	eliminates mites (scabies)
Glucotrol	controls the level of glucose (blood sugar)
Lipitor	decreases the level of blood lipids
Restoril	restores rest/sleep to treat insomnia

6. The trade name indicates how often the drug is to be taken.

Lithobid	lithium drug taken twice a day for bipolar disorder (*b.i.d*. is a Latin abbreviation that means *twice a day*)
Nitro-Bid	nitroglycerin drug taken twice a day to treat angina

7. The trade name indicates the duration of the drug's effect.

Cardizem CD	controlled-delivery (CD) drug for hypertension
Ritalin LA	long-acting (LA) drug for hyperactivity
Slow Fe	slow-release iron (Fe) supplement

8. The trade name indicates the strength of the drug.

Bactrim DS	double-strength (DS) dose of the antibiotic drug
Cortizone-5	0.5% hydrocortisone anti-inflammatory topical drug

9. The trade name indicates the route of administration.

Nasonex	nasal spray for seasonal allergies
Transderm Scop	transdermal skin patch for motion sickness

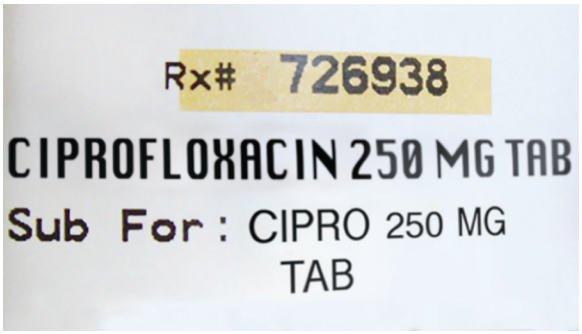


Figure 1-19 Ciprofloxacin drug label.
This prescription drug label is for the generic drug ciprofloxacin, which is a less expensive substitute for the trade name drug Cipro.
Source: Susan Turley

TYPES OF DRUGS

There are several types of drugs: prescription drugs, Schedule drugs, over-the-counter drugs, dietary supplements, orphan drugs, and designer drugs.

Prescription Drugs

Prescription drugs were first defined by law in 1951 as those drugs that can only be given to persons who are under the care of a licensed healthcare provider, such as a physician, physician's assistant, nurse practitioner, dentist, and so on. Prescription drugs can only be obtained with a prescription (handwritten, faxed, submitted electronically, etc.). The symbol ***Rx*** comes from the Latin word *recipere*, which means "to take or receive." The phrase "Rx only" must appear on the drug packaging from the drug manufacturer. The federal **Food and Drug Administration (FDA)** regulates prescription drugs.

DRUG CONTROVERSY

According to the FDA, it is illegal to have a prescription filled by a Canadian pharmacy and shipped to the United States. However, Americans continue to do this because Canada has price restrictions and their prescription drugs cost less.

Schedule Drugs

A **Schedule drug** is a prescription drug that has the potential for abuse or addiction. This means that this drug requires additional safeguards when it is prescribed. Drugs with the potential for abuse and dependence were first defined and regulated by the Harrison Narcotics Act of 1914, which called them *narcotics*. This Act was replaced in 1970 by the Drug Abuse Prevention and Control Act, which included the Controlled Substances Act. It established the Drug Enforcement Administration (DEA) to regulate the manufacturing and dispensing of addictive drugs. The Act divides potentially addictive drugs into five categories or Schedules based on their potential for physical and psychological dependence. These drugs are known as ***Schedule drugs*** or ***controlled substances***. The labeling and packaging of a controlled substance and all of its advertisements must clearly show the drug's assigned Schedule (see Figure 1-20). The manufacturing, storage, dispensing, and disposal of controlled substances are strictly regulated by both federal and state laws.

Figure 1-20 Controlled substance symbol.
The capital letter *C* stands for *controlled substance*. The Roman numeral inside it indicates the assigned Schedule. It is important to remember that a *C* with the Roman numeral *IV* inside it does not mean that the drug is given intravenously (by the IV route). It means that the drug is a Schedule IV (4) controlled substance.
Source: Pearson Education

Schedule I

- Extremely high potential for abuse and addiction
- No currently approved federal medical use; possession is a felony
- Not available under any circumstances, even with a prescription
- Examples: heroin, LSD, marijuana (see the Drug Controversy box), methaqualone, peyote, "Ecstasy"

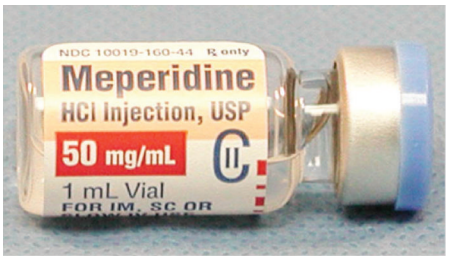


Figure 1-21 Meperidine.
Meperidine (and its trade name drug Demerol) are Schedule II drugs that are often used to treat severe pain.
Source: Susan Turley

Schedule II

- High potential for abuse and addiction
- Currently approved medical uses
- Requires an official prescription form
- Severe physical and psychological dependence may result
- Examples: amphetamine (Dexedrine, Adderall), cocaine (topical), codeine, fentanyl (Duragesic), hydrocodone, hydromorphone (Dilaudid), meperidine (Demerol) (see Figure 1-21), methadone, methamphetamine (Desoxyn), methylphenidate (Ritalin), morphine, oxycodone (OxyContin), pentobarbital (Nembutal), Percocet

Schedule III

- Less potential for abuse than Schedule II drugs
- Currently approved medical uses
- Moderate physical and psychological dependence may result
- Examples: dronabinol (Marinol), paregoric, oxandrolone (anabolic steroid), testosterone (Androderm)

Schedule IV

- Less potential for abuse and addiction than Schedule III drugs
- Currently approved medical uses
- Limited-to-moderate physical and psychological dependence may result
- Examples: alprazolam (Xanax), carisoprodol (Soma), diazepam (Valium), eszopiclone (Lunesta), lorazepam (Ativan), phenobarbital (see Figure 1-22), tramadol (Ultram), zolpidem (Ambien)

Schedule V

- Limited potential for abuse
- Currently approved medical uses
- Examples: cough syrup with codeine, difenoxin (Motofen), diphenoxylate (Lomotil), pregabalin (Lyrica) (see Figure 1-23)

