

CHAPTER 1

Pharmacology: An Introduction

Overview

Pharmacology is the study of drugs. A drug can be any substance that, when administered to living organisms, produces a change in function. Thus, substances such as water, metals (iron), or insecticides can be classified as drugs. However, the term *drug* commonly refers to any medication that is used for diagnosing, curing, or treating disease.

Pharmacology is a subject that requires some background knowledge of anatomy, physiology, pathology, and related medical sciences. In that sense, pharmacology is an integrative course of study that applies the relevant information of all medical sciences to the treatment of disease. The major focus of this chapter is to provide an understanding of the mechanisms of action, main therapeutic effects, clinical uses, and adverse reactions of drugs.

Learning Outcomes

After studying this chapter, students should be able to:

- 1.1 List and define the major areas of pharmacology.
- 1.2 Describe what a drug is and explain the differences between therapeutic effect, side effect, and toxic effect.
- 1.3 Understand the terms site and mechanism of action, and how agonist and antagonist drugs interact at drug receptor sites.
- 1.4 Characterize the relationship between drug dosage and drug response, and the relationship between drug response and time.
- 1.5 Understand the terms associated with drug safety: therapeutic index, idiosyncrasy, drug allergy, and teratogen.
- 1.6 Explain the drug nomenclature used to name and classify drugs.
- 1.7 Recall the main drug references and the information they provide.

Lecture Outline

Drug Sources and Major Areas of Pharmacology (LO 1.1)

There are several sources of drugs. In the early days of medicine, most drugs were obtained from plant or animal sources. The main source of new drugs today is from chemical synthesis. Pharmacology is a large discipline that can be subdivided into different areas of study. These include pharmacodynamics, pharmacokinetics, pharmacotherapeutics, pharmacy, posology, and toxicology.

Terminology Related to Drug Effects (LO 1.2)

Pharmacologists know that all drugs produce more than one effect. Every drug produces its intended effect, or therapeutic effect, along with other effects. The therapeutic use(s) of any drug is referred to as the drug indication, meaning indications for use. The term contraindication refers to the situation or circumstance when a particular drug should not be used. Some drug effects, other than therapeutic effects, are described as undesirable. Undesired drug effects are categorized as side effects, adverse effects, and toxic effects.

Many side effects are more of a nuisance than they are harmful. Adverse effects are also undesired effects, but these are effects that may be harmful or that with prolonged treatment may cause conditions that affect the function of vital organs such as the liver or kidney. Toxic effects, or toxicity, implies drug poisoning, the consequences of which can be extremely harmful and may be life-threatening.

Allied health professionals spend the majority of their time in patient contact. Therefore, they have an important responsibility to observe the undesired effects of drugs, to recognize the side effects that are often expected, and to identify and report the adverse and toxic effects that are potentially harmful and that often require medical attention.

Basic Concepts in Pharmacology (LO 1.3)

The site of action of a drug is the location within the body where the drug exerts its therapeutic effect. Mechanism of action explains how a drug produces its effects.

Drug action is usually thought to begin after a drug has attached itself to some chemical structure located on the outer cell membrane or within the cell itself. For a few drugs and for some normal body substances, there seems to be a specific location on certain cells. This area is referred to as the receptor site. The attachment, or binding, of a drug to its receptors begins a series of cell changes referred to as the drug action.

When a specific receptor site for a drug is known, that receptor site becomes the site of action for that particular drug. Drugs that bind to specific receptors and produce a drug action are called agonists. Drugs that bind to specific receptors and block agonist drug action or cellular functions are called antagonists.

Dose–Response and Time–Plasma Drug Concentration Curves (LO 1.4)

A dose is the exact amount of a drug that is administered in order to produce a specific effect. The effect is referred to as the response. When the relationship between the dose and the response is plotted as a graph, it is referred to as a dose–response curve.

The main feature of the dose–response relationship is that a drug response is proportional to the dose. As the dose increases, so does the magnitude of the response. For example, dose–response curves can be used to measure the potency of similar drugs.

