# Drugs, Dose Forms, and Delivery Systems

## **Learning Objectives**

- Define the term *drug* and distinguish between over-the-counter and legend drugs.
- Explain the parts of a National Drug Code number.
- Categorize drugs by source as natural, synthetic, synthesized, or semisynthetic.
- Explain the uses of drugs as therapeutic, pharmacodynamic, diagnostic, prophylactic, and destructive agents.
- Define and differentiate between the terms *dose form* and *delivery system*.
- Enumerate and explain the properties and identify advantages and disadvantages of the major dose forms and delivery systems for drugs.
- Identify the function of various commonly used pharmaceutical reference texts.

n the past five decades technological advances in the synthesis and delivery of pharmaceuticals have transformed everyday lives, providing improved antibiotics, vaccines, cancer chemotherapy, and medications to better control chronic diseases such as high blood pressure, high cholesterol, and diabetes. Modern pharmaceutical science has given us a vast array of medicines to be administered in an equally wide variety of forms. In this chapter, you learn the dose forms and delivery systems of the many pharmaceuticals scientists have created.

Chapter

## PHARMACEUTICALS

A **drug** is defined as any substance taken into or applied to the body for the purpose of altering the body's biochemical functions and thus its physiological processes. In years past, the pharmacist and the physician compounded drugs in a more crude state, often powders, extracts, and tinctures containing herbal remedies. Modern science has led to the development of highly researched and standardized medications that are more potent and toxic than the natural herbal remedies of the past.

Drugs are products designed with a specific use in mind and contain many other components besides the active ingredient. The **active ingredient** (or ingredients) is the biochemically reactive component (or components) of the drug. An active ingredient is rarely given in pure (i.e., undiluted, uncut) form. Instead, one or more active ingredients are combined with one or more **inert ingredients** or inactive ingredients that have little or no physiological effect. Most drugs contain one or more active ingredients commingled, dispersed, or in solution or suspension within an inert primary base, or vehicle, that may contain other ingredients, such as antimicrobial preservatives, colorings, and flavorings. These inactive ingredients are needed to stabilize the tablet or liquid formulation, provide the raw material for many topical creams and ointments, ensure sterility of injectable products, or assist in the masking of unpleasant tasting medications for pediatric patients.

#### Figure 3.1

#### NDC Number and **Bar Code**

For both of these labels for Vistaril, the first four digits of the NDC number (0069) indicate Pfizer Labs. The second four digits indicate the product code. The last two digits of the NDC numbers define the packaging size and type. (a) The product code (5420) identifies the drug as hydroxyzine pamoate, 50 mg. (b) The product code (5440) identifies the drug as hydroxyzine pamoate, 25 mq/5 mL.





#### National Drug Code

Under the Drug Listing Act of 1972, each medication must have a unique National Drug Code (NDC) number that appears on all drug labels, including labels of prescription containers. The 10-character NDC includes a four- or five- digit labeler *code*, identifying the manufacturer or distributor of the drug; a three- or four- digit product code, identifying the drug (active ingredient and its dose form); and a twodigit *package code*, identifying the packaging size and type. The NDC *bar code* number is commonly used by the Food and Drug Administration (FDA) for drug recalls and by pharmacies to compare medications dispensed in the filling process to minimize medication errors. Figure 3.1 shows NDC numbers and corresponding bar codes on labels for two different forms of hydroxyzine pamoate.

#### **Classes of Drugs**

Drugs are classified as **over-the-counter (OTC)** or *legend*. A legend drug can be dispensed only with a prescription from a healthcare professional licensed in that state to practice. Such drugs are labeled with the legend "Caution: Federal Law Prohibits Dispensing Without Prescription" or an equivalent symbol (Rx) (Figure 3.2). Therefore prescription drugs are also known as *legend drugs*. The new legend in the updated labeling law is "Rx only."

Drugs with potential for abuse are classified, under the Comprehensive Drug Abuse Prevention and Control Act of 1970, according to five drug schedules as presented in Chapter 2 (based on the potential for abuse and physical and psychological dependence). Schedule II drugs such as narcotics and amphetamines have a high potential for abuse and dependence, whereas Schedule V cough syrups have a low potential for abuse and limited potential for creating physical or psychological dependence.

Sterile

Figure 3.2 Drug Caution Legends





the Drug Facts label, visit the Consumer Healthcare Products Association Web site at http://www .chpa-info.org and select "For Consumer."



To learn more about independent testing of diet supplements, visit www .consumerlab.com

Safety Note Not all homeopathics are OTC. An OTC drug is one that can be dispensed without a prescription. The FDA has approved many drugs that have come off patent and proven relatively safe over the years to be sold as OTC medications. Such examples include Advil (ibuprofen), Aleve (naproxen), Benadryl (diphenhydramine), Claritin (loratadine), and hydrocortisone. The label of an OTC drug must contain all the information necessary for a consumer to safely take the medication including indication, dose for various age groups, side effects, warnings, and expiration date.

Most pharmacies have an inventory of vitamins, minerals, herbs, and diet supplements. Diet supplements, especially herbs, should be considered weak drugs that can cause side effects, adverse reactions, and drug interactions. As discussed in Chapter 2, these medications do not have the same stringent controls as legend and OTC medications, and they are loosely regulated by the Dietary Supplement Health and Education Act (DSHEA) amendments of 1994. The quality of many of these products should be verified with an independent laboratory. Diet supplements are considered "food supplements" to maintain health, and a patient should not exceed the recommended daily dose without the knowledge of a physician or pharmacist. The pharmacy technician can assist the pharmacist by gathering information on the patient use of diet supplements and adding this data to the computer profile.

Another class of drugs is called **homeopathic medications**. The term *homeopathy* is derived from the Greek words *homos* (i.e., similar) and *pathos* (i.e., suffering or disease). Homeopathic practice uses subclinical doses of natural extracts or alcohol tinctures. In other words, the active ingredient is diluted from one part per ten (1:10) to more than one part per thousand (1:1000). The concept is that these small doses are sufficient to stimulate the body's own immune system to overcome the specifically targeted symptom. Most homeopathics are OTC, but some are prescription only. Homeopathy was popular in the United States in the early nine-teenth century and remains popular in many areas of Europe today.

## SOURCES OF DRUGS

Drugs come from various sources and can be classified as natural, synthetic (created artificially), synthesized (created artificially but in imitation of naturally occurring substances), and semisynthetic (containing both natural and synthetic components).

### **Drugs from Natural Sources**

Some drugs are naturally occurring biological products, made or taken from singlecelled organisms, plants, animals, and humans. Many herbal products come from natural sources. Examples of modern-day drugs from natural sources are listed:

- Penicillin was discovered in 1928 and is extracted from certain molds.
- Vitamin B<sub>12</sub> and the antibiotic streptomycin are produced from cultures of the bacterium *Streptomyces griseus*.
- Opium, the narcotic, comes from the poppy plant and is a source for both legal drugs such as morphine and illegal drugs such as heroin.
- Quinine, used to treat malaria and colchicine, as well as acute gout, comes from the bark of the cinchona tree.
- Acetylsalicylic acid, more commonly known as *aspirin*, is derived from the bark of the white willow tree (which contains salicylic acid).
- Insulin, a life-saving drug for the treatment of diabetes mellitus, is extracted from the pancreas of various animals.
- Human growth hormone, or somatotropin, comes, as its name suggests, from human bodies (the anterior pituitary produces it).



The bark of the willow tree, which contains salicylic acid, has been used for centuries to treat toothache.

• (Milk of) Magnesia is a combination of magnesium oxide or hydrated magnesium carbonate and is used as an antacid or laxative.

# Synthetic, Synthesized, and Semisynthetic Drugs

In the modern era many naturally occurring chemicals have been synthesized. A synthesized drug is a drug created artificially in the laboratory but in imitation of naturally occurring drugs like adrenaline, which is used for heart and asthmatic attacks. A synthetic drug is one that is created artificially to exert a specific pharmacological effect. Barbiturates, sometimes prescribed as a sleep medication, are examples of synthetic drugs. A naturally occurring drug like a barbiturate does not exist. **Semisynthetic drugs** contain both natural and synthetic molecules. An example would be semisynthetic penicillins, which combine artificially created molecules with naturally occurring ones. These new penicillin derivatives are effective against different bacteria or bacteria that have developed resistance to the natural penicillins.

