Cynthia J. Watkins

THIRD EDITION

Pharmacology Clear & Simple

A Guide to Drug Classifications and Dosage Calculations

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F.A. Davis Company • Philadelphia

F. A. Davis Company
1915 Arch Street
Philadelphia, PA 19103
www.fadavis.com

Printed in the United States of America

Last digit indicates print number: 10 9 8 7 6 5 4 3 2 1

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Library of Congress Cataloging-in-Publication Data

Names: Watkins, Cynthia J., author.
Title: Pharmacology clear & simple : a guide to drug classifications and dosage calculations / Cynthia J. Watkins.
Other titles: Pharmacology clear and simple
Description: Third edition. | Philadelphia, PA : F.A. Davis Company, [2018] | Includes bibliographical references and index.
Identifiers: LCCN 2018006898 (print) | LCCN 2018007839 (ebook) | ISBN 9780803677319 (epub) | ISBN 9780803666528 (pbk. : alk. paper)
Subjects: | MESH: Pharmaceutical Preparations—administration & dosage | Drug Dosage Calculations | Drug Administration Routes | Pharmaceutical Preparations—classification | Medication Errors—prevention & control | Problems and Exercises
Classification: LCC RM300 (ebook) | LCC RM300 (print) | NLM QV 18.2 | DDC 615/.1—dc23
LC record available at https://lccn.loc.gov/2018006898

I would like to dedicate this textbook
to the love of my life, Jeffrey Watkins,
who continues to be incredibly supportive of my venture
into the realm of being an author.

Preface

In my 32 years as a nurse, I have been involved with direct patient care as well as taught a variety of students in nursing, medical assisting, surgical technology, and respiratory therapy. I have also taught those who may not deliver direct patient care, such as students of psychology and clinical lab science. There is always one constant challenge: to provide students with enough pharmacology knowledge so that they feel confident as they embark on their health profession careers but not so much that they are overwhelmed. For those students who will administer medication, pharmacology is critical; for others, it is a subject that will aid their understanding of the patient care relationship, although they may not be directly involved with the patient.

This edition of the book has been expanded in response to the requests of our reviewers. I've tried to build on the solid foundation of the second edition and to expand the coverage of drugs, keeping in mind always the suggestions we received from pharmacology faculty from around the nation. I hope you will be pleased with the results.

My goal for the third edition of this book is to continue to bring the most current information to pharmacology topics as well as continue to provide elemental concepts that will enable students to understand how medications work and how they are administered. These concepts include the health professionals' role in the process. This edition is divided into four units:

Unit 1: Introduction to Pharmacology discusses the fundamentals of pharmacology, including history, patient safety and regulations, and prescription labels. Each topic lays the foundation for the work ahead.

Unit 2: Calculations begins with Chapter 6, Review of Mathematics, which begins with a basic review of fractions and decimals and progresses to more advanced mathematical calculations. This review provides many testing opportunities for students to assess their knowledge through the Check Up exercises throughout the chapter. Chapter 7, Measurement Systems, addresses the various measurements systems and shows students how to convert among the metric, household, and apothecary systems. Chapter 8, Dosage Calculations, ends this unit by showing students how to calculate dosages. In this chapter, students have many opportunities to practice dosage calculations using a variety of examples to increase their knowledge and confidence in administering medications.

Unit 3: Administration of Medications includes Chapters 9 and 10, Enteral Medications and Administration and Parenteral Medications and Administration, respectively, which provide step-by-step instructions through Procedure Boxes with supporting images.

Unit 4: Classifications of Drugs addresses all major drug classifications by body system. Although individual drugs are mentioned, each chapter primarily focuses on key attributes of that particular body system. This focus allows the student to understand how a particular set of drugs works and how individual drugs within that set function the same way.

FEATURES

The following features are included to further facilitate students in their learning and to help them better retain pharmacological content.

- **Check Up** boxes have mathematical calculation exercises in Unit 2. Each Check Up appears following a math review section to test the student's knowledge and understanding of basic math concepts.
- **Fast Tip** boxes provide brief bits of useful information on various topics within the chapters.
- **A Closer Look** boxes examine special topics in each chapter.
- **Drug Spotlight** boxes highlight one or two drugs in each chapter and provide detailed information.