The relationship of time and the plasma drug concentration is known as the time–plasma drug concentration curve or time–response curve since it reflects the duration of action.

Drug Safety (LO 1.5)

Every drug must fulfill two major requirements before it can be approved for use in humans: efficacy and safety. The therapeutic index gives an estimate of the relative safety of a drug. All drugs produce adverse and toxic effects if taken in excess. Most adverse effects are dose dependent, which means the higher the dose, the greater the chances for producing an adverse effect. A few adverse effects are not dose dependent. These effects, such as drug idiosyncrasy and drug allergy, are determined by individual variation.

Drug Nomenclature (LO 1.6)

All drugs are chemicals, and many have long chemical names. As a result, all drugs are given a shorter name, known as the nonproprietary name, which is usually a contraction of the chemical name. The nonproprietary name is more commonly referred to as the generic name.

When the drug is marketed by a pharmaceutical company, it is given a third name, known as the proprietary name, or trade name or brand name. Drugs are also divided into prescription and nonprescription drugs. Prescription drugs require a written or phone order (the prescription), which can only be issued by or under the direction of a

licensed physician, dentist, or veterinarian. Nonprescription drugs, usually referred to as “over-the-counter” (OTC) drugs, can be purchased anywhere and do not require a prescription.

Drug References and Drug Legislation (LO 1.7)

The United States Pharmacopeia/National Formulary (USP/NF) is the official drug list recognized by the U.S. government. It provides information concerning the physical and chemical properties of drugs. Drug Facts and Comparisons is a loose-leaf index and drug information service subscribed to by most medical libraries. The following are the major legislative acts:

- 1906: Federal Pure Food and Drug Act
- 1938: Federal Food Drug and Cosmetic Act
- 1970: Federal Comprehensive Drug Abuse Prevention and Control Act

Instructor Lesson Plan

Chapter: 1

Estimated chapter teaching time: 90 minutes

Date:

	Time 	Activity and Instructions	Materials	Learning Outcomes
Introduction	10 min	Ask students if they know where the drug digitalis comes from. Introduce the topics for Chapter 1, starting with drug sources.		1.1
Lecture	50 min	Utilize lecture outlines and PPTs. Introduce new terminology and vocabulary. Discuss the major areas of pharmacology. Introduce the basic concepts in	Lecture outline PPTs (1-1 to 1-11)	1.1–1.3, 1.5

	Time 	Activity and Instructions	Materials	Learning Outcomes
		pharmacology. Discuss therapeutic, side, adverse, and toxic effects.		
Active Learning and Practice	20 min	See the group activity below.	See supplies listed below	1.3
Review	10 min	Review new terminology and theory.	Learning outcomes	1.1–1.3
Assignment		Complete the Understanding Terminology questions at the end of the chapter.	Textbook	1.1

Discussion Topics: LO 1.2 and 1.5

Ask students why people concern themselves with the adverse and toxic effects of drugs? (It is to ensure patient safety and recognize the signs of toxic doses.) Ask them to mention some side effects that can be used as a benefit to the patient? (Benadryl causes drowsiness, which can be helpful if someone isn't getting sleep due to a cold or allergies.)

Written Assignments: LO 1.1

Have students write out the definitions for pharmacodynamics, pharmacokinetics, pharmacotherapeutics, pharmacy, posology, and toxicology. Have them explain the differences between each field of study.

Group Activities: LO 1.3

Separate students into groups of three or four, and then give them the following supplies:

- Color-coated candies with at least three different colors—agonists/antagonists and chemical change in cell
- Red licorice ropes—cell with receptor sites

Then have them demonstrate receptor binding in the following way: Give each color-coated candy a specific title. For example, if one is using yellow-, orange-, and brown-coated candies, then yellow would be an agonist, orange an antagonist, and brown the chemical change in the cell. The red licorice can be shaped as a cell with indents that serve as receptor sites. Tell students to demonstrate what would happen when agonist and antagonist drugs bind to receptors.