**Biotechnology** combines the science of biology, chemistry, and immunology to

produce synthetic, unique drugs with specific therapeutic effects. These drugs can be created by means of the recombinant deoxyribonucleic acid (recombinant DNA) techniques of genetic engineering. **Deoxyribonucleic acid (DNA)** is the complex, helically shaped molecule that carries the genetic code (Figure 3.3). This molecule contains the instructions, or recipe, for creating messenger **ribonucleic acid (RNA)**, which in turn contains the recipe for arranging amino acids into proteins for living organisms. **Recombinant DNA** is DNA constructed of segments taken from different sources (e.g., for example, from a human being and a sheep). By transferring a segment of recombined DNA into a host cell, scientists can change what proteins the cell produces. In effect, this converts the cell into a small-scale protein factory to produce chemical substances that can be used as drugs. For example, using the bacterium *Escherichia coli*, microbiologists and geneticists can induce the production of human insulin or human growth hormone. Human insulin has replaced animal-derived insulin; it is more active with fewer side effects.

Another biotechnological method of drug production is the use of cells from inoculated animals to produce, in the laboratory, hybrid cells that create substances known as **monoclonal antibodies (MAbs)**. **Antibodies** are created by the immune system in response to foreign substances in the body known as *antigens*. Laboratory-produced MAbs can be used to attack tumors and to diagnose a great variety of conditions, from pregnancy to anemia to syphilis. **Genetic engineering**, the hybridization techniques for creating MAbs, and other biotechnologies are already used to create a great variety of drugs, such as clotting factors for treating hemophiliacs and interferons for

#### Figure 3.3

Modeling DNA (a) A single nucleotide. (b) A short section of a DNA molecule consisting of two rows of nucleotides connected by weak bonds between the bases adenine (A) and thymine (T), guanine (G) and cytosine (C). (c) Long strands of DNA twisted to form a double helix.



combating viral infection and some cancers. Such technologies promise to bring many new drugs to the market.

Numerous drugs in various stages of research use technology involved with the mapping of the human genome. The Human Genome Project has been under way since the 1980s and is best described as the mapping of the biochemical instructions that make up the human body in health and disease. For example, a defective gene has been identified in many patients with breast cancer. As more of the genome is mapped and understood and more disease states are located, potential disease can be identified at an earlier date, and new treatments can be specifically designed to treat the identified biochemical errors located in the human genome.

## **USES OF DRUGS**

Medications today are being used not just to treat and cure illnesses but also to aid in diagnosis and even prevent illnesses. Healthcare providers have numerous agents at their disposal and a wide variety of dose forms and drug delivery systems to customize treatment of a patient. It is essential to understand the inherent differences, as well as the advantages and disadvantages, of the different dose forms used today. The action of a medication cannot be taken into account without considering the dose form selected. The patient outcome may depend on selecting the most appropriate medication *and* dose form to meet the patient's needs.

Several classifications for uses of drugs exist, and most are not mutually exclusive. The following should assist the student in sorting out which classification best describes the various uses of drugs.

#### **Therapeutic Agents**

A **therapeutic agent** is any drug that helps to do the following:

• *Maintain Health*—Drugs with this purpose include vitamins and minerals to regulate metabolism and otherwise contribute to the maintenance of normal growth and functioning of the body. A specific example is the use of baby aspirin for patients identified as being at risk for heart attack.



- *Relieve Symptoms*—Drugs with this purpose include anti-inflammatory drugs like ibuprofen used to treat fever, pain, or inflammation; narcotics to treat and prevent severe pain in terminally ill patients with cancer; or a diuretic or water pill to control excess fluid.
- *Combat Illness*—Drugs with this purpose include antibiotics to cure pneumonia, strep throat, or a bladder infection. Although antiviral medications do not cure human immunodeficiency virus (HIV) or acquired immunodeficiency syndrome (AIDS), they may allow the immune system to remain intact so as to delay disease progression.
- *Reverse Disease Processes*—Drugs with this purpose include medications that control depression, blood pressure, cholesterol, or diabetes.

#### **Pharmacodynamic Agents**

A **pharmacodynamic agent** alters bodily functioning in a desired way. Drugs can be used, for example, to stimulate or relax muscles, to dilate or constrict pupils, or to increase or decrease blood sugar. Examples of pharmacodynamic agents include caffeine to forestall sleep, oral contraceptives that depress hormones to prevent pregnancy, expectorants to increase fluid in the respiratory tract, anesthetics to cause numbness or loss of consciousness, glucagon to increase blood sugar in diabetics, and digoxin to increase heart muscle contraction or slow heart conduction in patients with heart disease.

#### **Diagnostic Agents**

A **diagnostic agent** facilitates an examination (usually one conducted to arrive at a diagnosis) or conclusion as to the nature or extent of a disease condition. Chemicals containing radioactive isotopes, used diagnostically (and also therapeutically), are known as **radiopharmaceuticals**. Isotopes are forms of an element that contain the same number of protons but differing numbers of neutrons. Unstable, radioactive isotopes give off energy in the form of radiation, measured in rads. One rad is equal to 100 erg of energy absorbed by 1 g of body tissue. Nuclear medicine uses radioactive isotopes such as technetium (<sup>99m</sup>Tc) and iodine (<sup>131</sup>I) for imaging regional function and biochemistry in the body, as in positron emission tomography (PET) or single photon emission computed tomography (SPECT). Nuclear pharmacy involves the procuring, storage, compounding, dispensing, and provision of information about radiopharmaceuticals, and it is one possible area of specialization for both pharmacists and pharmacy technicians.



tion on nuclear pharmacy technician training programs, visit www.aphanet.org

#### **Prophylactic Agents**

A **prophylactic agent** prevents illness or disease from occurring. Examples of prophylactic agents include the antiseptic and germicidal liquid iodine used to prep skin preoperatively for the prevention of infection. Any vaccine is considered a prophylactic agent to prevent diseases such as influenza, pneumonia, measles, mumps, rubella, chicken pox, smallpox, poliomyelitis, and hepatitis.

#### **Destructive Agents**

A **destructive agent** has a *-cidal* action; that is, it kills bacteria, fungi, viruses, or even normal cells or abnormal cancer cells. Many antibiotics, especially given in high doses and **intravenous (IV) infusions**, are bactericidal (i.e., they kill [rather

than just maim] the bacterium if it is sensitive to the drug). Another example of a destructive agent is radioactive iodine, which is used to destroy some of the thyroid gland in patients with hyperthyroidism.

Another common example of destructive agents are **antineoplastic drugs** used in cancer chemotherapy to destroy malignant tumors. Cancer is often caused by an unregulated growth of abnormal dysfunctional cells. Antineoplastics are used in combination to slow cancer cell growth. Unfortunately, most cancer drugs cannot distinguish cancer from normal cells, so side effects such as hair loss, further depression of the immune system, and ulcerations of the mouth or gastrointestinal (GI) tract commonly occur. These drugs require special storage, preparation, and monitoring (see Chapter 10, *Infection Control and Safe Handling of Hazardous Agents*). Research from drug studies and the development of unique drug delivery systems continue to improve our ability to dose and target cancer cells more specifically.

## COMPARISON OF DOSE FORMS AND DELIVERY SYSTEMS

The term **dose form** refers to the physical manifestation of a drug as a solid, liquid, or gas that can be used in a particular way. Examples of common dose forms include tablets, capsules, creams, ointments, solutions, injections, and aerosols.

