SECTION I

PRINCIPLES OF PHARMACOLOGY

Introduction to Pharmacology, 2
Pharmacokinetics, 10
Pharmacodynamics, 28
Drug Development and Safety, 36
CHAPTER 1

Introduction to Pharmacology

PHARMACOLOGY AND RELATED SCIENCES

Pharmacology is the study of drugs and their effects on life processes. It is a fundamental science that sprang to the forefront of modern medicine with demonstrated success in treating disease and saving lives. It is also a discipline that drives the international pharmaceutical industry to billion-dollar profits. This chapter reviews the history and subdivisions of pharmacology and discusses, in detail, the types of drugs, formulations, and routes of administration.

History and Role of Pharmacology

Since the beginning of the species, people have treated pain and disease with substances derived from plants, animals, and minerals. However, the science of pharmacology is less than 150 years old, ushered in by the ability to isolate pure compounds and the establishment of the scientific method. Historically, the selection and use of drugs were based on superstition or on experience (empiricism).

In the first or earliest phase of drug usage, noxious plant and animal preparations were administered to a diseased patient to rid the body of the evil spirits believed to cause illness. The Greek word *pharmakon*, from which the term *pharmacology* is derived, originally meant a magic charm for treating disease. Later, *pharmakon* came to mean a remedy or drug.

In the second phase of drug usage, experience enabled people to understand which substances were actually beneficial in relieving particular disease symptoms. The first effective drugs were probably simple external preparations, such as cool mud or a soothing leaf, and the earliest known prescriptions from 2100 BCE included salves containing thyme. Over many centuries, people learned the therapeutic value of natural products through trial and error. By 1500 BCE, Egyptian prescriptions called for castor oil, opium, and other drugs that are still used today. In China, ancient scrolls from this time listed prescriptions of herbal medicines for more than 50 diseases. Dioscorides, a Greek army surgeon who lived in the 1st century, described more than 600 medicinal plants that he collected and studied as he traveled with the Roman army. Susruta, a Hindu physician, described the principles of Ayurvedic medicine in the 5th century. During the Middle Ages, Islamic physicians (most famously Avicenna) and Christian monks cultivated and studied the use of herbal medicines.

The third phase of drug usage, the rational or scientific phase, gradually evolved with important advances in chemistry and physiology that gave rise to the new science of pharmacology. At the same time, a more rational understanding of disease mechanisms provided a scientific basis for using drugs whose physiologic actions and effects were understood.

The advent of pharmacology was particularly dependent on the isolation of pure drug compounds from natural sources and on the development of experimental physiology methods to study these compounds. The isolation of *morphine* from opium in 1804 was rapidly followed by the extraction of many other drugs from plant sources, providing a diverse array of pure drugs for pharmacologic experimentation. Advances in physiology allowed pioneers, such as François Magendie and Claude Bernard, to conduct some of the earliest pharmacologic investigations, including studies that localized the site of action of curare to the neuromuscular junction. The first medical school pharmacology laboratory was started by Rudolf Büchheim in Estonia. Büchheim and one of his students, Oswald Schmiedeberg, trained many other pharmacologists, including John Jacob Abel, who established the first pharmacology department at the University of Michigan in 1891 and is considered the father of American pharmacology.

The goal of pharmacology is to understand the mechanisms by which drugs interact with biological systems to enable the rational use of effective agents in the diagnosis and treatment of disease. The success of pharmacology in this task has led to an explosion of new drug development, particularly in the past 50 years. Twentieth-century developments include the isolation and use of insulin for diabetes, the discovery of antimicrobial and antineoplastic drugs, and the advent of modern psychopharmacology. Recent advances in molecular biology, genetics, and drug design suggest that new drug development and pharmacologic innovations will provide even greater advances in the treatment of medical disorders in this century.

The history of many significant events in pharmacology, as highlighted by selected Nobel Prize recipients, is presented in Table 1–1.
**Pharmacology and Its Subdivisions**

Pharmacology is the biomedical science concerned with the interaction of chemical substances with living cells, tissues, and organisms. It is particularly concerned with the mechanisms by which drugs counteract the manifestations of disease and affect fertility. Pharmacology is not primarily focused on the methods of synthesis or isolation of drugs, or with the preparation of pharmaceutical products. The disciplines that deal with these subjects are described below.