Students would show instructors that they understand receptor theory by having the agonist (yellow) bind to the receptor site (indented red licorice) and then a chemical change (brown) appears in the cell. If the antagonist (orange) binds to the receptor (red licorice) then no chemical change appears within the cell.

Instructor Lesson Plan

Chapter: 1

Estimated chapter teaching time: 90 minutes

Date:

	Time 	Activity and Instructions	Materials	Learning Outcomes
Review	5 min	Review the new terminology presented in the last lesson plan.		1.1–1.3 1.5
Introduction	5 min	Ask students to recall the main cause of adverse effects. Introduce the remaining topics for Chapter 1.		1.4–1.7
Lecture	50 min	Utilize lecture outlines and PPTs. Introduce drug–response curves. Discuss drug safety and approval. Introduce drug nomenclature. Discuss the different drug reference	Lecture outline PPTs (1-12 to 1-20)	1.4–1.7

	Time 	Activity and Instructions	Materials	Learning Outcomes
		materials and drug legislation acts.		
Active Learning and Practice	15 min	Choose a lesson activity below.		
Review	10 min	Review major points of the chapter.	Learning outcomes	1.1–1.7
Assignment		Complete end-of-chapter exercises for Chapter 1.	Textbook	1.1–1.7

Discussion Topics: LO 1.4

Ask students why dose–response curves and time–plasma concentration curves are so important to the administration of medications? (Dose–response curves show the action of the drug proportional to the dose given, so one can give accurate doses to the patient and get effective therapeutic doses without giving toxic doses. Time–plasma concentration curves tell one about the onset of action and duration of action of the drug, so one can give doses on an accurate schedule to allow the patient to have the correct blood levels of drug at all times.)

Written Assignments: LO 1.6 and 1.7

Give students a list of drugs and have them use the reference materials to find the chemical name, generic name, and/or brand name for each drug.

Group Activities: LO 1.3, 1.5, and 1.7

Separate students into groups of three or four and have students utilize the reference materials to look up adverse effects for 10 different drugs. Have students report their findings and compare them with those of the rest of the class. Then discuss which reference book gave the best information for their assigned task.

Case Study: LO 1.2 and 1.7

The student should assume that they are working in a pharmacy and a patient calls stating that they are taking two different medications, Allegra and Digoxin. They want to know which medication is causing them dizziness, diarrhea, and blurred vision. Using the *Drug Facts and Comparisons*, look up the possible side effects of these medications

and determine which one is causing them reactions.

Answers for Case Study

Digoxin is the drug that is probably causing them reactions. They should check with their doctor to ensure they are taking the correct dosage.

Additional Readings

Liang, B. C. 2002. The drug development process I: Drug discovery and initial development. *Hospital Physician* 38(1):18.

Fitzgerald, M. A. 2007. Herbal facts, herbal fallacies. *American Nurse Today* 2(2):27.

Miser, W. F. 2006. An introduction to evidence-based medicine. *Primary Care: Clinics in Office Practice* 33(4):811.

Answer Key

Understanding Terminology

Match the definition in the left column with the appropriate term in the right column. (LO 1.1)

1. E
Posology is the study of the amount of drug that is required to produce therapeutic effects.
2. G
Toxicology is the study of the harmful effects of drugs on living tissue.
3. A
Pharmacodynamics is the study of the action of drugs on living tissue.
4. C
Pharmacology is the study of drugs.
5. F
Pharmacy is the science of preparing and dispensing medicines.
6. B
Pharmacokinetics is the study of the processes of drug absorption, distribution,

metabolism, and excretion.

7. D

Pharmacotherapeutics is the study of the use of drugs in treating disease.

Answer the following questions.

8. Define a drug. (LO 1.2)

A drug is a chemical substance that produces a change in body function.

9. Differentiate between therapeutic effect, side effect, and toxic effect. (LO 1.2)

Therapeutic effect is the reason for administering a drug, to alleviate some symptom or disease process. A side effect is an additional fact, unwanted but usually not harmful. Drowsiness after some cold remedies is an example of a side effect. A toxic effect is a harmful effect that requires a reduction in dosage or elimination of the drug.