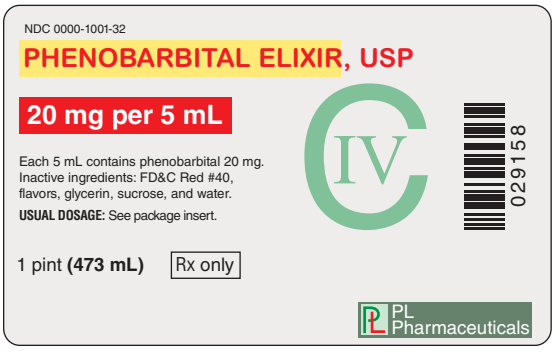


Figure 1-22 Phenobarbital.
This drug label shows that generic phenobarbital is a Schedule IV drug.
Source: Pearson Education

Figure 1-23 Lyrica.
This drug bottle shows that the generic drug pregabalin and its trade name Lyrica are Schedule V drugs.
Source: Susan Turley

DRUG CONTROVERSY

The federal government classifies marijuana as a Schedule I drug. Many states have passed laws to either legalize the use of marijuana or decriminalize its use for medical purposes, and farmers in those states are growing medical marijuana plants. However, those state laws still run contrary to the federal law that bans its use.

Source: Eric Limon/123RF

LOOK CLOSER

The body has receptors that bind with two substances in marijuana: tetrahydrocannabinol (THC) and cannabidiol (CBD). THC causes the "high" associated with the use of marijuana. CBD relieves pain and decreases inflammation. Studies have found that medical marijuana is helpful in treating patients with pain, muscle spasticity, HIV/AIDS, hepatitis, multiple sclerosis, Parkinson disease, glaucoma, Crohn disease, and the nausea and vomiting associated with chemotherapy drugs. The drug dronabinol (Marinol), a Schedule II drug, is a synthetic drug whose action is similar to marijuana. It is currently approved to treat the nausea and vomiting from chemotherapy drugs for cancer and to stimulate the appetite in patients with HIV/AIDS.

DID YOU KNOW?

In 1996, the Drug-Induced Rape Prevention and Punishment Act made it illegal to give a controlled substance to any person without that person's knowledge. This Act specifically targeted the illegal use of a "date-rape drug" to make a person unconscious before sexually assaulting him or her.

Figure 1-24 Prilosec OTC.
Prilosec is a prescription drug, but Prilosec OTC is an over-the-counter drug, indicated by "OTC" on the drug box. This drug is used to treat heartburn.
Source: Susan Turley

Over-the-Counter Drugs

The FDA also regulates **over-the-counter (OTC) drugs**. An OTC drug is defined as one that can be purchased without a prescription and is generally considered safe for consumers to use if the label's directions are followed carefully and all warnings are heeded (see Figure 1-24). The packaging for an over-the-counter drug may or may not say "OTC."

The manufacturer of a prescription drug can petition the FDA to change the status to that of an OTC drug. The topical drug hydrocortisone became the first prescription drug approved for OTC sales, and many other drugs followed. The OTC drug is the same as the original prescription drug but is usually at a lower dosage or strength. The OTC Drug Advisory Committee assists the FDA in reviewing prescription drugs and determining which ones are safe and appropriate for OTC use. A prescription drug can be reclassified as an OTC drug if the following criteria are met:

1. The indication for the drug's OTC use is similar to its use as a prescription drug.
2. The patient can easily diagnose and monitor his or her own condition when using the OTC drug.
3. The OTC drug has a low rate of side effects/toxicity and a low potential for abuse.
4. Use of the OTC drug does not require the patient to have any special monitoring or undergo laboratory tests.

DRUG CONTROVERSY

Supporters of the reclassification of prescription drugs to an OTC status claim that this will help lower the prices of drugs and allow quick treatment and fewer visits for prescription refills. Opponents of reclassification argue that consumers will actually pay more because health insurance plans do not cover OTC drugs. Some concerns have been raised as to whether the excessive use of OTC drugs could increase the number of adverse drug–drug interactions. Of greater concern is consumers who might treat a serious illness with an OTC drug instead of visiting a healthcare provider for appropriate treatment with a prescription drug.

Dietary Supplements

In 1994, the Dietary Supplements and Health Education Act was passed. This legislation allowed the FDA to set up guidelines for herbal products and dietary supplements. Although the FDA does not regulate these products and they are available without a prescription, the drug companies are now liable for any claims against their products. According to this Act, a **dietary supplement** must contain one or a combination of the following substances:

- Vitamin
- Mineral

- Herb or plant-based substance
- Amino acid
- Concentrate, metabolite, constituent, or extract.

Dietary supplements are manufactured in tablets and capsules that resemble prescription and over-the-counter drugs. However, their drug packages must clearly state "Dietary Supplement."

Orphan Drugs

The Orphan Drug Act was passed in 1983 to facilitate the development of new drugs used to treat rare diseases (those that affect fewer than 200,000 people in the United States). Normally, drug companies are reluctant to spend large amounts of time and money to research and test a drug if it has a limited market and potential for profit. The Orphan Drug Act provides financial incentives to a drug company to develop an **orphan drug**, including federal grants, a tax credit, and a streamlined process for obtaining FDA approval for the drug.

Designer Drugs

Designer drugs are synthesized in an unauthorized laboratory for the purpose of creating a substance with a chemical structure that is similar enough to a Schedule I or II drug that it produces the same effect and can be sold illegally for a profit. The new drug is known as an ***analog***. This process is done to avoid prosecution under existing drug laws. The Federal Analogue Act of 1986 stated that any substance that was similar to a Schedule I or II drug would be treated as if it were a Schedule drug. This made it easier to prosecute those who produced and sold recreational psychoactive designer drugs. However, as quickly as a designer drug was added to the list of illegal drugs, that drug underwent yet another chemical modification in order to create a slightly different drug that was not on the illegal list.

CHAPTER REVIEW EXERCISES

Quiz Yourself

1. Describe the language origin and meaning of the following words.
   a. pharmacology
   b. medicine
   c. drug
2. Describe the three medical uses for drugs and give an example for each one.
3. How are the words *drug* and *medicine* the same? How are they different?
4. Give the meaning of these symbols and abbreviations: CD, DEA, DS, FDA, LA, OTC, Rx, C^{IV}.
5. Give the name of a drug and its current use that originated from the natural sources listed below.