- **Critical Thinking** exercises encourage students to think beyond the chapter and apply their new knowledge to real-life scenarios.
- **Master the Essentials** tables cover indications, side effects, precautions, contraindications, interactions, and examples for each drug classification. They are perfect for study and review because all the drug classifications in the chapters are covered.
- **Chapter Review** questions in multiple formats appear at the end of each chapter to test student comprehension. **Internet Research** activities encourage students to use the Internet to research and locate important information on specific drugs, drug safety, and how to educate and instruct patients to use various medications.

ANCILLARY CONTENT

- Accompanying the text are online resources to help support both students and instructors. For the student, the eBook is available online at www.DavisPlus.com. For medical assisting educators and nursing educators, separate resources include test banks, instructor guides, teaching guides, and PowerPoint presentations. Medical assisting resources also include documentation exercises and a competencies checklist.

I hope this third edition of *Pharmacology Clear & Simple* meets all your teaching and learning needs.

Cynthia J. Watkins, RN, MSN, CPN

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Acknowledgments

I thank Andy McPhee for recruiting me and having faith in my ability to complete this project. Thank you to Dean DeChambeau for all the assistance required to bring this work to publication. I want to acknowledge all the staff of F. A. Davis as well as the editors who have also had input on this project. Thanks to all!

Contents in Brief

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1

Introduction to Pharmacology

CHAPTER 1

History of Pharmacology

Medications, their origins, and their uses are older than any written records that we have. Many ancient cultures have contributed to the knowledge base and evolution of pharmacology, including Greek, Chinese, Egyptian, Persian, and Arabic. The healers were called by many names, but all shared an extensive knowledge of plants, minerals, and animal products. Pharmacology has evolved significantly from the days when these resources were used to cure the ill without understanding why they worked or did not work. Some ancient remedies are still valuable medicines today, whereas others have been discarded as worthless or dangerous. With the advent of scientific inquiry and technology, researchers around the world have created new and better medications. The ability to isolate pure substances and formulate drugs in a laboratory enables pharmaceutical companies to mass-produce needed medicines in a timely manner.

In this chapter, you will learn about the history of pharmacology and sources used for developing drugs; the acceptance of alternative medicine, and its place in medicine; and the six main categories of drugs and their uses.

LEARNING OUTCOMES

At the end of this chapter, you should be able to:

1.1 Define all key terms.
1.2 List three societies critical to the development and evolution of pharmacology.
1.3 List four sources of drugs.
1.4 List 10 drugs, and record their sources.

KEY TERMS

Al-Hawi	Diagnostic	Pharmakon
Alternative medicine	Drug/*droog*	Porcine
Antineoplastic	Ebers Papyrus	Prophylactic
Bovine	Palliative	Replacement drugs
Curative	Pharmacodynamics	Synthetic drugs
Destructive	Pharmacology	

HISTORY OF PHARMACOLOGY

The history of pharmacology helps us to understand that even though there have been huge advances in medications, scientists are coming to understand that by disregarding ancient practices, they have been missing a treasure trove of useful medications. Many practitioners are utilizing **alternative medicine** to maximize their patients' health, and scientists are looking to older remedies to see if and why they work and how to reproduce them in the modern world. We as practitioners also need to understand that many patients are using many different forms of self-medication, from home remedies to substances they learned about on an infomercial that promise to cure all types of problems; if these substances are not understood, they may interfere or counteract a prescribed pharmaceutical medication. In other words, we need a complete picture of every substance patients are taking in order to assist in their care.

The term **pharmacology** is of Greek origin from two words: **pharmakon,** meaning "medicine," and *ology,* meaning "the study of." Pharmakon also meant poison *and* remedy, poison because some of the early medicines were toxic enough to kill, and remedy because, at times, early medicines cured the illness. The word **drug** has a Dutch origin in which **droog** meant "dry" as in the use of dry herbs.