10. What is the difference between site of action and mechanism of action? (LO 1.3)

Site of action is the location within the body where a drug exerts its therapeutic effect. It may be a body organ, tissue, or specific drug receptor site. The mechanism of action refers to how the drug produces its effects. Mechanism of action may involve inhibition of a body enzyme or chemical process or may involve the drug acting as an antagonist on a receptor to block the action of a hormone or body substance.

11. What is the relationship between ED₅₀, LD₅₀, and therapeutic index? (LO 1.5)

The effective dose 50 (ED₅₀) is the dose that will produce half the maximal response possible. The lethal dose 50 (LD₅₀) is the dose that will kill half of the animals tested during a test of drug toxicity. The therapeutic index is the ratio of the ED₅₀ to the LD₅₀, which provides an estimate of the relative safety of a drug.

12. Explain the difference between a prescription drug, OTC drug, and a controlled substance. (LO 1.6)

Prescription drugs require a written or phone order by a licensed physician and must be dispensed by a licensed pharmacist. OTC drugs can be sold at a variety of stores and do not require a physician or pharmacist. Controlled substances are drugs that have the potential for misuse and are scheduled and regulated by the Drug

Enforcement Administration (DEA).

13. Explain the difference between idiosyncrasy and drug allergy. (LO 1.5)
Idiosyncrasy is an unusual or unexpected drug response. It is usually caused by genetic differences among individuals. Drug allergy is an adverse drug reaction that occurs when an individual becomes sensitized to a drug. Antibodies produced within the body react with the drug to cause an allergic reaction.
14. Write a short paragraph describing the terms *receptor site*, *binding*, *drug action*, *agonist*, *antagonist*, and *competitive antagonism*. (LO 1.3)

Students' answers will vary. Drug action is produced when a drug binds to a specific location on certain cells, its receptor sites, to initiate some effect. Agonists stimulate receptors, while antagonists block the availability of receptors to other drugs or body substances. When an agonist drug and an antagonist drug bind specifically to the same receptors, they are referred to as competitive antagonists. If they are both administered at the same time, they compete with each other for binding to the receptors; this is known as competitive antagonism.

Acquiring Knowledge

Answer the following questions.

1. Examine a copy of *Drug Facts and Comparisons*.
2. Briefly describe the information found in the five sections. (LO 1.7)

Drug Facts and Comparisons sections:

- a. Manufacturer's Index—lists the pharmaceutical manufacturers, addresses, phone numbers, and emergency contacts.
 - b. Brand and Generic Name Index—gives the page number of each drug by trade (brand) name and generic name.
 - c. Product Category Index—lists all fully described products by prescribing category.
 - d. Product Identification Guide—presents full-color, actual-size photos of tablets, capsules, and dosage forms.
 - e. Product Information—main section of book; describes pharmacology and clinical information concerning the use of these drugs.
3. Look up the popular decongestant pseudoephedrine in Section 2 of the *Drug Facts and Comparisons*. What is your conclusion based on the available trade names? (LO 1.7)

Pseudoephedrine is available under many different trade names and in combination with other cold and allergy medications.

4. What is a dose–response curve and what information is given by a dose–response curve? (LO 1.4)

A dose–response curve graphically plots the dosage range of a drug and the response it produces. It shows how the response increases as the dosage increases until a maximal response is attained (the ceiling effect).

5. What is the importance of a time–plasma drug concentration curve? How often would you estimate that a drug should be administered per day if the drug is eliminated in 4 hours? In 24 hours? (LO 1.4)

The time–plasma drug concentration curve shows the change in the drug response over time as various pharmacokinetic processes affect the amount of drug in the body. A drug that is eliminated from the body in 4 hours would require six doses per day. Drugs that are eliminated in 24 hours are usually given once a day.