The term **delivery system** has several definitions in healthcare and may include any of the following:

- Device used to deliver the drug (e.g., teaspoon, syringe, nebulizer, IV fluid, infusion pump)
- Design feature of the dose form that affects the delivery of the drug, such as the coating on some capsules that resists breakdown by the gastric fluids in the stomach so that the capsule will release medication, instead, into the intestines
- Means for *transporting a drug to its site(s) of action within the body*

Delivery systems differ in their pharmacological properties; that is, their sites of action, rate of delivery, and quantities of active ingredient delivered differ. Consider, for example, the drug nitroglycerin, commonly used to treat angina pectoris (pain in the chest and left arm associated with a sudden decrease in blood supply to the heart). Nitroglycerin dilates blood vessels, thus increasing blood supply to the heart and decreasing blood pressure. Three common delivery systems for nitroglycerin are sublingual tablets, placed under the tongue; ointment measured and applied directly on the skin; and transdermal patches, worn on the skin. Sublingual nitroglycerin tablets are fast acting but deliver their active ingredient for only a short period of time, about 30 minutes. Transdermal patches, in contrast, act slowly, with a delivery onset of about 30 minutes, but they can deliver a steady amount of the drug for up to 24 hours. The ointment is much less costly than the patch; it has a similar onset but a shorter duration of effect (up to 12 hours).

The choice of delivery system depends on many factors, including the following:

- active ingredient to be delivered
- amount of active ingredient to be delivered
- means or route that ingredient is to be delivered
- to what sites
- at what rate
- over what period of time
- for what purpose

Currently drugs are administered in a wide variety of dose forms that are part of an even wider variety of delivery systems. Because of the variety and overlap of dose forms and delivery systems, it is impossible to create a rigid, mutually exclusive taxonomy, or classification. The following discussion reviews the characteristics of both dose forms and the delivery systems used.

## SOLID DOSE FORMS

Solid dose forms are used more frequently than any other form and are safer for the patient to self-administer. Capsules and tablets are the two most common types and are very inexpensive to manufacture. A wide variety of capsule types and sizes exist. Other solid dose forms such as effervescent salts, implants, lozenges, plasters, powders, and suppositories are used less frequently but are still very important, because they enable the physician and pharmacist to meet the needs of an individual patient more adequately.

#### **Tablets**

Tablets are available in a wide variety of shapes, sizes, and surface markings. The **tablet** is a solid dose form produced by compression and contains one or more active ingredients and, commonly, other pharmacological ingredients. These ingredients include diluents, binders (to promote adhesion of the materials in the tablet), lubricating agents (to give the tablet a sheen and to aid in the manufacturing process), disintegrates (to help break up the ingredients), solubilizers (to maintain the ingredients in solution or to help the ingredients pass into solution in the body), colorings, and coatings. For obvious reasons, tablets also commonly contain flavorings. Coatings can be used to protect the stability of the ingredients in tablets; improve appearance, flavor, or ease of swallowing; or provide for controlled (sustained or delayed) release of medication.

Tablets are extremely convenient because of the ease with which various doses can be delivered. A patient can take one tablet, several tablets, or a portion of a tablet, as required. Some tablets are *scored* once or twice to facilitate breaking into portions for half or even quarter doses. Scoring of a tablet is designed to equally divide the dose in each section. If a tablet is not scored, then it is generally recommended that it should not be broken because the dose may not be equal in each piece. However, because of rising drug costs, it is not uncommon for patients, as well



Capsules and tablets come in a variety of sizes and colors. Distinctive markings help patients identify the drugs.

as managed-care organizations and Veterans Administration (VA) hospitals, to use a tablet splitter for unscored tablets to treat conditions such as high blood pressure and high cholesterol (providing up to 50% savings). Limited studies suggest that the practice does not appreciably affect the control of the disease state with select medications. Odd-shaped tablets are often difficult to cut, even with a tablet splitter.

Punch-and-die machines that compress the ingredients of each tablet in a single stroke create almost all tablets produced today. Compression tablets are the most inexpensive and common dose form used today. Some tablets are produced by multi-



A tablet splitter can save money for the patient on high-cost medications.

#### Safety Note

Careful tablet splitting may be a way to reduce medication costs, but it is not recommended for all drugs. Patients must be warned not to take a full tablet if such action would result in an overdose of medication.

#### Safety Note

ECT tablets should not be split.

#### Figure 3.4

Multiple Compression Tablets (MCTs) (a) Two layers or compressions. (b) Three layers or compressions. ple compressions and are, in effect, either tablets on top of tablets or tablets within tablets. These are called *multiple compression tablets (MCTs)* (Figure 3.4). An MCT may contain a core and one or two outer shells (or two or three different layers), each containing a different medication and colored differently. MCTs are created for appearance alone, to combine incompatible substances into a single medication, or to provide for controlled release in successive events, or stages.

Some manufacturers have begun to manufacture an oblong tablet that is a hybrid of the capsule and tablet, called the *caplet*. The caplet is simply a tablet shaped like a capsule and sometimes coated to look like a capsule. The inside of the caplet is solid, whereas the inside of a capsule is often powder or granular material. The caplet offers the advantage of easier swallowing than a large tablet and more stability (and longer shelf life) than a capsule. Caplet formulations on the market include the OTC drug Tylenol and the antibiotic erythromycin.

Most tablets are uncoated; however, some contain a special outside layer that dissolves or ruptures at the site of application. These coatings may help mask the bitter taste of a tablet, prevent destruction in the stomach, or delay release of drug into the intestines. Common tablet coatings include sugar, film, or enteric.

- Sugar-coated tablets (SCTs) contain an outside layer of sugar that protects the medication and improves both appearance and flavor. The sugar coating of tablets tends to improve taste and increases the chance that the patient will be compliant and take the prescribed medication at the prescribed time. The major disadvantage of sugar coating is that it makes the tablets much larger and heavier, thus more difficult to swallow.
- Film-coated tablets (FCTs) contain a thin outer layer of a polymer (a substance containing very large molecules) that can be either soluble or insoluble in water. Film coatings are thinner, lighter in weight, and cheaper to manufacture than sugar coatings, and they are colored to provide an attractive appearance. The antibiotic erythromycin is an example of an FCT formulation designed to mask a bitter taste.
- Enteric-coated tablets (ECTs) are used for drugs that are destroyed by gastric acid, which might irritate the esophageal tract or stomach, or are better absorbed by the intestines if they bypass the stomach. The enteric coating is designed to resist destruction by the acidic pH of the gastric fluids and to release



(b)

the active ingredient once it reaches the higher pH of the small or large intestine, such as in serious inflammatory diseases of the GI tract. For this reason, these tablets should not be split. Examples of ECTs are aspirin and potassium chloride, because both drugs can be irritating to the stomach.

A **controlled-release medication** is designed to regulate the rate at which a drug is released from the tablet and into the body. Such dose forms may vary the rate of dissolution or the release of the active drug and may offer a therapeutic advantage over conventional dose forms, thus cannot be split or crushed (see Appendix D). The major types of controlled-release medications are delayed, extended, and transdermal.

- A delayed-release dose form does not release the active drug immediately after administration. An example of delayed-release dose forms is an enteric-coated product.
- An extended-release form allows a reduced frequency of dosing compared with conventional forms; this term is synonymous with long-acting, timed-release, and sustained-release dose forms. Many medications for blood pressure use this type of dose form that allows once-daily dosing and better compliance to the prescribed regimen.
- The transdermal system dose form is also a delivery system designed to deliver drugs to the systemic circulation by passage *through the skin* (similar to how the extended-release tablets act by passage through the stomach and/or small intestine). A common example is the various commercially available nicotine patches. (See Chapter 4, *Routes of Drug Administration*, for additional discussion on the transdermal system.)

Most tablets are meant to be swallowed whole and to dissolve in the gastrointestinal (GI) tract. For example, some tablets are designed to be chewed or to be dissolved in liquid, in the mouth, under the tongue, or in the vagina.