Natural Source	Drug and Current Use
a. foxglove plant	_____
b. venom of the cone snail	_____
c. rose hips	_____
d. poppy	_____

Natural Source	Drug and Current Use
e. mold	_____
f. periwinkle	_____
g. gold	_____
h. coal tar	_____
i. hot pepper plant	_____
j. saliva of the Gila monster	_____
k. pregnant mares' urine	_____
l. willow tree bark	_____
m. French lilac	_____
n. Pacific yew tree	_____
o. daffodil flower bulb	_____

6. Name three ancient "drugs" whose use seems silly or outrageous to us today.
7. Is it possible that some of the "drugs" you named for Question 6 could be found to have some therapeutic value in the future? State the reason for your answer.
8. In the 1700s and 1800s, drugs frequently contained addictive ingredients not listed on the label. Name two such ingredients.
9. What federal agency regulates prescription drugs?
10. Define the following: prescription drug, over-the-counter drug, Schedule drug, designer drug.
11. Describe how the Controlled Substances Act categorizes drugs of potential abuse.
12. What is the purpose of the Orphan Drug Act? What three incentives does it offer drug companies to develop an orphan drug?
13. What words on a drug label tell you that it is a prescription drug?
14. Give an example of a dextrorotary drug and of a levorotary drug.
15. Define these words: pharmacy, pharmacogenetics, pharmacogenomics, recombinant DNA technology.
16. Describe the role and responsibilities of a pharmacy technician.
17. What two other phrases mean the same thing as "trade name"?

True or False

1. An OTC drug has a low rate of side effects but a high potential for abuse. _____
2. Pharmacology is closely connected to botany, chemistry, and genetics. _____
3. Vaccination is an example of the diagnostic use of a drug. _____
4. A pharmacopeia is a comprehensive list of all drugs and their ingredients. _____

Fill in the Blank

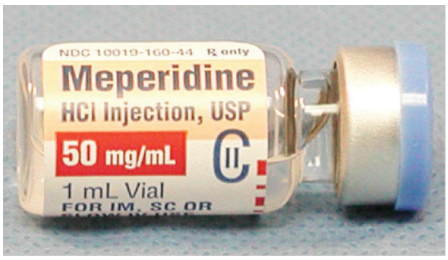
1. The process of drying, crushing, and combining substances to make a drug is known as _____.
2. An outpatient pharmacy is also known as a/an _____ pharmacy.
3. The abbreviation for a pharmacist's Doctor of Pharmacy degree is _____.
4. A/An _____ is a molecule that has the same number and types of atoms as another molecule but in a different arrangement.

5. The drug name Nitro-Bid indicates it is to be taken _____ a day.
6. Originally in 1914, a drug with the potential for abuse and dependence was called a/an _____.
7. The DEA and federal law say marijuana is a Schedule _____ drug.
8. A _____ drug is produced in an illegal laboratory and is similar but not identical to a Schedule I or II drug.

Clinical Applications

1. Read the labels and boxes of these drugs carefully. Indicate whether each is a prescription drug, an over-the-counter drug, a dietary supplement, or a Schedule drug (see Figure 1-25). If it is a Schedule drug, indicate to which schedule it belongs._____

a. _____
b. _____
c. _____
d. _____
e. _____
f. _____
g. _____
h. _____
i. _____
j. _____
k. _____
l. _____
m. _____
n. _____
o. _____
p. _____
q. _____
r. _____



(a)

(b)

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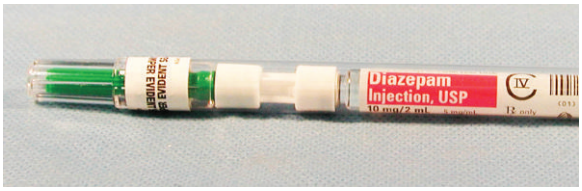

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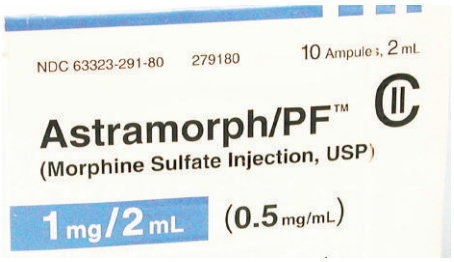
(e)

Figure 1-25 Prescription, OTC, dietary supplements, and Schedule drugs.
Source: Susan Turley

(f)



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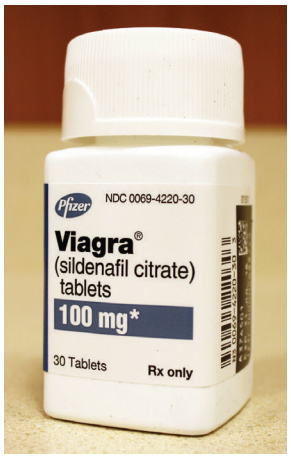

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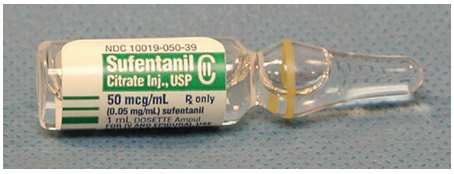

(j)

(k)

(l)

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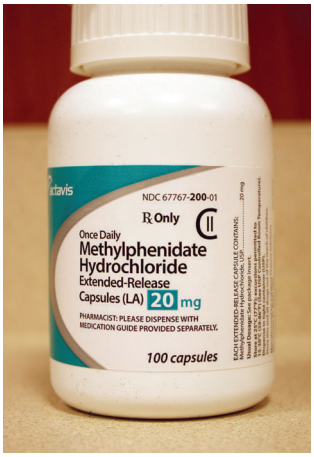
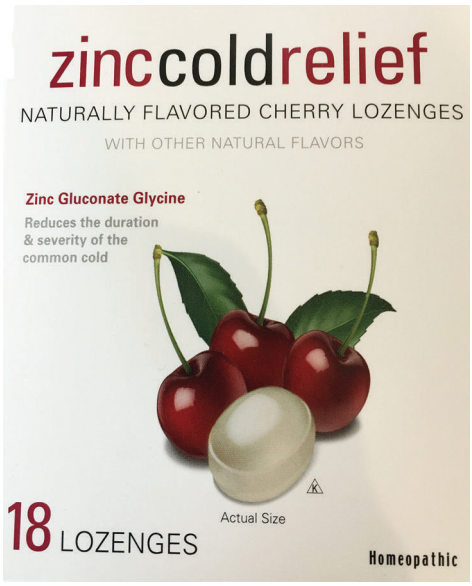


(n)

Figure 1-25 Prescription, OTC, dietary supplements, and Schedule drugs (*continued*).