Pharmacology is divided into two main subdivisions, pharmacokinetics and pharmacodynamics. The relationship between these subdivisions is shown in Figure 1–1. Pharmacokinetics is concerned with the processes that determine the concentration of drugs in body fluids and tissues over time, including drug absorption, distribution, biotransformation (metabolism), and excretion. Pharmacodynamics is the study of the actions of drugs on target organs. A shorthand way of thinking about it is that pharmacodynamics is what the drug does to the body, and pharmacokinetics is what the body does to the drug. Modern pharmacology is focused on the biochemical and molecular mechanisms by which drugs produce their physiologic effects and with the dose-response relationship, defined as the relationship between the concentration of a drug in a tissue and the magnitude of the tissue’s response to that drug. Most drugs produce their effects by binding to protein receptors in target tissues, a process that activates a cascade of events known as signal transduction. Pharmacokinetics and pharmacodynamics are discussed in greater detail in Chapters 2 and 3.

**Toxicology**

Toxicology is the study of poisons and organ toxicity. It focuses on the harmful effects of drugs and other chemicals, and on the mechanisms by which these agents produce pathologic changes, disease, and death. As with pharmacology, toxicology is concerned with the relationship between the dose of an agent and the resulting tissue concentration and biologic effects that the agent produces. Most drugs have toxic effects at high enough doses and may have adverse effects related to toxicity at therapeutic doses.

**Pharmacotherapeutics**

Pharmacotherapeutics is the medical science concerned with the use of drugs in the treatment of disease. Pharmacology provides a rational basis for pharmacotherapeutics by explaining the mechanisms and effects of drugs on the body and the relationship between dose and drug response. Human studies known as clinical trials are then used to determine the efficacy and safety of drug therapy in human subjects. The purpose, design, and evaluation of human drug studies are discussed in Chapter 4.

**Pharmacy and Related Sciences**

Pharmacy is the science and profession concerned with the preparation, storage, dispensing, and proper use of drug products. Related sciences include pharmacognosy, medicinal chemistry, and pharmaceutical chemistry. Pharmacognosy is the study of drugs isolated from natural sources, including plants, microbes, animal tissues, and

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**Table 1–1. The Nobel Prize and the History of Pharmacology**

<table>
<thead>
<tr>
<th>Person(s) and Year Awarded</th>
<th>Significant Discovery in Pharmacology</th>
</tr>
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<tbody>
<tr>
<td>Elie Metchnikoff, Paul Ehrlich (1908)</td>
<td>First antimicrobial drugs (“magic bullet”)</td>
</tr>
<tr>
<td>Frederick Banting, John Macleod (1923)</td>
<td>Isolation and discovery of insulin and its application in the treatment of diabetes</td>
</tr>
<tr>
<td>Sir Henry Dale, Otto Loewi (1936)</td>
<td>Chemical transmission of nerve impulses</td>
</tr>
<tr>
<td>Ernst Chain, Sir Alexander Fleming, Sir Howard Florey (1945)</td>
<td>Discovery of penicillin and its curative effect in various infectious diseases</td>
</tr>
<tr>
<td>Edward Kendall, Tadeus Reichstein, Philip S. Hench (1950)</td>
<td>Hormones of the adrenal cortex, their structure and biological effects</td>
</tr>
<tr>
<td>Daniel Bovet (1957)</td>
<td>Transmitters in the nerve terminals and the mechanism for storage, release, and inactivation</td>
</tr>
<tr>
<td>Earl Sutherland, Jr. (1971)</td>
<td>Discovery of prostaglandins and the mechanism of action of aspirin which inhibits prostaglandin synthesis</td>
</tr>
<tr>
<td>Sune Bergström, Bengt Samuelsson, John R. Vane (1982)</td>
<td>Development of the first beta-blocker, propranolol, and anticancer agents that block nucleic acid synthesis</td>
</tr>
<tr>
<td>Sir James W. Black, Gertrude B. Elion, George H. Hitchings (1988)</td>
<td>Discovery of G proteins and the role of these proteins in signal transduction in cells</td>
</tr>
<tr>
<td>Alfred Gilman, Martin Rodbell (1994)</td>
<td>Recognition of nitric oxide as a signaling molecule in the cardiovascular system</td>
</tr>
<tr>
<td>Robert Furchgott, Louis Ignarro, Ferid Murad (1998)</td>
<td>Role of dopamine in schizophrenia and signal transduction in the nervous system leading to long-term potentiation</td>
</tr>
</tbody>
</table>

*Selected from the list of recipients of the Nobel Prize for Physiology or Medicine; note that many other discoveries pertinent to pharmacology were made by other Nobel Prize winners in this field and in the field of chemistry and that the original discovery was often made many years before the Nobel Prize was awarded.