- Chewable tablets contain a base that is flavored and/or colored. The dose form is designed to be masticated (or chewed), and it is preferred for antacids, anti-flatulents, commercial vitamins, and tablets for children. Single chewable tablets, for example, can be dosed in small children in lieu of other dose formulations to control asthma symptoms.
- Effervescent tablets are granular salts that release gas and so disperse active ingredients into solution when placed in water or juice. Most people are familiar with effervescent tablets such as Alka-Seltzer to relieve headaches or hangovers.
- Buccal tablets (and gum) are placed in the buccal pouches (between the cheek and the gum) and dissolved and absorbed by the buccal mucosa. (For more information on this route of administration, see Chapter 4.)
- Sublingual tablets are designed to be dissolved under the tongue (*sub*, meaning *under*, and *lingua*, meaning tongue) and absorbed. Medication dissolved under the tongue (e.g., nitroglycerin) is absorbed very quickly and has the advantage of immediately entering the bloodstream.
- Vaginal tablets (or inserts) are designed to be placed into the vagina by means of an applicator and dissolved and absorbed through the vaginal mucosa; vaginal tablets may be less "messy" than equivalent cream formulations, although absorption of active drug is less predictable.

#### Capsules

The **capsule** is a solid dose form consisting of a gelatin shell that encloses the drug. Gelatin is a protein substance obtained from vegetable matter and from the skin, white connective tissue, and bones of animals. The gelatin shell of a capsule, which can be hard or soft, may be transparent, semitransparent, or opaque and may be colored or marked with a code to facilitate identification. In commercial manufacturing, the body and the cap may be sealed to protect the integrity of the drug within (a practice that has increased since the 1980s, when highly publicized incidents of capsule tampering occurred). In most cases the capsule is meant to be swallowed whole (patients often prefer capsules because they are tasteless and are often easier to swallow than tablets).

## Safety Note

Controlled-release tablets should not be split.

### Safety Note

Watch the drug labels very carefully! Delayed-release medication is not the same as extended- or controlled-release medication of the same drug! The capsule will contain powders, granules, liquids, or some combination with one or more active ingredients. In most cases these active ingredients will also contain one or more pharmacologically inert filler substance, or diluent. The capsule may also contain disintegrants, solubilizers, preservatives (which maintain the integrity of the ingredients), colorings, and other materials. Because a capsule is enclosed, flavorings are not common for this dose form.

As with tablets, capsules can be designed in a controlled-release dose form to deliver a drug over a particular period of time (i.e., sustained release) or at a particular site (i.e., delayed action). Names for controlled-release dose forms include constant release, continuous action, continuous release, controlled release, delayed absorption, depot, extended action, extended release, gradual release, long acting, long lasting, long-term release, programmed release, prolonged action, prolonged release, protracted release, rate controlled, repository, slow acting, slow release, sustained action, sustained release, sustained-release depot, timed coat, timed disintegration, and timed release.

The controlled-release capsules are taken less often, and patients are more likely to be compliant. It is much easier to remember to take medication once daily than to take several doses throughout the day. A long-acting form may also give the patient better control over the disease state such as high blood pressure. Although the units may be initially more expensive, fewer need to be purchased. In addition to cost, another drawback is the longer time it may take for side effects to subside.

#### **Suppositories**

**Suppositories** are solid dose forms designed for insertion into body orifices such as the rectum or the vagina or, less commonly, the urethra. Suppositories may be the preferred dose form in some cases when the patient has severe nausea and vomiting. However, many patients avoid the use of a suppository when possible because of their discomfort.

Safety Note The patient must

remove the foil before inserting the

suppository!

Suppositories vary in size and shape, depending on their site of administration and the age and gender of the patient for whom they are designed. Some are meant for local action, such as in the treatment of rectal hemorrhoids. Rectal suppositories, however, are often used as vehicles for systemic drugs because the rich supply of blood and lymphatic vessels in the rectum provides for exceptional absorption. They



Its site of administration determines the size and shape of a suppository.

are often used in children or adults who cannot take oral medication to control symptoms of fever, nausea, or vomiting, as well as to treat those with severe symptoms of inflammatory bowel disease or pain.

#### **Effervescent Salts**

Effervescent salts are granules or coarse powders containing one or more medicinal agents such as an analgesic, as well as some combination of sodium bicarbonate with citric acid, tartaric acid, or sodium biphosphate. When dissolved in water, effervescent salts release carbon dioxide gas, causing a distinctive bubbling. A common example of an effervescent salt is sodium phosphate, used as a cathartic for stimulating evacuation of the bowels before a procedure.

#### **Implants or Pellets**

**Implants**, or pellets, are dose forms that are placed under the skin by means of minor surgery. They are used for long-term, controlled release of medications, especially as long-term contraceptives. An example of an implant is Norplant, which contains levonorgestrel to prevent pregnancy. The advantages of such products include enhanced patient compliance and convenience, but complications at the site of insertion have limited their widespread use.

#### Lozenges, Troches, or Pastilles

**Lozenges**, also known as *troches* or *pastilles*, are dose forms containing active ingredients and flavorings, such as sweeteners, that are dissolved in the mouth. They generally have local effects. Commercial OTC lozenges for relief of sore throat are quite common, although many other drugs, including such prescription drugs as nystatin or clotrimazole, are also available in lozenge form.

#### **Plasters**

**Plasters** are solid or semisolid and medicated or nonmedicated preparations that adhere to the body and contain a backing material such as paper, cotton, linen, silk, moleskin, or plastic. An example is the salicylic acid plaster used to remove corns.

#### **Powders and Granules**

Commonly dispensed powders include antacids, brewer's yeast, laxatives, douche powders, dentifrices and dental adhesives, and powders for external application to the skin. These are usually ordered in bulk by the pharmacy and are dispensed as needed in the prescribed amount. In large-scale commercial manufacturing, powders are milled and pulverized by machines. An example of a medication in the powder dose form is polymyxin B sulfate and bacitracin zinc topical powder, which is used to prevent infection.

Granules are larger than powders and are formed by adding very small amounts of liquid to powders; then the mixture is passed through a screen or a granulating device. Tablets are often prepared by compressing granules, and capsules are often filled with granules. Granules are generally of irregular shape, have excellent flow characteristics, are more stable than powders, and are generally better suited than powders for use in solutions because they are not as likely simply to float on the surface of a liquid. They may contain colorings, flavorings, and coatings and may have controlled-release characteristics (Theo-Dur Sprinkles). The pharmacist combines some granular drug products with water before dispensing such as antibiotic suspensions, whereas others are dispensed as granules.

## LIQUID DOSE FORMS

Liquid dose forms consist of one or more active ingredients in a liquid vehicle. These dose forms can be divided into two major categories: (1) solutions, in which active ingredients are dissolved in the liquid vehicle; and (2) dispersions, in which undissolved ingredients are dispersed throughout a liquid vehicle.

Liquid dose forms that are meant for oral consumption have several advantages over solid dose forms, including ease of swallowing and of adjusting the dose. A liquid dose can be easily adjusted, whereas tablets or capsules cannot always be divided as easily. For the patient, taste preference may be either an advantage or



Liquid medications are easy to swallow, and the dose can be adjusted.

disadvantage. For adults this is not usually a concern; however, children's medication is often flavored in the most palatable way possible to improve compliance. Liquid dose forms are often less stable than their solid counterparts, and care should be taken to monitor storage conditions of the liquid dose forms, to rotate stock, and to check expiration dates often.

Liquid and semisolid dose forms meant for topical application are common examples of dispersions. **Creams** and lotions, for example, are easily absorbed (i.e., "vanishing") and can cover large areas of the skin. **Ointments**, however, are "sticky" and will leave the area feeling greasy. An ointment is especially good for extremely dry areas where moisture needs to be retained, as well as for areas prone to friction from clothing or other body parts. Ointments generally have a longer contact time with the skin and thus a longer duration of action. **Gels** are yet another product that may be designed with a specific indication in mind. They apply evenly and leave a dry coat of the medication in contact with the area.

### **Solutions**

**Solutions** may be classified by vehicle as aqueous (i.e., water based), alcoholic (alcohol based), or hydroalcoholic (i.e., water and alcohol based). The vehicle that makes up the greater part of

a solution is known as a **solvent**. An ingredient dissolved in a solution is known as a **solute**. An enema is usually a water-based solution administered rectally for cleansing the bowel before a GI procedure or for delivering active drug. An evacuation enema, like Fleet, is administered to clean the bowels. A retention enema, such as Cortenema, is administered to deliver medication locally or systemically.