Source: Susan Turley

(o)



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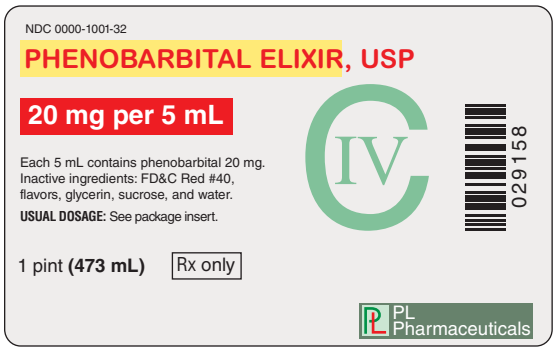


(q)

(r)

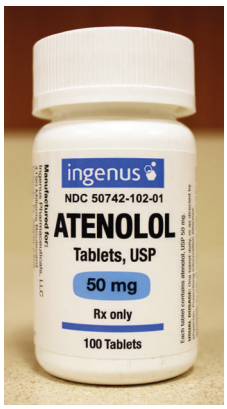
■ **Figure 1-25 Prescription, OTC, dietary supplements, and Schedule drugs (*continued*).**
Source: Susan Turley; Pearson Education

2. How was this drug created? See ■ Figure 1-26.

■ **Figure 1-26 Humulin R drug box.**
Source: Susan Turley

3. Read the labels and boxes of these drugs carefully (see ■ Figure 1-27). Identify the name of the generic drug and the trade name (if there is one on the drug's label). Lowercase generic drug names, capitalize trade name drugs, and spell all drug names correctly.

(a)



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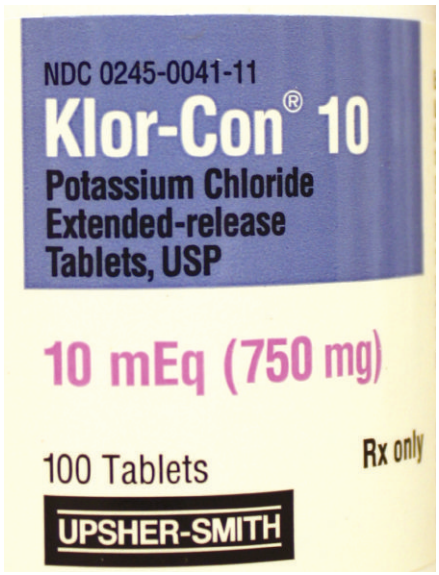

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■ **Figure 1-27 Generic and trade name drugs (*continued*).**
Source: Susan Turley

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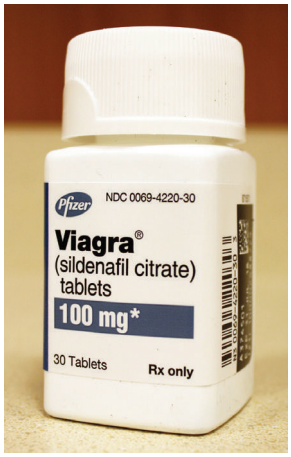


(i)

Figure 1-27 Generic and trade name drugs (*continued*).

Source: Susan Turley

Critical-Thinking Questions

1. Describe in detail how a monoclonal antibody drug is created to treat a specific kind of cancer.
2.
   a. Describe the four criteria that must be met in order for the FDA to allow a prescription drug to be offered as an over-the-counter drug.
   b. In the past, the drug company that manufactures lovastatin, a cholesterol-lowering drug, asked the FDA to allow this drug to be offered as an over-the-counter drug. The FDA OTC Drugs Advisory Committee voted against this request. If you had been on that Committee, would you have voted for or against approving this drug for OTC use? Explain why or why not. (*Hint*: Look up and read about lovastatin in Chapter 7, "Cardiovascular Drugs.")

2

Drug Testing, Drug Forms, and Drug Measurements

Chapter Contents

Learning Objectives

After you study this chapter, you should be able to:

1. Describe the process of chemical and animal testing and clinical drug trials.
2. Name laws and federal agencies that control drug testing and marketing.
3. Name the forms in which drugs are manufactured.
4. Describe seven types of tablets and two types of capsules.
5. Describe the difference between an ointment, a cream, and a lotion.
6. Describe the difference between a solution and a suspension.
7. Describe the metric system of drug measurement.
8. Describe other drug measurements: units, milliequivalents, percentages, and ratios.
9. Define each key word and phrase.
10. Demonstrate mastery of the chapter by completing the Chapter Review Exercises.

KEY WORDS and PHRASES

ampule *37*
aqueous *37*
bioavailability *31*
caplet *34*
clinical drug trials *28*
compassionate use *30*
control group *29*
desiccant *31*
direct-to-consumer marketing *32*
effervescent tablet *34*
elixir *37*
emulsion *39*
enteric-coated tablet *34*
expanded access *30*
Food and Drug Administration *27*
frequency distribution curve *27*
half-life *27*
in vitro testing *27*
in vivo testing *27*
inert ingredients *31*
international unit (IU) *42*
investigational drug *30*
lozenge *34*
metric measurement *41*
milliequivalent (mEq) *42*
National Drug Code *31*
New Drug Application *29*
pharmacodynamics *27*
placebo *29*
scored tablet *34*
therapeutic index *27*
tincture *38*
transdermal patch *40*
troche *34*
unit *42*
vial *37*
viscous *37*

DRUG TESTING AND LEGISLATION

No matter how a drug was originally discovered or designed, it must be thoroughly tested by the drug company before it can be marketed. A drug is tested to determine its effectiveness and safety according to guidelines specified by the **Food and Drug Administration (FDA)**. The development, testing, manufacturing, and eventual marketing of any drug is a time-consuming and expensive process. A drug company may evaluate thousands of different chemicals before finding one that moves successfully through all phases of testing and is finally approved by the FDA for release and marketing. This chapter traces the steps from a newly discovered or designed chemical to final FDA approval and then the clinical use of a drug with its many drug forms and systems of drug measurement.

Chemical and Animal Testing

The chemical analysis of a drug that is done in a laboratory is known as ***in vitro* testing** (*in vitro* is a Latin phrase that means "in glass," as "in test tubes," although chemical analysis is done by computers now). Testing carried out in animals or humans is known as ***in vivo* testing** (*in vivo* is a Latin phrase that means "in living").

