UNIT 1

Introduction to Pharmacology

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CHAPTER 1

A Brief 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. Pharmacology has evolved significantly from the days when resources were used to cure the ill without understanding why they worked or did not work. 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 medications 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 medications; the acceptance of alternative medicine, and its place in medicine; and the six main categories of medications 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 10 common medications and record their sources.

KEY TERMS

Alternative medicine (al-tĕr-nā´tuv med´ĭ-sin)
Antineoplastic (ant´´i-nē´´ō-plas´tik)
Bovine (bō´vīn)
Curative (kū´ră-tĭv)
Destructive (duh·struhk·tuhv)
Diagnostic (dī´´ăg-nos´tik)
Drug/droog (drŭg/drôge)
Ebers Papyrus (Ebers puh·pai·ruhs)
Palliative (păl´ē-ā´´tĭv)
Pharmacodynamics (făr´´mă-kō-dī-năm´ĭks)
Pharmakon (făr´´mă-kn)
Porcine (por´sīn´´)
Prophylactic (prō´´fī-lak´tik)
Replacement medications (ri-plās´mĕnt med-ĭ-kā´shŏns)
Synthetic medications (sĭn-thĕt´ĭk med-ĭ-kā´shŏns)

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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 using **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 with or counteract a prescribed pharmaceutical medication. It is important to assess a complete list of the patient's medication.

CRITICAL THINKING

Harold P. comes to the office complaining of sinus pressure and pain. In the intake interview, you discover that he has been using aromatherapy for the past 3 weeks.

• What do you do?

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 depending on the culture and were chosen based on their knowledge of which plants or other substances to use, how to prepare them, 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 AD and included 365 medicines, 252 of which were herbs. In Egypt, a medical document called the **Ebers Papyrus** was written circa 1550 BC and lists about 700 "recipes" for a host of illnesses, from crocodile bites to psychiatric illnesses.

The contributions from these cultures and many others 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 of 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.

Pharmacological Advances Through the 19th and 20th Centuries

Over time, an increasingly scientific approach to the discovery and understanding of medicines 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 medicine 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. 1-1). Not until World War II (1939 to 1945) did the mass production of medicine begin (Fig. 1-2). 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

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

FIGURE 1-2 Mass production of medication, 1944. *(From the Library of Congress Prints and Photographs Division, Washington, D.C.)*

World War II. For instance, the death rate from pneumonia 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 medications such as penicillin that could save millions of lives, the belief grew that new medicines 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 medications were either discovered or developed. Researchers studied plants, marine animals, and microorganisms in the soil, water, and air in order to discover possible new medications. 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 combining 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 medications 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 medications 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 medications 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 medicines and dosages for opioids and antihypertensives, among other medications.

SOURCES OF MEDICATIONS

Although most medications 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 medicines are made by combining chemicals with natural products, such as hydrocodone and acetaminophen (Vicodin, Norco, Lorcet), which combines natural opium in the form of codeine combined with acetaminophen (a human-made medication), whereas other medicines are synthesized in a laboratory. Barbiturates are an example of synthetic medicines 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 medicine. Digoxin (Lanoxin), a medication 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

1. If people rely on plants for medication, what effect does the increasing human population have on the potential supply of medications?
2. Raymond H. comes to his cardiologist with complaints of an irregular heartbeat and dizziness. In further talking with him, you discover he has been seeing a homeopathic healer and has been drinking foxglove tea to improve his circulation.
   - What do you say?

Animals

Domesticated animals are also a source of medications. To ensure the purity of the medication, donor animals are generally well cared for. Some examples include sheep, which provide lanolin, a topical skin medication that comes from 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 immunoglobulin G (IgG) by injecting an antigen into animals (most commonly cows) and collecting the antibody that is formed. The medication heparin is extracted from porcine intestinal mucosa and bovine lungs.

CRITICAL THINKING

1. Cows and pigs are good sources of hormones. Do you think animals may be a better hormone source than humans? Why or why not?
2. Muhammed A. is a devout Muslim. He does not eat pork. What is the best choice of insulin for him? Explain your rationale for this choice.

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. Diuretics 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.

Minerals are also used to treat certain conditions. For example, gold is used in the treatment of arthritis, iodine is used to treat goiters, 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), overactive bladder, and migraines. It is used in tiny doses.

CRITICAL THINKING

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

Synthetic Medications

Synthetic medications can be created by chemical processes, by genetic engineering, or by altering animal cells. Often, medications that are obtained from another source can be synthesized in the laboratory, thus preserving natural resources. For example, paclitaxel (Taxol), a medicine used to treat patients who have 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 medication, thus preserving the yew tree. Insulin can be obtained from pigs or cows, but a synthetic source is now 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 less expensive 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. One area of uniqueness is the variation in the amount of medication-metabolizing enzymes each patient has and the effectiveness of these enzymes. The scientists 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 medication-metabolizing enzyme. Therefore, prescribers can choose the specific medication that will work best for the patient. Research is also being conducted on the use of existing medications in targeted populations. For example, BiDil, the first Food and Drug Administration–approved medication for a single racial group (African Americans) with heart failure, is a combination of two generic medicines—hydralazine hydrochloride and isosorbide dinitrate.