Collodion is an example of a vehicle that is a liquid dissolved in a mixture of alcohol and ether and used for a variety of topical purposes. On application, the highly volatile alcohol and ether solvent vaporizes, leaving a film coating containing the medication on the skin. The OTC product, Compound W, is a collodion containing salicylic acid used to remove corns or warts.

Solutions may also be classified by their contents: aromatic waters, elixirs, syrups, extracts, fluidextracts, tinctures, spirits, or irrigating solutions. A low-alcohol or alcohol-free product is preferred for most pediatric products.

- Aromatic waters is a solution of water containing oils or other substances that have a pungent, and usually pleasing, smell and are volatile (i.e., easily released into the air). Rose water is an example.
- An elixir is a clear, sweetened, flavored solution containing water and ethanol (hydroalcoholic). An example of a drug in this dose form is phenobarbital elixir, containing phenobarbital, orange oil, propylene glycol, alcohol, sorbitol solution, color, and purified water.
- A syrup is an aqueous solution thickened with a large amount of sugar, generally sucrose, or a sugar substitute such as sorbitol or propylene glycol. Syrups may contain additional flavorings, colors, or aromatic agents. Syrups may be medicated, such as lithium citrate or ipecac, or nonmedicated such as cherry syrup or cocoa syrup. Syrups are often the preferred vehicle to mask the taste of pediatric medications, because they do not contain alcohol. Syrups are also sometimes used for older patients who cannot easily swallow the commonly available solid forms of certain drugs.

- An extract is a potent dose form derived from animal or plant sources from which most or all the solvent has been evaporated to produce a powder, an ointment-like form, or a solid. Extracts are produced from fluidextracts and used in the formulation or compounding of medications.
- A fluidextract is a liquid dose form prepared by extraction from plant sources and commonly used in the formulation of syrups. Vanilla extract is an example of a fluidextract.
- A tincture is an alcoholic or hydroalcoholic solution of extractions from plants. Examples include iodine tincture and belladonna tincture.
- Spirits are alcoholic or hydroalcoholic solutions containing volatile, aromatic ingredients. Examples include camphor and peppermint spirit, both of which can be used as medicines or flavorings.
- An irrigating solution is any solution for cleansing or bathing an area of the body. Some are used topically in the eye or ear or for irrigation of tissues exposed by wounds or surgical incisions. Examples of irrigating solutions used in surgical procedures are Neosporin-Polymyxin and 1% acetic acid. The term *douche* is most commonly used for irrigating solutions, often reconstituted from powders, administered into the vaginal cavity.

Solutions are sometimes classified by site or method of administration as topical (local), systemic (throughout the body), epicutaneous (on the skin), percutaneous (through the skin), oral (for or through the mouth), otic (for or through the ear), ophthalmic (for the eye), parenteral (for injection or intravenous [IV] infusion), rectal (for or through the rectum), urethral (for the urethra), or vaginal (for or through the vagina).

**Parenteral solutions** are sterile solutions, with or without medication, for administration by means of a hollow needle or catheter used to place the solution through one or more layers of the skin. Two major delivery systems for parenteral solutions exist: (1) IV infusions and (2) injections, which are commonly IV, intramuscular (IM) (into the muscle), subcutaneous (under the skin), or intradermal (ID) (into the skin). Parenteral solutions are discussed in greater detail later in this chapter and in Unit 3, *Institutional Pharmacy*.

#### **Dispersions**

Unlike a solution, a dispersion is not dissolved but simply distributed throughout the vehicle. A **suspension** is the dispersion of a solid in a liquid, whereas an **emulsion** is the dispersion of a liquid in another liquid. In either case an incomplete mixture of the solid or liquid exists. **Dispersions** are classified by the size of the dispersed ingredient(s) into suspensions and emulsions that both contain relatively large particles, as well as magmas, gels, and jellies, which contain fine particles. If a dispersion contains ultrafine particles, less than a micron in size, then it is said to be a **colloidal dispersion**. One type of colloidal dispersion is the microemulsion.

Some suspensions come already prepared, whereas others come in the form of dry powders that are reconstituted with purified water. Suspensions may be classified by route of administration into oral (taken by mouth), topical (lotions applied to the skin), and injectable suspensions. A well-prepared suspension settles slowly but can be redispersed easily by a gentle shake and pours easily. A suspension may be a preferred method for dispensing a solid to a young or older adult patient who would find it difficult to swallow a solid dose form. Examples of suspensions include antacids like the magnesia and alumina oral suspension with the brand name Maalox, the antifungal mycostatin oral suspension, and the injectable NPH insulin.

Emulsions vary in their viscosity, or rate of flow, from free-flowing liquids such as lotions to semisolid preparations such as ointments and creams. Common types of

Safety Note Suspensions should always include a "Shake Well" label.

emulsions are **oil-in-water (O/W) emulsion** or **water-in-oil (W/O) emulsion**. For example, O/W emulsions contain a small amount of oil dispersed in water. Emulsions contain an emulsifying agent to render the emulsion stable and less prone to separation. A liniment is an oleaginous (hydrocarbon-containing) emulsion containing medications and meant for rubbing on the skin. The OTC pain medication Ben-Gay is an example of this type of dose form.

A **lotion** is a liquid for topical application containing insoluble dispersed solids or immiscible liquids. Examples include calamine lotion, used for relief of itching, and benzoyl peroxide lotion, used to control acne.

Like suspensions, gels contain solid particles in liquid, but the particles are ultrafine, of colloidal dimensions, and sufficient in number (therefore linked to form a semisolid). Examples of gels include lidocaine gel and the antacid aluminum hydroxide gel. The following are examples of ultrafine dispersion dose forms:

- A jelly is a gel that contains a higher proportion of water in combination with a drug substance, as well as a thickening agent. Jellies are present in many antiseptics, antifungals, contraceptives, and lubricants. Lubricants are commonly used in pelvic and rectal examination of body orifices or as an aid in sexual intercourse to postmenopausal women with vaginal dryness from a hormone deficiency. Because of their high water content, jellies are subject to contamination; therefore they usually contain preservatives.
- Glycerogelatins are topical preparations made with gelatin, glycerin, water, and medicinal substances. The hard substance is melted and brushed onto the skin, where it hardens again and is generally covered with a bandage. An example is zinc gelatin (Unna's Boot), used as a pressure bandage to treat varicose ulcers.
- A magma, or milk, is similar to a gel in that it contains colloidal particles in liquid, but the particles remain distinct, in a two-phase system. An example is Milk of Magnesia, containing magnesium hydroxide, used to neutralize gastric acid.
- A microemulsion, like other emulsions, contains one liquid dispersed in another; however, unlike other emulsions, it is clear because of the extremely fine size of the droplets of the dispersed phase. An example of a microemulsion is Haley's M-O. Ointments are semisolid dose forms meant for topical application and are packaged in jars or tubes. Ointments may be medicated or nonmedicated and may contain various kinds of bases:



Ointments are referred to as *water-in-oil (W/O) preparations*. They contain a small amount of water dispersed throughout oil. They will apply smoothly to the skin but will often leave the skin with a greasy feeling. Ointments are often yellowish and opaque.

- oleaginous or greasy bases made from hydrocarbons such as mineral oil or petroleum jelly
- W/O emulsions such as anhydrous lanolin, lanolin, or cold cream
- O/W emulsions such as hydrophilic ointment
- water-soluble or greaseless bases such as polyethylene glycol ointment

**Pastes** are like ointments but contain more solid materials and consequently are stiffer and apply more thickly. Examples are zinc oxide paste (an astringent) and acetonide dental paste (an anti-inflammatory preparation).

Creams are considered O/W emulsions. They apply smoothly to the skin and leave a very thin film. Most creams are considered vanishing, which means they are invisible once applied and thus preferred by many patients. Like ointments, they are packaged in jars or tubes.

## INHALATION DOSE FORMS

Gases, vapors, solutions, or suspensions intended to be inhaled via the nasal or oral respiratory routes are known as **inhalations**.