The animal phase of drug testing precedes testing on humans. During animal testing, any side effects, toxic effects, addictions, cancerous tumors, or fetal deformities are noted and evaluated (see ■ Figure 2-1). Also during this phase, the **pharmacodynamics** of the drug are determined. This involves describing the mechanism of action by which the drug produces its effects (desired or undesired), based on time and dose. It includes the following calculations.

frequency distribution curve	The number of animals who responded or did not respond to the drug at a particular dose
half-life	The time required for the drug level in the blood to decrease from 100 percent to 50 percent. The half-life can be prolonged when liver or kidney disease decreases either metabolism or excretion of a drug. The shorter a drug's half-life, the more frequently it must be given.
therapeutic index (TI)	The relative margin of safety between the dose that produces a therapeutic effect and the dose that produces a toxic effect in animals. The higher the therapeutic index, the more desirable, as this indicates the drug has a wide margin of safety (see ■ Figure 2-2).

Figure 2-1 ***This drug was tested on 2000 white mice, and they had a ball.***

Source: David W. Harbaugh

DID YOU KNOW?

Animal studies are not always a reliable indicator of how well a drug will perform in humans. For example, penicillin is toxic to some animals, even in small doses, but causes few side effects in humans even at fairly high doses. If animal studies alone had been used to evaluate the potential of penicillin as a drug, it might never have been approved for use in humans.

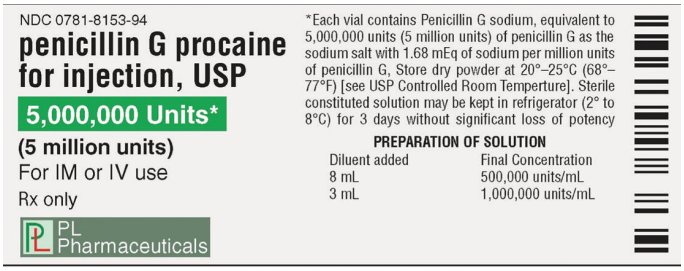


Figure 2-2 Therapeutic index.

Penicillin, with a therapeutic index of more than 100, has a wide margin of safety. The therapeutic index of the drug digoxin (Lanoxin), which is used to treat heart failure, is less than 2. It is not uncommon for patients being treated with digoxin to develop symptoms of toxicity.

Source: Pearson Education

When animal studies are complete, the drug company submits an Investigational New Drug (IND) application to the FDA to request permission to test the drug in humans. The IND contains information from the animal studies, showing that the drug should not pose an undue risk to humans. It also includes information about the chemistry and manufacturing process for the drug. If the FDA approves the IND application, then the drug company can begin human testing at a number of clinical sites.

Clinical Drug Trials

There are three phases of human testing. Phases I, II, and III are collectively known as ***clinical drug trials***.

Phase I. During phase I, about 10 to 100 healthy volunteers are used. It is not uncommon to see "want ads" in the classified section of the newspapers of large

cities, asking for volunteers for phase I clinical drug trials (see ■ Figure 2-3). The trial may specify the gender or age of the volunteer. Volunteers must sign an informed consent, stating that they are aware of the possible risks. During the trial, they are monitored and given medical examinations. Phase I is used to study a safe dose range, evaluate side effects, and establish a final, correct dose. The pharmacokinetics of the drug (movement of the drug through the body and its absorption, distribution, metabolism, and excretion) are also studied. In 1993, the FDA issued guidelines that clinical trials should also address the issue of gender: how a drug acts in both men and women. Phase I testing of a new drug usually lasts for 1½ years.

Phase II. During this phase, the drug is given on an experimental basis to 50 to 500 patients who actually have the disease that the drug is intended to treat. This is done to determine the extent of its therapeutic effect. Phase II testing usually lasts for 2 years.

Phase III. During this phase, the drug is administered to several hundred or several thousand ill patients in exactly the way it will be used (dose, route of administration, frequency, etc.) if it is approved by the FDA. The effectiveness of the drug is compared with that of other drugs currently being used to treat the same disease. In addition, double-blind trials are performed with the drug and a **placebo** (see the Look Closer box). Drug companies that agree to test the new drug on children, so that pediatric doses can be standardized, receive a 6-month extension on the standard 17-year patent on new drugs. Phase III testing usually lasts for 3 years.

EARN $400

Healthy male/female volunteers age 18 to 35 needed now to participate in upcoming inpatient studies. Stay in our pleasant dormitory at Utopia University, with recreational facilities available.

CENTER FOR VACCINE DEVELOPMENT
Utopia University

■ **Figure 2-3 Newspaper advertisement.**

A typical newspaper ad seeking volunteers to participate in a Phase I clinical trial to test a new drug.

LOOK CLOSER

A placebo is a drug form that exerts no pharmacologic effect, no therapeutic effect, and has no side effects when administered. The word *placebo* means "I will please" in Latin. A placebo is used in double-blind clinical trials in which neither the researcher nor the patient knows whether the patient received the drug being tested or a placebo. Those receiving the placebo are the **control group**. Placebos are commonly sugar pills or injections of sterile normal saline solution. Interestingly, while it is physiologically impossible for a placebo to exert any drug effect, some patients report a decrease in certain types of symptoms and can even experience "side effects" when given a placebo. These effects are quite real and demonstrate that, in some situations, the mind can produce changes in the body that closely mimic the effect of an actual drug.

Once phase III is complete, the drug company submits all of its documentation about the new drug to the FDA in a **New Drug Application (NDA)** and waits for a final decision for approval or denial. It is the responsibility of the FDA to evaluate a new drug based on the drug company's documentation and an examination of the relative risks and benefits of the drug. On average, it can take 12 years for a drug to go from its creation, through animal testing and human clinical trials to the FDA's final approval or denial (see ■ Figure 2-4).

DID YOU KNOW?

The data collected for just one patient in just one clinical trial can exceed 100 pages of documentation, and the total documentation for all aspects of new drug testing can exceed 100,000 pages. After four years of testing the new drug cimetidine (Tagamet) (to treat stomach ulcers), the SmithKline drug company had a stack of documents 17 feet high that had to be taken to the FDA in a truck.

Once a drug has received its final approval from the FDA, its ingredients, doses, manufacturing process, labeling, and packaging cannot be changed. With further clinical trials, however, a drug's indicated uses can be expanded.