Most ancient societies had little knowledge about the human body and how it worked, so treating illness was often based on trial and error. Early records document that treatments consisted of plants, minerals, and animal products because no other sources were available. "Healers" were known as wise men, shamans, witch doctors, medicine men and women, and so on (Fig. 1-1), depending on the culture, and were chosen based on their knowledge of which plants or other substance to use, how to prepare it, and how much to give the patient.

Pharmacology in Ancient Times and Cultures

Early documentation of medicine and various remedies is evident in several cultures. For example, "The Yellow Emperors' Inner Classic," a Chinese document, was a very early discussion of yin-yang and acupuncture. The first Chinese manual on pharmacology was written in the first century A.D. and included 365 medicines, 252 of which were herbs. In Egypt, a medical document called the **Ebers Papyrus** was written circa 1550 B.C. and lists about 700 "recipes" for a host of illnesses, from crocodile bites to psychiatric illnesses. Another document, the **Al-Hawi,** is a large, 20-volume medical book written by the physician Al-Razi in ancient Persia (Iran). It was translated into Latin in the 13th century and greatly influenced medicine in medieval Europe.

The contributions from these cultures led to the advancement of pharmacology. When treatments for many conditions were discovered, the findings were recorded on papyrus or paper to pass on to future generations. Documenting this early information was extremely important, as belief systems changed over time. Without these earlier writings, traditional oral knowledge might have been lost or suppressed and much progress could not have been made.

During the 17th and 18th centuries, there was a real lack of knowledge in the use of medications and their dangers. A prime example of this is mercury, which was used for a variety of ailments from skin conditions to syphilis. Specifically, in the late 1700s a prominent physician, Dr. Benjamin Rush used a mercury compound in high doses to treat yellow fever patients. Of course, it has since been discovered that mercury is so harmful to humans that we no longer use mercury blood pressure cuffs or thermometers for fear of exposure.

FIGURE 1-1: Eskimo medicine man. *(From the Library of Congress Prints and Photographs Division, Washington, D.C.)*

Pharmacological Advances Through the 19th and 20th Centuries

Over time, an increasingly scientific approach to the discovery and understanding of drugs was taken. During the 1800s, chemists were able to identify and then isolate the active ingredients (those pure chemicals in the plants that had the actual therapeutic properties). They were also able to determine how the drug acted on the body. This marked the beginning of modern pharmacology. Up until the early 1900s, preparing medicine was very labor-intensive; the pharmacist had to distill and prepare each medicine when it was ordered (Fig. 1-2). Not until World War II (1939 to 1945) did the mass-production of medicine begin (Fig. 1-3). More U.S. soldiers died in World War I from infection and accidents than from actual combat injuries; however, the mass-production of penicillin minimized the number of deaths from infection during World War II (Table 1-1). For instance, the death rate from pneumonia

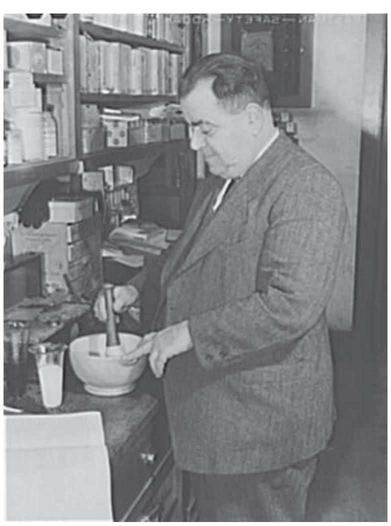

FIGURE 1-2: Pharmacist preparing a prescription, 1939. *(From the Library of Congress Prints and Photographs Division, Washington, D.C.)*

FIGURE 1-3: Mass-production of medication, 1944. *(From the Library of Congress Prints and Photographs Division, Washington, D.C.)*

TABLE 1.1 U.S. Casualties in Major Wars

War	Number Serving	Battle Deaths	Disease and Accidents
Civil War	2,213,363	140,414	224,097
Spanish-American War	306,760	385	2,061
World War I	4,743,826	53,513	63,195
World War II	16,353,659	292,131	115,185

Source: U.S. Department of Justice

in the U.S. Army was 18% during World War I, decreasing to 1% during World War II. Death from combat injuries complicated by infections also decreased.