AMP = adenosine monophosphate.
minerals. Medicinal chemistry is a branch of organic chemistry that specializes in the design and chemical synthesis of drugs. Pharmaceutical chemistry, or pharmaceutics, is concerned with the formulation and chemical properties of pharmaceutical products, such as tablets, liquid solutions and suspensions, and aerosols.

**DRUG SOURCES AND PREPARATIONS**

A drug can be defined as a natural product, chemical substance, or pharmaceutical preparation intended for administration to a human or animal to diagnose or treat a disease. The word drug is derived from the French drogue, which originally meant dried herbs and was applied to herbs in the marketplace used for cooking rather than for any medicinal reason. Ironically, the medical use of the drug marijuana, a dried herb, is hotly debated in many societies today. Medication, and less frequently, medicament are terms that are synonymous with the word drug.

Natural Sources of Drugs

Drugs have been obtained from plants, microbes, animal tissues, and minerals. Among the various types of drugs derived from plants are alkaloids, which are substances containing nitrogen groups and give an alkaline reaction in aqueous solution. Examples of alkaloids include morphine, cocaine, atropine, and quinine. Antibiotics have been isolated from numerous microorganisms, including Penicillium and Streptomyces species. Hormones are the most common type of drug obtained from animals, whereas minerals have yielded a few useful therapeutic agents, including the lithium compounds used to treat bipolar mental illness.

Synthetic Drugs

Modern chemistry in the 19th century enabled scientists to synthesize new compounds and to modify naturally occurring drugs. Aspirin, barbiturates, and local anesthetics (e.g., procaine) were among the first drugs to be synthesized in the laboratory. Semisynthetic derivatives of naturally occurring compounds have led to new drugs with different properties, such as the morphine derivative oxycodone.

In some cases, new drug uses were discovered by accident when drugs were used for another purpose, or by actively screening a huge number of related molecules for a specific pharmacologic activity. Medicinal chemists now use molecular modeling software to discern the structure-activity relationship, which is the relationship between the drug molecule, its target receptor, and the resulting pharmacologic activity. In this way, a virtual model for the receptor of a particular drug is created, and drug molecules that best fit the three-dimensional conformation of the receptor are synthesized. This approach has been used, for example, to design agents that inhibit angiotensin synthesis, treat hypertension, and inhibit the maturation of the human immuno-deficiency virus in AIDS patients.

Drug Preparations

Drug preparations include crude drug preparations obtained from natural sources, pure drug compounds isolated from natural sources or synthesized in the laboratory, and pharmaceutical preparations of drugs intended for administration to patients. The relationship between these types of drug preparations is illustrated in Figure 1–2.

Crude Drug Preparations

Some crude drug preparations are made by drying or pulverizing a plant or animal tissue. Others are made by extracting substances from a natural product with the aid of hot water or a solvent such as alcohol. Familiar examples of crude drug preparations are coffee and tea, made from distillates of the beans and leaves of Coffea arabica and Camellia sinensis plants, and opium, which is the dried juice of the unripe poppy capsule of the plant, Papaver somniferum.

Pure Drug Compounds

It is difficult to identify and quantify the pharmacologic effects of crude drug preparations because these products contain multiple ingredients, the amounts of which may vary from batch to batch. Hence, the development of methods to isolate pure drug compounds from natural sources was an important step in the growth of pharmacology and rational therapeutics. Frederick Sertürner, a German apothecary, isolated the first pure drug from a natural source.
A tablet must disintegrate after it is ingested, and then the drug must dissolve in gastrointestinal fluids before it can be absorbed into the circulation. Variations in the rate and extent of tablet disintegration and drug dissolution can give rise to differences in the oral bioavailability of drugs from different tablet formulations (see Chapter 4).

Tablets may have various types of coatings. Enteric coatings consist of polymers that will not disintegrate in gastric acid but will break down in the more basic pH of the intestines. Enteric coatings are used to protect drugs that would otherwise be destroyed by gastric acid and are also to slow the release and absorption of a drug when a large dose is given at one time, for example, in the formulation of the antidepressant, fluoxetine, called Prozac Weekly.