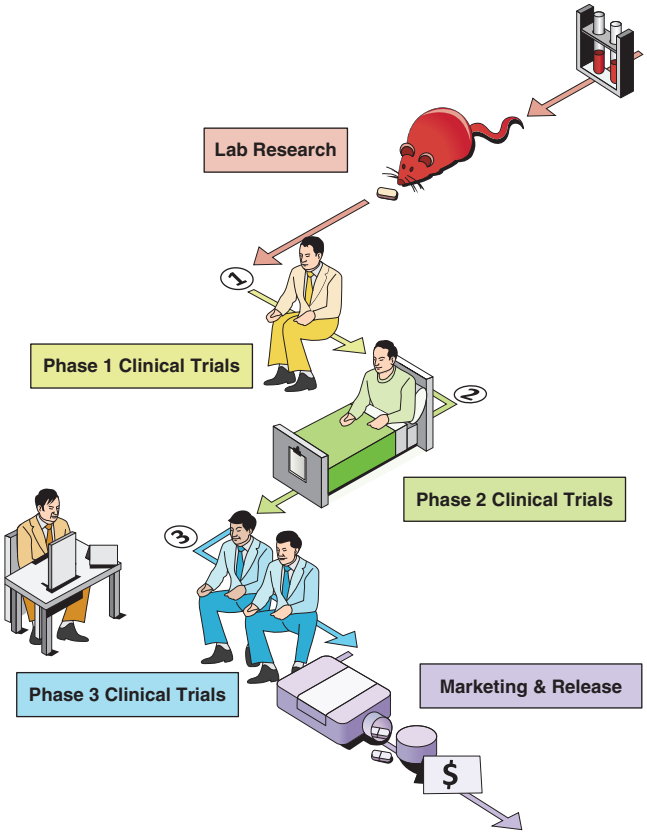


Figure 2-4 Animal testing and clinical drug trials.

Animal testing is followed by the three phases of clinical drug trials.

Source: Pearson Education

Although new clinical indications for a drug often seem very different from the drug's original use, they are based on the drug's therapeutic effects or possibly even its side effects.

> Example: Propranolol (Inderal) was originally approved by the FDA in 1967 for heart arrhythmias. In 1973, it was approved for hypertension. In 1979, it was approved for migraine headaches. Now, it is also approved for treating angina, myocardial infarction, essential tremor, and pheochromocytoma.

LOOK CLOSER

The drug azidothymidine (AZT) was being tested in the mid-1980s to determine its effect on slowing the progression of human immunodeficiency virus (HIV). At that time, there was no drug treatment for this infection. During the AZT clinical drug trials, only one person who had taken the drug died, while nearly all of the patients in the control group (who had not taken the drug) died. Because of these dramatic results, the FDA accelerated the approval process to quickly get AZT on the market. At present, the FDA has three different programs that help speed up the approval process—Fast Track, Breakthrough Therapy, and Accelerated Approval. These programs are particularly for drugs that will treat serious medical conditions that currently do not have any available drug treatment.

A drug that has not yet received FDA approval is an **investigational drug**. The FDA can allow a physician to prescribe an investigational drug for a patient with a life-threatening disease when there are no other drugs to treat it. This is known as **expanded access** or **compassionate use**. AZT was the first drug authorized by the FDA for compassionate use.

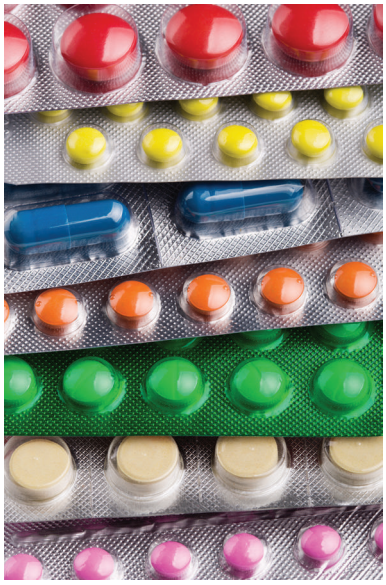
Drug Manufacturing

The FDA carefully monitors the quality of both generic and trade name drugs manufactured by all drug companies. Unlike in years past when pharmacists hand-mixed drug ingredients and molded drugs into tablets, today's manufacturing processes are strictly regulated for drug quality, as well as for sanitation and packaging.

Generic drugs that are in the same drug form and have the same dose strength must all contain exactly the same amount of active drug ingredient and be administered in the same way that has already approved by the FDA— even if they are from different drug companies. That does not mean, however, that the **bioavailability** will be identical for each drug. Drug companies use different types of **inert ingredients** (e.g., binders, fillers, preservatives, antioxidants, buffers, etc.). In most cases, these inert ingredients have no effect on the disintegration, absorption, metabolism, or excretion of the drug. However, in some cases, the inert ingredients do affect the bioavailability of the drug, particularly a drug with a low therapeutic index (low margin of safety between the therapeutic dose and the toxic dose). A study in the *New England Journal of Medicine* compared four preparations of the generic drug digoxin from different drug companies. All met the FDA standards for manufacturing, but the bioavailability of one drug (portion of total dose available to actually produce a therapeutic effect) was much higher than the others. This resulted in a blood level of digoxin that ranged from toxic for that one generic drug to subtherapeutic for the others.

The manufacturing process also includes securing the drug in an appropriate container to keep out moisture and light. A packet of a **desiccant** (a moisture-absorbing silica gel) can be added to a drug bottle to keep the tablets or capsules from deteriorating or losing strength, and the top of the drug container is tightly sealed with foil. Alternatively, a single drug dose can be placed in an individually sealed blister pack (see ■ Figure 2-5).

The label of every prescription drug bottle must include a unique identifier number known as the ***National Drug Code (NDC)*** (see ■ Figure 2-6). The drug label must also have an expiration date printed on it. This date changes as new batches of the drug are manufactured. Physicians, nurses, pharmacists, and other healthcare professionals who administer or dispense drugs know not to use a drug if its expiration date has passed.



■ Figure 2-5 Protective drug packaging.

A clear plastic blister pack protects a drug from moisture and damage. Access is through a peel-off backing that has the drug's name and dose printed on it.

Source: Nomad_Soul.Shutterstock

Drug Marketing

The marketing and advertising of prescription drugs is regulated by the FDA, based on the federal Food, Drug, and Cosmetic Act. The marketing and advertising of over-the-counter drugs is regulated by the Federal Trade Commission (FTC).

Drug companies promote their prescription drugs by advertising in medical journals, giving away promotional literature and DVDs, and having their drug sales representatives visit healthcare providers. Drug companies often provide free samples of their drugs for healthcare providers to give to patients. This provides the patient with a limited supply of the drug to try. If it helps the symptoms, the healthcare provider then gives the patient a prescription for the full amount needed for treatment (see ■ Figure 2-7).

■ Figure 2-6 National Drug Code (NDC).