With the discoveries of new drugs like penicillin that could save millions of lives, the belief grew that new drugs must be better than old standard herbs and treatments, especially if created or refined in a scientific manner. Pharmacology therefore advanced rapidly in the second half of the 20th century as many new drugs were either discovered or developed. In an effort to discover possible new drugs, researchers studied plants, marine animals, and micro-organisms in soil, water, and air. Partially or totally synthesized medications were produced by combining two or more compounds or elements. Partially synthesized medications were made by adding a pure chemical to a natural substance. Totally synthesized medications were created by combing two or more pure chemicals to produce a new substance that could be used as a medication. One major breakthrough was the discovery of ways to create large amounts of viable drugs from a small amount of natural resources using genetic engineering. For example, human insulin can be mass-produced by adding the human insulin gene to a nonpathogenic strain of *Escherichia coli*.

Pharmacology in the 21st Century

In the 21st century science is booming. One of the most promising advances in the field of medications is that of pharmacogenetics, which is the “study of individual candidate genes as powerful tools to explain interindividual variability in drug response.” In other words, the patient’s genetic material is analyzed, and then in the case of cancer, the tumor’s genetics are analyzed to figure out the best drug and what dosage will work best to combat the disease. Currently there are certain medications and doses used to treat conditions for every adult patient with that condition. Through these advances in pharmacogenetics, the ability to individualize drugs and their dosage is happening in the treatment of HIV and rheumatoid arthritis. In addition, the hope is that in the future we can specifically tailor drugs and dosages for opioids and antihypertensives among other medications.

SOURCES OF DRUGS

Although most drugs are now manufactured in laboratories, many agents are still derived from natural substances such as plants, animals, minerals, and toxins. Some are utilized by extracting active ingredients from animals or plants and using these ingredients to manufacture a medication. Other times the original or natural source serves as a template for creating a synthetic equivalent, which is especially useful if the natural source is a rare plant. Scientists are constantly researching natural sources (plants, animals, marine animals, and microbes) in the hope of finding new sources of medications. Some drugs are made by combining chemicals with natural products, such as hydrocodone, which combines natural opium in the form of codeine combined with acetaminophen (a man-made medication), whereas other drugs are synthesized in a laboratory. Barbiturates are an example of synthetic drugs because they are chemically derived from barbituric acid (itself an artificial compound of urea and malonic acid).

Plants

Today plants are rarely used as medications; instead the active component of the plant is extracted and utilized in the manufacturing of the drug. Digoxin (Lanoxin), a drug used to treat heart failure, is made from the foxglove plant and has been used for healing since the 1500s. Most estrogen hormone replacements come from yams. Procaine (Novocain), used as an anesthetic, is derived from the coca plant. Rose hips are a rich source of vitamin C and are sold as an ingredient in vitamin C supplements. Aspirin (acetylsalicylic acid) is a compound based on salicin, which is found in the bark of a white willow tree, and is used to relieve pain and to treat inflammation.

Unfortunately, as less land becomes available for growing plants, fewer plants will exist for making medications. For example, as the rain forest diminishes, the rare plants that are located only in this environment may become extinct. In this instance, these rare plants are used as a template to manufacture a medication instead of using the plants and depleting them.

CRITICAL THINKING

If people rely on plants for medication, what effect does the increasing human population have on the potential supply of medications?

Animals

Domesticated animals are also a source of drugs. To ensure the purity of the drugs, donor animals are generally well cared for. Some examples include sheep, which provide lanolin, a topical skin medication that comes from the wool. Cows **(bovine)** and pigs **(porcine)** are good sources of hormone replacements. If a patient's body cannot manufacture a hormone, animal hormones can serve as a substitute. Horses provide humans with the replacement hormone conjugated estrogen (Premarin), which comes from a pregnant mare's urine. In addition, insulin is collected from the pancreases of cows or pigs. We obtain IGG (Immunoglobulin G) by injecting an antigen into animals (most commonly cows) and collecting the antibody that is formed. The drug heparin is extracted from porcine intestinal mucosa and bovine lungs.