A **spray** is a dose form that consists of a container with a valve assembly that, when activated, emits a fine dispersion of liquid, solid, or gaseous material. An aerosol is a spray in a pressurized container that contains a propellant, an inert liquid or gas under pressure, meant to carry the active ingredient to its location of application. Depending on the formulation of the product and on the design of the valve, an aerosol may commonly emit a fine mist or a coarse liquid spray. Several inhalation products (e.g. Advair Diskus [fluticasone-salmeterol] and Spiriva [tiotropium]) are available as breath-activated devices of powders in place of aerosolized propellants.

Most sprays and aerosols are for topical application to the skin or to oral mucous membranes such as OTC local anesthetics, antiseptics, deodorants, and breath sprays. Other sprays are inhalation aerosols that the patient breathes in through the nose or mouth to deliver prescription drugs. Sprays and aerosols are often used for nasal decongestants and for inhalation of antiasthmatic drugs. Many anti-inflammatory medications are available both as a nasal spray for allergies and as an aerosol for inhalation for asthma.

## DELIVERY SYSTEMS

Modern prescription drugs often are created using a high level of technology, and in some cases the technology is carrying over to the way a medication is delivered to the patient. Delivery systems used to deliver specific medications are often manufactured and packaged as a unit and then dispensed as a unit for the patient. They contain not only the medication but also a specialized delivery mechanism. The wide variety of delivery systems available offer patients a welcome alternative to traditional administration.

#### **Inhalation Delivery Systems**

This method of administration is one of the most rapid means (second only to the IV method) of administering any medication. Gases such as oxygen, nitrous oxide or "laughing gas," and ether are administered by inhalation. General anesthetics used



Nebulizers, also called *atomizing machines*, are effective for delivering mists or micronized powders to the lungs.

during surgical procedures often use this delivery system. Pharmacists and pharmacy technicians in both community pharmacy and home healthcare settings are increasingly dealing with the delivery of oxygen tanks to the homes of patients with chronic lung disease.

Medicated inhalations intended for the lung are often administered via devices such as metered-dose inhalers (MDIs) or nebulizers. MDIs are handheld, breath-activated, propellant-driven inhalers that are commonly used for patients with asthma or chronic lung disease. (Proper technique and use of spacer devices is critical to proper use and is further discussed in Chapter 4.)

**Nebulizers** are atomizing machines that deliver the medication as a mist containing extremely small, or micronized, powder. Common vehicles for inhalation solutions include sterile water for injection (SWI) and sodium chloride, also called *normal saline (NS)*. The solution is placed in a device that will aerosolize both the medication and the vehicle. An example of a medication delivered by inhalation is albuterol for relief of bronchial spasms. A "nebulized" mist of medication may be more effective than an "aerosolized" spray in delivering medications into the deeper areas of the lung in infants and young children.

Vaporizers and humidifiers are other mechanical devices commonly used to deliver moisture to the air for relief of cold symptoms. Volatile medications can be used with some vaporizers. A good example of a volatile medication is Vicks Vaposteam.

#### Syringe, Injection, and Infusion Delivery Systems

Injections of medications act rapidly to control and treat symptoms. Some medications are only available in an injection form, such as insulin. Syringes are calibrated devices used to accurately draw up, measure, and deliver medication to a patient through a needle. Injections must be sterile because they introduce medication directly into the body. Only trained professionals and healthcare providers should give injections, and some risk to the patient is always present. In recent years patients have been taught how to self-administer injections or infusions at home by the home health nurse or pharmacist.

Two types of syringes are commonly used for injections: (1) glass and (2) plastic. Glass syringes are fairly expensive and must be sterilized between uses, whereas plastic syringes are easy to handle and disposable, and they come from the manufacturer in sterile packaging. Plastic is clearly preferred and used both within and outside the hospital setting. Different states have different regulations on the sale of syringes because of their potential diversion for injection of illegal drugs; some states (or insurance companies) may require a prescription or the placement of syringes behind the prescription counter to control their sales.

The larger hypodermic syringes have cannulas or barrels that range from 3 to 60 mL of liquid. The cannula is the bore area inside the syringe that correlates with the volume of solution. Common types of syringes (Figure 3.5) include the insulin syringe (which measures from 30 to 100 U) and the tuberculin syringe (with cannulas ranging from 0.01 to 1 mL [used for skin tests and drawing up very small volumes of solution]). The syringe and needle will be explained in more detail in Chapter 11, *Preparing Sterile Intravenous Products*.

Injections may be administered to almost any organ or part of the body. The advantages and disadvantages of the various routes of parenteral administration are discussed in the next chapter. Injectables come prefilled or are filled at the time of injection from single or multidose vials. Single-dose vials generally have no preservative and are dispensed as single use only. Multiple-dose vials, although they contain a preservative, should be dated and discarded (usually after 30 days) per policy and procedures of the pharmacy. Sometimes the medication comes in ampules, which are small glass containers that are opened by breaking off the neck of the container. Because of the danger of contaminating the medication with glass particles, medication that comes in ampules must be filtered before it is injected. (For more information on injections, see Chapter 11.)

In addition to syringes, devices available for injection include **patient-controlled analgesia (PCA) infusion devices**, which are programmable machines that deliver small doses of painkillers on patient demand; jet injectors, which use pressure rather than a needle to deliver the medication; and ambulatory injection devices, like insulin

Safety Note

Injections should be given by a trained healthcare professional and not by the pharmacy technician.

Safety Note Only the patient

should control the PCA pump button.





#### **Typical Syringes**

(a) Insulin syringes in 100-U and 50-U sizes. (b) Hypodermic syringes in 6-cc and 3-cc sizes. (c) Tuberculin syringes marked with both metric and apothecary measures.



A patient-controlled analgesia (PCA) pump can allow the patient to regulate the amount of pain medication he or she receives. This results in better pain control with less drug used.





pumps, that the patient can wear while moving about. Some injection devices make use of pumps that regulate the amount, rate, and/or timing of injections.

IV infusion is a method for delivering a large amount of fluid over a prolonged period of time and at a slow, steady rate into the blood system. Infusions are used to deliver blood; water; other fluids; electrolytes; nutrients such as proteins, amino acids, lipids, and sugars; and drugs. When drugs are prepared and added to an IV solution line, they are *piggybacked*. Typical uses of IV infusions are to deliver pain-killing or blood-clot-buster medications, to replenish body fluids, and to deliver nutrients to patients who cannot or will not feed themselves.

#### Intrauterine and Cervical Delivery Systems

An **intrauterine delivery system** is a drug-releasing device placed into the uterus. Several such systems contain a progestin hormone that is used to prevent pregnancy on a long-term (1 to 5 years) basis. This system is not as effective a contraceptive as oral contraceptives. Devices also exist that remain in the vagina and are placed as a ring surrounding the cervix to slowly release medication. They are replaced monthly by the patient and used as contraceptive aids. Occasionally, the patient will expel these devices spontaneously and may experience a high risk of pelvic infection.

#### **Transdermal Delivery Systems**

A **transdermal delivery system (TDS)**, or patch, is a dose form meant for delivery percutaneously (through the skin). It consists of a backing, a drug reservoir, a control membrane, an adhesive layer, and a protective strip. The strip is removed, and the adhesive layer is attached to the skin. Drug movement is by osmosis through the control membrane, delivering medication systemically, rather than locally. In some patches, the membrane controls the rate of drug delivery, whereas in others the skin itself controls it. Medications given with this dose form can be controlled over 24 hours or longer. Patient convenience and compliance are improved with the use of transdermal patches. Examples will be discussed in Chapter 4, *Routes of Drug Administration*.

#### **Other Delivery Systems**

In the hospital, unit dose disposable syringes are prefilled syringes that contain a single premeasured dose of medication and are thrown away after use. These special syringes are used to deliver oral liquid medications to pediatric patients in the hospital setting. An **oral syringe** is a calibrated device consisting of a plunger and a cannula, or barrel, used without a needle for administration of precisely measured amounts of medication by mouth.