The NDC is a unique 10-digit identification number with segments that are separated by hyphens. The first segment of the NDC identifies the drug manufacturer, the second segment identifies the drug's strength/dose, and the last segment identifies the package size and type. The NDC is at the very top of this drug box. The NDC may also appear on the label of a patient's prescription bottle from the pharmacy.

Source: Susan Turley

■ Figure 2-7 Drug sample.

A healthcare provider gave these prescription eye drops to the patient as a free sample to see if they would be effective in treating the patient's eye allergies. The drug box is clearly marked, "For Professional Use—Not for Sale."

Source: Susan Turley

DRUG CONTROVERSY

The United States is one of the few countries that allows direct-to-consumer advertising of prescription drugs. These advertisements are heavily weighted toward prescription drugs for chronic conditions that require long-term treatment. These ads suggest, "Ask your doctor if [this drug] is right for you." This has created a marketing shift in which consumers proactively ask for certain prescription drugs by name and pressure healthcare providers to prescribe the more expensive advertised trade name prescription drugs.

The public recognizes advertising slogans, such as "the purple pill™" (for the trade name drug Nexium for heartburn and stomach ulcers). It comes as a purple capsule with three gold bands around one end and Nexium printed on it. Even its website www.purplepill.com is colored with purple. Cialis, a drug for erectile dysfunction in men, made history when it was advertised during the 2004 Super Bowl. Television advertisements for the antipsoriasis drug tildrakizumab (Ilumya) have a personal, upbeat invitation to the patient to "show more of yourself."

Now, **direct-to-consumer (DTC) marketing** has become common, with drug advertisements frequently appearing in magazines and on television.

Drug Legislation

Laws were passed in the 1900s to protect the public from worthless or dangerous drugs. The Pure Food and Drug Act of 1906 was the first federal drug law. This Act established the FDA. It also said that only drugs listed in the *United States Pharmacopeia* or *National Formulary* could be prescribed. At that time, however, the burden of proof lay with the government to show fraud or misrepresentation on the part of the drug company.

LOOK CLOSER

It took a national tragedy to force a much-needed update to the Pure Food and Drug Act. The anti-infective drug sulfonamide was widely used in the United States. The drug manufacturer advertised a raspberry-flavored *Elixir of Sulfonamide*. The alcohol base had been tested for flavor and fragrance but not for safety. It contained an industrial-strength solvent that poisoned many people. Because of this, the Food, Drug, and Cosmetic Act of 1938 was passed. This Act shifted the burden of proof to the drug manufacturer to show that the drug was safe. In 1951, the Durham-Humphrey Amendment to this Act stated that prescription drugs could only be given to patients who were under the care of a physician. The Kefauver-Harris Amendment stated that drugs must be shown to be both safe and effective before being marketed.

Drug Patents

After a new drug is approved by the FDA, the drug company is protected by a 17-year patent. The trade name of the drug is registered with the U.S. Patent Office as a registered trademark.

While the drug is under patent, only the original drug company has the right to advertise and market the drug. No other drug company can manufacture or market an identical drug. The original drug company hopes that the trade name of its drug will be so successful that it becomes firmly entrenched in the minds of the public and the prescribing healthcare providers.

When the patent expires, another drug company can manufacture its own generic version of the drug under a new trade name and compete for a place in the market. If a generic drug is manufactured by several different drug companies, it will have several different trade names. (See the Did You Know? box.)

DID YOU KNOW?

Original generic name and trade name of a drug for ulcerative colitis	
mesalamine (Rowasa*)	Mylan drug company
Subsequent trade names	
Apriso	Bausch Health drug company
Asacol	Warner Chilcott Pharmaceuticals
Lialda (see ■ Figure 2-8)	Shire US, Inc., drug company
Pentasa	Shire US, Inc., drug company

* This trade name drug is no longer on the market.

■ Figure 2-8 The trade name drug Lialda.

This is one of four different trade names for the generic drug mesalamine.

Source: Susan Turley

DRUG FORMS

The drug company must state in what form or forms the drug will be manufactured. Different forms of a drug are appropriate for different routes of administration. A drug may be effective in one form but ineffective in another; a drug can seriously injure a patient if administered in the wrong drug form. Drugs are manufactured in the following different forms: tablet, capsule, film, ointment, cream, lotion, liquid (solution, suspension), powder, suppository, transdermal patch, pellet, wafer, insert, and gas.

Tablet

A tablet is a solid drug form that contains an active drug plus inert ingredients that provide bulk and ensure a standardized tablet size. In prescriptions, *tablet* is sometimes abbreviated as *tab* or *tabs*. Tablets come in many colors and shapes (see ■ Figure 2-9).

■ Figure 2-9 Fosamax tablet.

Fosamax is used to treat osteoporosis in women who are in menopause because they have an increased loss of bone mass. Each tablet has the shape of a bone imprinted on it.

Source: Susan Turley

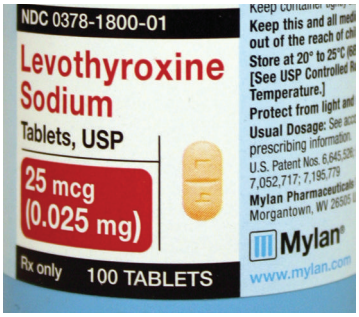


Figure 2-10 Scored tablet.
A scored tablet can be divided easily and accurately into two or three equal doses, depending on the number of score marks on the tablet.
Source: Susan Turley

- A tablet of Cialis, a drug used to treat erectile dysfunction, is mustard colored and manufactured in the shape of a teardrop with a large *C* on it.
- A tablet of the antianxiety drug Valium has a cut-out "V" in its center.

FOCUS ON HEALTH CARE

Seventy percent of pharmacists report that patients often ask them to identify tablets or capsules that are not in the original packaging. The FDA advises patients who take more than one drug to be able to tell them apart by size, shape, color, imprint, or drug form.

Tablets are also manufactured in several specialized types: scored, effervescent, enteric coated, caplet, slow-release, lozenge, and troche. A **scored tablet** has an indented line running across it, from one side to the other, so that it can be easily broken into equal pieces to produce an accurate, but reduced, dose (see Figure 2-10 and Figure 2-11).