CRITICAL THINKING

Cows and pigs are good sources of hormones. Do you think animals may be a better hormone source than humans? Why or why not?

Minerals

When foods grown from rich soil are unavailable, calcium, iron, zinc, magnesium, copper, and selenium are some of the minerals that are offered as necessary supplements.

For patients taking certain medications, mineral replacement is critical. Diuretic drugs such as furosemide (Lasix) cause the body to lose excess water through the kidneys, and potassium, a vital mineral, is also excreted with the water. Potassium is needed for the heart to function normally, so supplemental potassium chloride is frequently prescribed in addition to the medication. Potassium is also contained in sweet potatoes, bananas, and oranges.

Minerals are also used to treat certain conditions. For example, gold is used in the treatment of arthritis, iodine is used to treat goiter, and magnesium sulfate is used for constipation and eclampsia.

Toxins

Toxins, by definition, are poisons. Despite this fact, chemical and biological toxins are commonly used in medicine. The key is in the dosage. For instance, certain radioactive chemicals are used to diagnose and treat illnesses. Radioactive iodine, for example, in small doses can help pinpoint problems in a patient's thyroid, a small gland in the neck. In higher doses, radioactive iodine is used to shrink thyroid tumors.

Biological toxins can also be used in medicine. Botulinum toxin (Botox), which comes from a bacterium called *Clostridium botulinum,* is used in patients with torticollis (a condition in which neck muscles contract causing the head to turn to one side), strabismus (eye misalignment), and migraines. It is used in tiny doses.

CRITICAL THINKING

What are some of the dangers of using toxins as medicine?

Synthetic Medications

Synthetic drugs can be created by chemical processes, genetic engineering, or by altering animal cells. Often, drugs that are obtained from another source can be synthesized in the laboratory, thus preserving natural resources. For example, paclitaxel (Taxol), a drug for patients with cancer, was first made from the bark of the Pacific yew tree. Then a template or blueprint was developed to create a synthetic form of this drug, thus preserving the yew tree. Insulin can be obtained from pigs or cows, but a synthetic source is most commonly used. Human insulin is produced by using recombinant technology to add the insulin gene into a nonpathogenic strain of *E. coli*. This change occurred because of concern over the possible transmission of disease from animals to humans. In addition, there is a risk for immune reactions because of impurities found in the animal products. One additional advantage is that synthetic medications are usually more inexpensive because they are mass-produced.

Because scientists have been able to map the human genome, it is becoming possible to choose medications that are appropriate for individual patients, not patients as a whole. One area of uniqueness is the variation in the amount of drug-metabolizing enzymes each patient has and the effectiveness of these enzymes. The scientist can manipulate the DNA material of the medication source by changing it or combining it with DNA from another organism to target the patient's levels of the drug-metabolizing enzyme. Therefore, prescribers are able to choose drugs that work better for one population than for another. Research is also being conducted on the use of existing drugs in targeted populations. For example, BiDil is a combination of two generic drugs—hydralazine hydrochloride and isosorbide dinitrate—and is used to treat African American patients with heart failure.

CRITICAL THINKING

What are some of the ethical issues of genetically engineered drugs?

CATEGORIZING MEDICATIONS

The term **pharmacodynamics** refers to the effect of a drug on the body, or more scientifically, the negative and positive biochemical or physiological changes that a drug creates. Drugs fall into six categories of desired effects (Table 1-2).

- **Curative.** Some drugs restore normal physiological function, as in diuretics, which help the body rid itself of excess fluid.
- **Prophylactic.** These drugs prevent diseases or disorders, as in antibiotics given before surgery to prevent infection.