CRITICAL THINKING

1. What are some of the ethical issues of genetically engineered medications?
2. Mary L. is adamantly against stem cell research and is refusing to use Humulin insulin. What do you think? How is Humulin insulin created?
3. Explain how Humulin insulin is okay to be used, or not used, based on Mary's beliefs.

CATEGORIZING MEDICATIONS

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

1. **Curative.** Some medications restore normal physiological function, as in diuretics, which help the body rid itself of excess fluid.
2. **Prophylactic.** These medicines prevent diseases or disorders, as in antibiotics given before surgery to prevent infection.
3. **Diagnostic.** Some medications help diagnose a disease, such as barium (a contrast agent) that patients swallow to help highlight digestive problems on a radiograph.
4. **Palliative.** Other medications, such as pain relievers, do not cure disease, but they make patients more comfortable.
5. **Replacement.** These medicines "replace" missing substances. Levothyroxine sodium (Synthroid, Levoxyl), for example, replaces a missing thyroid hormone.
6. **Destructive.** Some medications destroy tumors and microbes. **Antineoplastics** (anticancer medications) are an example of destructive, toxic medications.

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 medications may affect a patient. Understanding this information will help you provide effective counseling, patient care, and safe administration of medications depending on your role and scope of practice.

CRITICAL THINKING

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

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

TABLE 1-1 Medication 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) • Contrast agents
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 (Synthroid, Levoxyl) • Natural thyroid to treat hypothyroidism
Destructive	Destroys tumors and/or microbes	• Doxorubicin (Adriamycin) is an antitumor antibiotic that can target and damage rapidly growing cells.

THE ROLES OF THE LICENSED PRACTICAL NURSE (LPN), LICENSED VOCATIONAL NURSE (LVN), AND MEDICAL ASSISTANT (MA) 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 practice for licensed practical nurses (LPNs) and licensed vocational nurses (LVNs). LPNs/LVNs generally administer oral, rectal, ophthalmic, otic, intradermal, subcutaneous, and IV medications. In most states, LPNs/LVNs may not give medications by rapid IV push. Many states additionally regulate whether 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 (RN).

Medical assistants (MAs) may usually administer oral, intradermal, subcutaneous, and intramuscular medications, as well as rectal, otic, and ophthalmic medications. In some states, MAs 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 the direct supervision of a physician, physician assistant, nurse practitioner, or nurse.

SUMMARY

- Ancient cultures have contributed to the knowledge base and evolution of pharmacology. An example of early documentation is the Egyptian Ebers Papyrus (1550 BC).
- 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 medications.
- 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 medication creates in the body.
- Mass production of medications began around 1939 to 1945, and genetic engineering produced large amounts of medications 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 their disease.
- Sources of medications include plants, animals, minerals, toxins, and synthetic creations.
- The six categories of a medication's effect on the body are curative, prophylactic, diagnostic, palliative, replacement, and destructive.
- Roles of the LPN/LVN and MA in medication administration are governed by their scope of practice, which is established by state regulations and facility policies.

Activities

To make sure that you have learned the key points covered in this chapter, complete the following activities.

Multiple Choice

Choose the best answer for each question.

1. Which of the following is the source of lanolin?

A. Animal
B. Plant
C. Mineral
D. Human
E. Synthesis

2. Which of the following is the source of potassium chloride?

A. Animal
B. Plant
C. Mineral
D. Human
E. Synthesis

3. Which of the following is the source of digoxin (Lanoxin)?

A. Animal
B. Plant
C. Mineral
D. Human
E. Synthesis

4. Which of the following is the source of barbiturates?

A. Animal
B. Plant
C. Mineral
D. Human
E. Synthesis

5. Which of the following is the source of leukocytes?

A. Animal
B. Plant
C. Mineral
D. Human
E. Synthesis

6. During which war did mass production of penicillin begin?

A. Civil War
B. World War I
C. World War II
D. Korean War
E. Vietnam War

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7. Genetic engineering is used to make what type of medications?

A. Synthetic
B. Homeopathic
C. Natural
D. None of the above

8. What was the source of insulin before the synthetic production of medicine?

A. Cows
B. Horses
C. Pigs
D. Both A and C
E. All of the above

9. Toxins are commonly used to treat what aging symptom?

A. Loss of hearing
B. Diminished sight
C. Wrinkling of skin
D. Depression

10. What medication used in the treatment of menopause is obtained from horses?

A. Estrogen
B. Premarin
C. Paxil
D. None of the above

Short Answer Questions

1. Are animals a good source for medications? Explain your answer.

_____

_____

2. What source of medications is in danger of disappearing?

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_____

3. What was the catalyst to begin mass production of medicine?

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4. Discuss alternative medicine and what role it should play (in your opinion) in patient care.

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Internet Research

1. Use the keywords “the future of pharmacology” to research possible directions that pharmacology is headed. Select and describe one specific area of future development that you find.

2. Use your search engine to discover sources of medications used now and possibly in the future. Use the keywords “medication sources past, present, and future.” Pick one source that was not discussed in this chapter and write about it to share with your class.

3. Use the keywords “medications made using recombinant DNA” to locate information on recombinant DNA. Pick one medication that you find and write about how recombinant DNA is used to make it.

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