A **bulb syringe** consists of a bulb and a tapering funnel with a hollow end and is used to administer liquids topically, as for irrigation of the ears (to remove ear wax) or eyes (to flush out an irritant). The bulb is first depressed to expel the air that it contains, and the tip is then inserted into the liquid to be administered. The bulb is released while the end is in the liquid, and the liquid rises to fill the vacuum thus created. The end of the bulb is then removed from the liquid, and the liquid is administered by depressing the bulb again.

Like a bulb syringe, a dropper uses a bulb to create a vacuum for drawing up a liquid. A dropper contains a small, squeezable bulb at one end and a hollow glass or plastic tube with a tapering point. The dropper may be incorporated into the cap of a vial or other container. The abbreviation *gtt* is used as a unit of pharmaceutical measurement for droppers and IV infusions to indicate *drops*. Because of the differing viscosities (the thicknesses and flow characteristics) of differing fluids, the size of a drop varies considerably from medication to medication. Medication droppers are medication specific; that is, they cannot be used to measure other medications. Droppers are often used for otic or ophthalmic administration, as well as for oral medications. Droppers are critically important to deliver the correct dose of medication to infants.

**Ocular inserts** are small, transparent membranes containing medications that are placed between the eye and the lower conjunctiva (i.e., the mucous membrane on the inside of the eyelid). An example is the product with the brand name Ocusert, used to deliver pilocarpine for the treatment of glaucoma.

Some hospices (facilities caring for the terminally ill) and long-term care facilities make use of straws (long, hollow tubes) prefilled with pain medications. Another delivery system of a contraceptive is the recently reintroduced polyurethane sponge containing a spermicide, nonoxynol 9.

## **DRUG REFERENCES**

Two reference works published by the United States Pharmacopeia (USP) establish the official legal standards for drugs in the United States: *United States Pharmacopeia* (which describes drug substances and dose forms) and the *National Formulary* (which describes pharmaceutical ingredients). Both are revised every 5 years, and supplements are published in the interim between revisions. They are also printed in a combined edition, *United States Pharmacopeia–National Formulary* (USP–NF).

Several other reference books are also helpful to practitioners:

- *Physician's Desk Reference* is published annually with reprints of package inserts from the pharmaceutical manufacturers of most drugs. It is also useful for identifying unknown drugs by color, shape, and coding.
- *Drug Facts and Comparisons* includes factual information on product availability, indications, administration and dose, pharmacological actions, contraindications, warnings, precautions, adverse reactions, overdose, and patient instructions. It is updated monthly with new inserts and is also available on CD-ROM.
- *USP Drug Information*, originally published by the USP, is a source of patient counseling information for the pharmacist.
- *American Hospital Formulary Service (AHFS)* is an excellent source of information, especially on parenteral drugs commonly used in the hospital.
- *Handbook of Nonprescription Drugs* is published by the American Pharmacists Association and provides a good reference for OTC drugs.
- FDA Electronic Orange Book (also called Approved Drug Products with Therapeutic Equivalence Evaluations) is available on-line and provides information on generic equivalency of drugs that may have many sources; for example, can a less-expensive blood pressure medication be "substituted" for a brand name of the same drug? Each state may vary in procedures for dispensing "generic equivalents."
- *Remington: The Science and Practice of Pharmacy* is an excellent text, especially



Pharmacists will use *Drug Facts and Comparisons* and computerized databases for up-to-date drug information.

for use in a compounding pharmacy where determinations of drug stability and compatibility are important.

- *Lawrence Review of Natural Products* provides scientific monographs on herbal medications.
- *Homeopathic Pharmacopeia of the United States* is a compilation of standards for the source, composition, and preparation of homeopathic medications that may be sold in the community pharmacy.



Check www.fda .gov/cder for the FDA Electronic Orange Book.



Go to this book's Information Resources Center (IRC) at www.emcp .com, and visit the Resources page found in the Pharmacy Library for a list of these and other valuable resources.

Chapter Terms

- **active ingredient** chemical in the drug product producing the desired therapeutic effect
- **antibodies** part of the immune system to neutralize antigens or foreign substances in the body
- antineoplastic drugs drugs used to kill cancer cells
- **biotechnology** field of study that combines the science of biology, chemistry, and immunology to produce synthetic, unique drugs with specific therapeutic effects
- bulb syringe device used to irrigate the eyes or ears with water
- **capsule** dose form containing powder, liquid, or granules in a gelatin covering
- **colloidal dispersion** dispersion of ultrafine particles
- **controlled-release medication** dose form that is formulated to release medication over a long duration of time
- **creams** cosmetically acceptable oil-in-water (O/W) emulsions for topical use on the skin
- **delivery system** device used to deliver the drug; a design feature of the dose form that affects the delivery of the drug; how a medication is formulated to release the active ingredient
- **deoxyribonucleic acid (DNA)** helix-shaped molecule that carries the genetic code
- **destructive agent** drug that kills bacteria, fungi, viruses, or even normal or cancer cells
- diagnostic agent drug used to diagnose other diseases
- **dispersions** liquid dose forms in which undissolved ingredients are mixed throughout a liquid vehicle
- **dose form** how a medication is manufactured (e.g., capsule, tablet)
- **drug** medical substance or remedy used to change the way a living organism functions; also called a *medication*
- **effervescent salts** granular salts that release gas and dispense active ingredients into solution when placed in water
- **emulsion** dispersion of a liquid in another liquid
- **gels** dispersions containing fine particles for topical use on the skin
- **genetic engineering** hybridization technique for creating monoclonal antibodies (MAbs)
- **homeopathic medications** very small dilutions of natural drugs claimed to stimulate the immune system
- **implants** medications placed under the skin to deliver the active ingredient slowly
- **inert ingredients** inactive chemicals that are added to active ingredients to improve drug formulations; also called inactive ingredients
- **inhalations** gases, vapors, solutions, or suspensions intended to be inhaled via the nasal or oral respiratory routes
- **intrauterine delivery system** way to deliver medication to prevent conception or treat cancer

**intravenous (IV) infusions** medications or fluids administered directly into a vein

- **lotion** liquid for topical application containing insoluble dispersed solids or immiscible liquids
- **lozenges** medications in a sweet-taste formulation that is absorbed in the mouth
- **monoclonal antibodies (MAbs)** single-cell antibodies produced in a laboratory to produce a pure antibody against a known specific antigen; used in cancer immunotherapy
- **National Drug Code (NDC) number** unique number assigned to a product to identify the manufacturer, drug, packaging size, and type
- **nebulizers** devices used to deliver medication in a fine-mist form to the lung; often used in treating asthma
- **ocular inserts** type of contact lens device with active medication for administration in the eye
- **oil-in-water (O/W) emulsion** emulsions containing a small amount of oil dispersed in water; like a cream
- ointments semisolid emulsions for topical use on the skin
- **oral syringe** device without a needle to administer medication to pediatric or elderly patients unable to swallow tablets or capsules
- over-the-counter (OTC) drug drug sold without a prescription
- **parenteral solutions** products that are prepared in a sterile environment for administration by injection
- **pastes** water-in-oil (W/O) emulsions containing more solid material than an ointment
- **patient-controlled analgesia (PCA) infusion devices** devices used by a patient to deliver small doses of medication to the patient for chronic pain
- **pharmacodynamic agent** drug that alters body functions in a desired way
- **plasters** solid or semisolid, medicated or nonmedicated preparations that adhere to the skin
- prophylactic agent drug used to prevent disease
- **radiopharmaceuticals** drugs containing radioactive ingredients often used for diagnostic or therapeutic purposes
- **recombinant DNA** technique that uses living organisms or parts of organisms for specific purposes such as creating a synthetic drug like insulin
- ribonucleic acid (RNA) important component of genetic code that arranges amino acids into proteins
- semisynthetic drugs drugs that contain both natural and synthetic components
- **solute** an ingredient dissolved in a solution or dispersed in a suspension
- **solutions** liquid dose forms commonly containing carbohydrates, proteins, electrolytes, minerals, or medications
- **solvent** vehicle that makes up the greater part of a solution
- **spray** dose form that consists of a container with a valve assembly that, when activated, emits a fine dispersion of liquid, solid, or gaseous material