TABLE 1.2 Drug Categories

Category	Main Action	Examples
Curative	Cures or treats a problem	• Penicillin to treat strep throat
Prophylactic	Prevents a problem	• Cefazolin (Ancef, Kefzol) to prevent infections from surgery • Vaccine to prevent measles, mumps, and rubella
Diagnostic	Helps diagnose a disease or condition	• Diatrizoate meglumine and diatrizoate sodium (Gastrografin) • Barium sulfate (Gastrografin and Barium sulfate are used for computed tomography scans)
Palliative	Treats symptoms to make the patient more comfortable	• Morphine to relieve the pain of cancer • Oxygen to make breathing more comfortable
Replacement	Replaces a missing substance	• Levothyroxine • Natural thyroid to treat hypothyroidism
Destructive	Destroys tumors and/or microbes	• Carbimazole to inhibit the production of thyroid hormone to treat hyperthyroidism

- **Diagnostic.** Some drugs help diagnose a disease, such as barium that patients swallow to help highlight digestive problems on a radiograph.
- **Palliative.** Other drugs, such as pain relievers, do not cure disease, but they make patients more comfortable.
- **Replacement.** These drugs "replace" missing substances. Levothyroxine sodium (Synthroid), for example, is a drug that replaces a missing thyroid hormone.
- **Destructive.** Some medications destroy tumors and microbes. **Antineoplastic** (anticancer) drugs are an example of destructive, toxic drugs.

Medications are used for various reasons during a patient's life span. As a health-care provider, you must know how the different categories of drugs may affect a patient. Understanding this information will help you provide effective counseling, patient care, and safe administration of drugs depending on your role and scope of practice.

CRITICAL THINKING

Identify the following drugs as curative, prophylactic, diagnostic, palliative, replacement, or destructive.

- Synthroid
- Diuretic ("water pill")
- Flu vaccine
- Radiopaque dye
- Fever reducer
- Anticancer drug

THE ROLES OF THE LICENSED PRACTICAL NURSE, LICENSED VOCATIONAL NURSE, AND MEDICAL ASSISTANT IN THE ADMINISTRATION OF MEDICATIONS

All health-care providers must work within their scope of practice, which is a standardized set of health-care services providers can render and the extent they may do so independently. These functions are based on state laws and the provider's education, experience, and skills. Facilities may have their own additional policies. It is important to know your scope of practice in your state so that you can provide the best care possible to your patients while abiding by state regulations.

The individual State Boards of Nursing are the governing bodies that determine the scopes of practices for Licensed Practical Nurses (LPNs) and Licensed Vocational Nurses (LVNs). LPNs/LVNs generally administer oral, rectal, ophthalmic, otic, intradermal, subcutaneous, intradermal, and intravenous (IV) medications. In most states, LPNs may not give medications by rapid IV push. Many states additionally regulate if an LPN/LVN can start, discontinue, and/or monitor IV fluids. They also may not be allowed to administer or monitor IV medications and fluids via a central line (one that is in a large vein close to the patient's heart). LPNs/LVNs usually work under the direct supervision of a registered nurse.

Medical assistants may usually administer oral, intradermal, subcutaneous, and intramuscular medications as well as rectal, otic, and ophthalmic medications. In some states, they are allowed to have some involvement with IV fluids and medications after additional training once they receive their initial certification. Medical assistants generally work under direct supervision of a physician, physician assistant, or nurse practitioner.

SUMMARY

- Ancient cultures have contributed to the knowledge base and evolution of pharmacology, including Greek, Chinese, Egyptian, Persian (Iranian), and Arabic. Examples of early documentation include the Egyptian Ebers papyrus (1550 B.C.) and the Persian Al-Hawi.
- The 19th and 20th centuries saw rapid advancement in organic chemistry and technology that enabled scientists to identify and isolate active ingredients in plants and allowed the creation of synthetic drugs.
- Advancements in the study of human physiology enabled a better understanding of pharmacodynamics, the study of the negative and positive biochemical or physiological changes that a drug creates in the body.
- Mass-production of medications began around 1939 to 1945, and genetic engineering produced large amounts of drugs from small amounts of natural resources.
- In the 21st century, the field of pharmacogenetics is developing as physicians use genetic testing to determine how a patient will respond to specific medications and thus individualize treatment for the patient and his or her disease.
- Sources of drugs include plants, animals, minerals, toxins, and synthetic creations.
- The six categories of a drug's effect on the body are curative, prophylactic, diagnostic, palliative, replacement, and destructive.
- Roles of the LPN/LVN and medical assistant in medication administration are governed by their scope of practice, which is established by state regulations and facility policies.