An **effervescent tablet** is one that is dissolved in a glass of water before being swallowed as a liquid (see Figure 2-12). An **enteric-coated tablet** is covered with a special coating that resists stomach acid, but dissolves in the alkaline environment of the small intestine to avoid irritating the stomach. (Example: Ecotrin for pain. The ***ec*** in the trade name Ecotrin stands for *enteric coated*.) **Caplets** are enteric-coated tablets, but in the shape of a capsule. A slow-release tablet or extended-release tablet provides a continuous, sustained release of the drug. The drug name often indicates that with the abbreviation CD (controlled delivery), CR (controlled release), ER (extended release), LA (long acting), SR (slow release), XL (extended length), or XR (extended release).

A **lozenge** is a tablet formed from a hardened base of sugar and water containing the drug and other flavorings. Lozenges are never swallowed whole but are allowed to disintegrate slowly into a liquid form that releases the drug topically in the mouth and throat. (Examples: A Cepacol lozenge is for a sore throat. The drug fentanyl [Actiq] is a lozenge on a stick—called an Actiq "lollipop"—that is sucked to treat severe pain.) A **troche** is an oblong tablet that has a base of sugar that disintegrates into a paste to release the drug topically in the mouth. (Example: A clotrimazole troche is used to treat an oral yeast infection.)

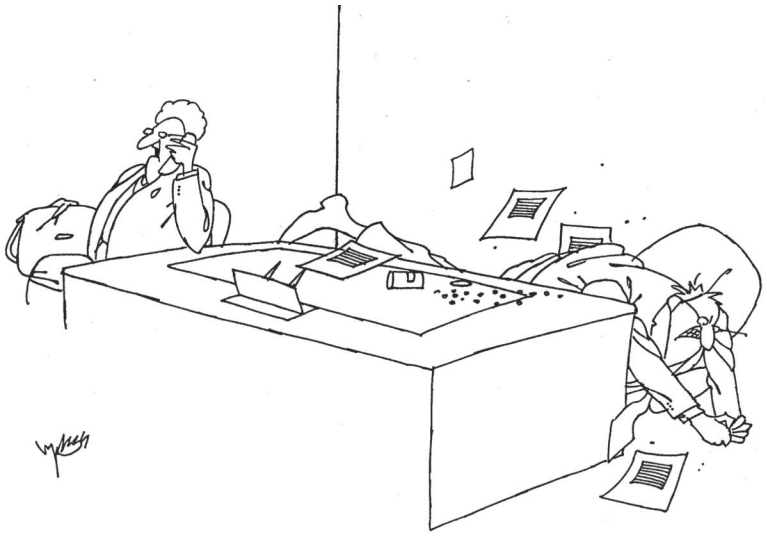


Figure 2-11 ***While the doctor's trying to split one of the tablets he prescribed, I thought I'd give you a call.***
Source: David W. Harbaugh

Figure 2-12 Effervescent tablet.

This large tablet needs to dissolve before the drug can be taken orally. This generic drug is for pain. Another well-known effervescent tablet is Alka-Seltzer for head colds and pain.

Source: Susan Turley

Capsule

There are two types of capsules. The first type is a soft, one-piece gelatin shell with the liquid drug inside (e.g., fat-soluble vitamin A or vitamin E capsules). The second is a hard shell in two pieces that fit together and hold a powdered or granular drug inside (see Figure 2-13). Capsules can also be in an extended-release form (see Figure 2-14). In prescriptions, *capsule* is sometimes abbreviated as *cap* or *caps*.

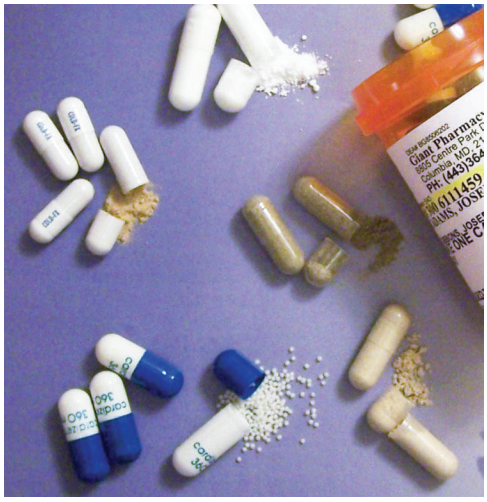


Figure 2-13 Capsules.

Hard shell capsules come in all colors and contain a granular or powdered form of the drug.

Source: Susan Turley

Figure 2-14 Extended-release capsule.

As with tablets, capsules can also have an extended-release action to provide a therapeutic level of the drug over many hours.

Source: Susan Turley

FOCUS ON HEALTH CARE

Capsules are usually swallowed whole. However, FDA-approved instructions for the drug diltiazem (Cardizem) for angina say that the capsule can also be opened and its drug contents sprinkled on a spoonful of applesauce.

HISTORICAL NOTES

In the past, many over-the-counter cold remedies and drugs for pain were manufactured as capsules. In the 1980s, the powdered drug in Tylenol capsules was purposely contaminated with cyanide. Now, drug companies manufacture their over-the-counter drugs in a tablet or caplet form to prevent tampering. Many prescription drugs, however, are still manufactured in two-piece capsules.

Film

A film is a thin, dissolvable form about the size of a postage stamp that contains a drug. The film is placed under the tongue (sublingual administration) or inside the cheek (buccal administration), and the drug enters the blood through large blood vessels in the mucosa of the oral cavity, bypassing the stomach and digestion. Dissolving films, wafers, or strips are suitable for pediatric patients, for patients with dementia, or for any patient who has difficulty swallowing.

Ointment

An ointment is a semisolid emulsion of oil (lanolin or petroleum) and water, the main ingredient being oil (see ■ Figure 2-15 and Table 2-1). Many topical drugs are manufactured in an ointment form (e.g., Kenalog ointment for skin inflammation). Topical ointments are absorbed into the area on which they are applied; most exert a local, not systemic, drug effect. Specially formulated ophthalmic ointment can be applied topically to the eye without causing irritation.

Cream

A cream is a semisolid emulsion of oil (lanolin or petroleum) and water, the main ingredient being water. An emulsifying agent is added to keep the oil and water mixed. Many topical drugs are manufactured in a cream form. Creams are absorbed into the skin and exert a local, not systemic, drug effect.

Lotion

A lotion is a suspension of a drug in a water base. Lotions are absorbed into the skin and exert a local, not systemic, drug effect. Many lotions are over-the-counter drugs for dry skin and irritation.

■ Figure 2-15 Ointment and cream drug forms.

These over-the-counter drugs are triple antibiotic ointment for a skin infection and hydrocortisone cream for skin inflammation. The feel, appearance, and consistency of these two drug forms are different.

Source: Susan Turley