- **suppositories** solid formulations containing a drug for rectal or vaginal administration
- suspension dispersion of a solid in a liquid
- synthesized drug drug that is artificially created
- **synthetic drug** drug that is artificially created but in imitation of natural-occurring substances
- **tablet** solid dose form produced by compression and containing one or more active ingredients
- **therapeutic agent** drug that prevents, cures, diagnoses, or relieves symptoms of a disease
- **transdermal delivery system (TDS)** method of delivering medication via the skin; like a patch
- **water-in-oil (W/O) emulsion** emulsion containing a small amount of water dispersed in an oil; like an ointment



- Drugs are natural, synthetic, synthesized, or semisynthetic substances taken into or applied to the body to alter biochemical functions and achieve a desired pharmacological effect.
- Uses of drug may include one or more of the following: therapeutic, pharmacodynamic, prophylactic, diagnostic, or destructive agents.
- Drugs can be classified as over-the-counter (OTC) or legend as regulated by the FDA.
- Diet supplements, which include vitamins, minerals, and herbals, are regulated under the DSHEA amendments.
- Drugs are administered in many dose forms and using many delivery systems. The choice of dose form and delivery system is based on what active ingredient is to be delivered, how much is to be delivered, by what means or route, to what sites, at what rate, over what period of time, and for what purpose.
- Solid dose forms commonly include tablets and capsules. Tablets may be coated, chewable, controlled release, effervescent, and/or specially formulated for buccal, sublingual, or vaginal use.
- Liquid dose forms include a wide variety of solutions, as well as dispersions such as suspensions and emulsions. Creams and ointments are special emulsions for application to the skin.
- Delivery systems commonly include syringe, injection, and infusion devices; metered dose inhalers (MDIs) or nebulizers for inhalation use; transdermal delivery systems (TDSs); and droppers and oral syringes for pediatric and infant use.
- A multitude of good reference texts and Internet Web sites exist that the practicing pharmacist and pharmacy technician can use to study various pharmaceutical products.

Chapter Review

#### **Knowledge Inventory**

Choose the best answer from those provided.

- 1. A biochemically reactive component in a drug is known as a(n)
  - a. inert ingredient.
  - b. active ingredient.
  - c. diluent.
  - d. vehicle.
- 2. A National Drug Code (NDC) number does not identify the
  - a. product manufacturer.
  - b. drug.
  - c. packaging size and type.
  - d. schedule of the drug.
- 3. A radiopharmaceutical used for imaging is an example of a
  - a. therapeutic agent.
  - b. pharmacodynamic agent.
  - c. diagnostic agent.
  - d. prophylactic agent.
- 4. When people use the term *delivery system*, they generally intend, in addition to the dose form, to refer to the
  - a. physical characteristics of the dose form that determine the method of administration and the site of action of the drug.
  - b. restrictions placed upon the ordering, storage, and dispensing of the drug because of its classification under the Comprehensive Drug Abuse Prevention and Control Act.
  - c. chemical composition of the drug, including its active ingredients, inert ingredients, and any colorings, flavorings, preservatives, disintegrants, solubilizers, and emulsifying agents.
  - d. use of the drug as a therapeutic, pharmacodynamic, diagnostic, prophylactic, or destructive agent.
- 5. A dose form used in the rectum, vagina, and urethra is a(n)
  - a. inhalation aerosol.
  - b. suppository.
  - c. elixir.
  - d. fluidextract.
- 6. Drugs with an enteric coating
  - a. dissolve in the stomach.
  - b. dissolve in the intestines.
  - c. are comprised of sugar for palatability.
  - d. are made of polymers, which form a protective film.

- 7. A solution containing water and ethanol would be described as
  - a. hydroalcoholic.
  - b. aqueous.
  - c. magma.
  - d. immiscible.
- 8. Some examples of dispersions are
  - a. suspensions and emulsions.
  - b. tinctures, fluidextracts, and extracts.
  - c. aromatic waters.
  - d. elixirs and syrups.
- 9. Dose forms that are often or always sweetened include
  - a. parenteral solutions, spirits, and tinctures.
  - b. medicated syrups and elixirs.
  - c. collodions, microemulsions, and ointments.
  - d. liniments and extracts.
- 10. To determine generic equivalency of a brand name product, which reference source would you use?
  - a. Drug Facts and Comparisons
  - b. FDA Electronic Orange Book
  - c. Physician's Desk Reference
  - d. Homeopathic Pharmacopeia of the United States

#### **Pharmacy in Practice**

- 1. Recombinant DNA will, in the future, play a great role in gene therapies, in which recombinant DNA is used to supply the body with genes to supplement or replace the action of the existing genes with which the body is endowed. Do some research on gene therapy for the treatment of cystic fibrosis, the most common of all fatal genetic diseases. Such therapy uses a cold virus containing recombinant DNA that carries a gene called the *cystic fibrosis transmembrane regulator*. Prepare a brief report explaining how such therapy works.
- 2. Determine the brand name, dose form, and primary indication for the following gene therapy or biotechnology-based medications:
  - a. epoetin alpha
  - b. efavirenz
  - c. infliximab
  - d. somatotropin
  - e. trastuzumab
  - f. becaplermin
  - g. palivizumab

3. A tree diagram is a chart that shows a classification system. A single characteristic is used to differentiate the items classified under each node on the chart. For example, a tree chart might classify animals in this way:

Animals	
Vertebrates	Invertebrates
(With Backbones)	(Without Backbones)
• mammals	• flatworms
• reptiles	<ul> <li>roundworms</li> </ul>
• fish	• insects
• birds	• arachnids
<ul> <li>amphibians</li> </ul>	• mollusks

Create tree charts to classify

- a. solid dose forms
- b. liquid dose forms
- c. solutions (by vehicle)
- d. solutions (by contents)
- e. solutions (by site or method of administration)
- f. dispersions (by size of the dispersed ingredients)
- 4. Go to a community or retail pharmacy and make a list of five over-the-counter (OTC) products of acetaminophen in as many different dose forms as you can identify. For each product on your list, give the manufacturer, the brand name, the active and inactive ingredient(s), and the dose form/delivery system.
- 5. Different dose forms have different pros and cons. For example, tablets and capsules are premeasured (pro) but may be difficult for some patients to swallow (con). Create a table comparing the ease of administration, dangers of contamination, duration of shelf life, ease of self-administration, suitability for patients of various ages or conditions, uniformity of dose size, control of dose rate, and site of application for each dose form.

Dose Form	Advantages	Disadvantages
a. tablets		
b. capsules		
c. injections (IM and SC)		
d. IV infusions		
e. syrup		
f. sublingual tablet		
g. transdermal patch		
h. suppository		

#### **Improving Communication Skills**

- 1. A prescription has been brought in for a steroid cream (0.25%) to be applied to an infant's eczema on the cheeks. The mother states that she has the same drug at home in an ointment (1%) and wants to know whether she should just use what she has at home, because the drug is expensive. Creams and ointments are very different, and in this case the strength is different as well. What will the pharmacist tell this mother about the differences between the two products?
- 2. A young man has come in to pick up some prescriptions for his asthma. His physician has just changed his prescription from oral prednisone to an inhaled steroid to control an exacerbation of his asthma. The physician told the patient that the inhaled product would be safer for him in the long run. Why? What are the advantages of the inhaled products over the oral tablets?
- 3. An older man has just picked up two prescriptions for nitroglycerin. One was for sublingual tablets and the other was for transdermal patches. Why is the patient using two different forms of the same drug? What are the advantages of each?

#### **Internet Research**

- 1. Go to the Web site of the Association of Natural Medicine Pharmacists (www.anmp.org) and locate the primary indication, dosage, and clinical efficacy of the following natural medicines:
  - a. Gingko
  - b. Saw Palmetto
  - c. Ginger
- 2. Go to www.consumerlab.com and check laboratory testing results for gingko biloba and saw palmetto. Report your findings.