6. It is interesting that a drug can produce a therapeutic effect and an undesired side effect in one situation, and that the same side effect may be considered a therapeutic effect in another situation. Explain this phenomenon using the drug promethazine (*Phenergan*) as an example. (LO 1.2)

Promethazine (Phenergan) is mainly used as an antihistamine in allergies. The most common side effects are drowsiness and sedation. It is also administered before bedtime in order to produce a hypnotic (sleep-inducing) effect.

7. Obtain a copy of *Drug Facts and Comparisons* from your school or library. It is divided into many sections. There are five sections that are frequently used. Examine each section and briefly explain how it might be useful in your field. (LO 1.7)
 - a. Table of Contents
 - b. Color Locator
 - c. Color Locator Index
 - d. Chapters; broken down by sections on drug classifications
 - e. Index

Drug Facts and Comparisons:

- a. It lists the contents of the book and where to find specific items.
- b. It has the ability to identify a listed medication with only a physical description.
- c. It has the ability to describe a listed medication.

- d. Medications are arranged according to classification and indication. Complete product information is supplied.
- e. The medications are arranged alphabetically by both brand name and generic name.

Applying Knowledge on the Job

Use your critical-thinking skills to answer the following questions.

1. Obtain a copy of the *Drug Facts and Comparisons* from your school, nursing unit, or clinic and use it to do some sleuthing. Find the drugs that solve the following “medical mysteries.” (LO 1.7)
 - a. **Ramón** is currently taking the drugs *Mephyton*, *Biaxin*, and *Entex LA* for his chronic celiac disease and acute sinusitis. He was just prescribed *Coumadin* for thrombosis, and it had no therapeutic effect. Dan’s doctor suspects it’s a case of drug antagonism. Which drug is Dan taking that is antagonistic with *Coumadin*?
 - b. Mary, a 85-year-old female, just came home from the doctor with a prescription for *Vaseretic*. Explain what this drug is, its indications, and the most common adverse effects.
 - c. Bill’s spouse, who may be pregnant, was just prescribed Vibra-Tabs for a respiratory infection. Bill asks you if it is safe to take this drug during pregnancy.

Answers from *Drug Facts and Comparisons*:

- a. Mephyton is a form of vitamin K that increases the synthesis of blood-clotting factors; this would antagonize Coumadin, which functions to delay blood clotting.
 - b. Vaseretic is a combination of an antihypertensive drug and a diuretic used to treat high blood pressure. Dizziness and headache are the most common adverse effects.
 - c. Vibra-Tabs contain doxycycline, a tetracycline antibiotic. These drugs are contraindicated during pregnancy; she should call her doctor and report that she may be pregnant.
2. Assume that your employer has asked you to help screen patients for potential prescription drug problems. Look up the following frequently prescribed medications and provide the information requested. (LO 1.7)
 - a. *Indocin*: What would indicate that a patient was showing adverse effects to the drug?
 - b. *Bicillin*: Describe symptoms of a patient who is allergic to this drug.
 - c. *Depakote*: For whom is this drug contraindicated?

Answers:

- a. The patient with adverse effects to Indocin is most likely to have gastrointestinal or central nervous system problems, particularly nausea, dyspepsia, or dizziness.
- b. Hypersensitivity reactions to Bicillin include skin eruptions, urticaria (hives), laryngeal edema, and fever.
- c. Depakote should not be administered to patients with liver disease or liver dysfunction. It also may be contraindicated during pregnancy.

Use *Drug Facts and Comparisons* to answer the following questions.

3.

- a. **A patient finds a single loose tablet on the carpet and calls you to help identify it. The patient describes the tablet as a small blue tablet with a heart cut out of the middle.** There is writing on the tablet, but it is too small to read. What is this medication? (LO 1.7)
- b. **While traveling, a patient's medications got mixed together. The patient needs to take a Cordarone tablet but isn't sure which tablet it is. Can you describe this medication to the patient?** (LO 1.7)

Answers from *Drug Facts and Comparisons*:

- a. Valium 10 mg.
- b. A pink tablet. One side is scored, with the name "Wyeth" imprinted above the scoring and the numbers "4188" imprinted below the scoring. The other side has a raised "C" along the outer side, with the number "200" imprinted in the middle.

4.

- a. A physician wants to know what glucose-elevating products are available and whether they require a prescription. Look under the hormone section and find these products. List the available products, strengths, forms, and status. (LO 1.7)
- b. A physician wants to know the available forms and strength of *Imitrex*. Using the index, look up the medication and list the available forms, strengths, and package sizes. (LO 1.7)

Answers from *Drug Facts and Comparisons*:

- a. Glucagon injection, 1-mg and 10-mg vial with diluent—RX; Proglycem capsule, 50 mg—RX; Proglycem oral suspension, 50 mg/ml—RX; glucose gel 40 percent—OTC; Insta Glucose Gel 40 percent—OTC; Insulin Reaction Gel 40 percent—OTC; B-D glucose chewable tablet, 5 g—OTC

- b. 25-mg tablet, #9; 50-mg tablet, #9; 12-mg/ml injection, 0.5-ml unit of use in a 1-ml syringe; 6-mg/0.5-ml injection, 0.5-ml unit of use in a 2-ml vial.
5. Sarah Roberts has liver damage due to a past history of alcohol use disorder. She is also taking carbamazepine 400 mg TID. Can she safely take acetaminophen for her chronic headaches? (LO 1.7)

No. This is contraindicated due to liver impairment as well as possible drug interaction with carbamazepine. Carbamazepine has the potential to increase hepatotoxicity. Refer the patient to her physician or pharmacist.

Multiple Choice

Use your critical-thinking skills to answer the following questions. Select the correct answer.

1. The study of drug absorption, distribution, metabolism, and excretion is known as (LO 1.1)
- A. pharmacotherapeutics
 - B. pharmacodynamics
 - C. pharmacokinetics
 - D. pharmacy
 - E. posology
- Answer: C
2. The medical situation when a particular drug should not be administered is referred to as (LO 1.2)
- A. side effect
 - B. adverse effect
 - C. drug allergy
 - D. contraindication
 - E. antagonism

Answer: D

3. An unusual or unexpected drug reaction by an individual is known as (LO 1.5)
- A. toxic effect
 - B. antagonism
 - C. idiosyncrasy
 - D. side effect
 - E. drug allergy

Answer: C

4. The proprietary drug name supplied by a pharmaceutical company is also referred to as the (LO 1.6)
- A. generic name
 - B. over-the-counter name
 - C. trade name
 - D. chemical name
 - E. none of these

Answer: C

5. The time from drug administration to the first observable drug effect is known as the (LO 1.4)
- A. duration of action
 - B. onset of action
 - C. ceiling effect
 - D. maximal response
 - E. none of these

Answer: B

6. A drug that has the potential for abuse and is regulated by the Drug Enforcement Agency is classified as a (LO 1.7)
- A. poison
 - B. OTC drug
 - C. prescription drug
 - D. controlled substance
 - E. nonproprietary drug

Answer: D

7. Select the term below that relates to the amount of drug administered to produce a therapeutic effect. (LO 1.1)
- A. posology
 - B. toxicology
 - C. pharmacodynamics
 - D. pharmacotherapeutics
 - E. pharmacy

Answer: A

8. A medication that does not require a physician's service to obtain is referred to as (LO 1.6)
- A. trade
 - B. nonproprietary
 - C. nonprescription
 - D. brand
 - E. generic

Answer: C

9. Which of the following could be categorized as an adverse reaction? (LO 1.5)
- A. idiosyncrasy
 - B. drug allergy
 - C. teratogenicity
 - D. carcinogenicity
 - E. all of these

Answer: E

10. The time a drug continues to produce its effect is its (LO 1.4)
- A. ED50
 - B. maximal response
 - C. ceiling effect
 - D. onset of action
 - E. duration of action

Answer: E

1.8