Sustained-release products, or extended-release products, release the drug from the preparation over many hours. The two methods used to extend the release of the drug are controlled diffusion and controlled dissolution. With controlled diffusion, release of the drug from the pharmaceutical product is regulated by a rate-controlling membrane. Controlled dissolution is done by inert polymers that gradually break down in body fluids. These polymers may be part of the tablet matrix, or they may be used as coatings over small pellets of drug enclosed in a capsule. In either case, the drug is gradually released into the gastrointestinal tract as the polymers dissolve.

Some products use osmotic pressure to provide a sustained release of a drug. These products contain an osmotic agent that attracts gastrointestinal fluid at a constant rate. The attracted fluid then forces the drug out of the tablet through a small laser-drilled hole (Fig. 1–3A).

Capsules are hard or soft gelatin shells enclosing a powdered or liquid medication. Hard capsules are used to enclose powdered drugs, whereas soft capsules enclose a drug in solution. The gelatin shell quickly dissolves in gastrointestinal fluids to release the drug for absorption into the circulation.

SOLUTIONS AND SUSPENSIONS. Drug solutions and particle suspensions, the most common liquid pharmaceutical preparations, can be formulated for oral, parenteral, or other routes of administration. Solutions and suspensions provide a convenient method for administering drugs to pediatric and other patients who cannot easily swallow pills or tablets. They are less convenient than solid dosage forms, however, because the liquid must be measured each time a dose is given.

Solutions and suspensions for oral administration are often sweetened and flavored to increase palatability. Sweetened aqueous solutions are called syrups, whereas sweetened aqueous–alcoholic solutions are known as elixirs. Alcohol is included in elixirs as a solvent for drugs that are not sufficiently soluble in water alone.

Sterile solutions and suspensions are available for parenteral administration with a needle and syringe, or with an intravenous infusion pump. Many drugs are formulated as sterile powders for reconstitution with sterile liquids at the time the drug is to be injected, because the drug is not stable for long periods of time in solution. Sterile ophthalmic solutions and suspensions are suitable for administration with an eyedropper into the conjunctival sac.

**Figure 1–2. Types of drug preparations.** A crude drug preparation retains most or all of the active and inactive compounds contained in the natural source from which it was derived. After a pure drug compound (e.g., morphine) is extracted from a crude drug preparation (in this case, opium), it is possible to manufacture pharmaceutical preparations that are suitable for administration of a particular dose to the patient.

**Pharmaceutical Preparations**

Pharmaceutical preparations or dosage forms are drug products suitable for administration of a specific dose of a drug to a patient by a particular route of administration. Most of these preparations are made from pure drug compounds, but a few are made from crude drug preparations and sold as herbal remedies.

**TABLETS AND CAPSULES.** Tablets and capsules are the most common preparations for oral administration because they are suitable for mass production, are stable and convenient to use, and can be formulated to release the drug immediately after ingestion or to release it over a period of hours.

In the manufacture of tablets, a machine with a punch and die mechanism compresses a mixture of powdered drug and inert ingredients into a hard pill. The inert ingredients include specific components that provide bulk, prevent sticking to the punch and die during manufacture, maintain tablet stability in the bottle, and facilitate solubilization of the tablet when it reaches gastrointestinal fluids. These ingredients are called fillers, lubricants, adhesives, and disintegrants, respectively.
SKIN PATCHES. Transdermal skin patches are drug preparations in which the drug is slowly released from the patch for absorption through the skin into the circulation. Most skin patches use a rate-controlling membrane to regulate the diffusion of the drug from the patch (Fig. 1–3B). Such devices are most suitable for potent drugs, which are therefore effective at relatively low dosages, and have sufficient lipid solubility to enable skin penetration.

AEROSOLS. Aerosols are a type of drug preparation administered by inhalation through the nose or mouth. They are particularly useful for treating respiratory disorders because they deliver the drug directly to the site of action and may thereby minimize the risk of systemic side effects. Some aerosol devices contain the drug dispersed in a pressurized gas and are designed to deliver a precise dosage each time they are activated by the patient. Nasal sprays, another type of aerosol preparation, can be used either to deliver drugs that have a localized effect on the nasal mucosa or to deliver drugs that are absorbed through the mucosa and exert an effect on another organ. For example, butorphanol, an opioid analgesic, is available as a nasal spray (STADOL NS) for the treatment of pain.

OINTMENTS, CREAMS, LOTIONS, AND SUPPOSITORIES. Ointments and creams are semisolid preparations intended for topical application of a drug to the skin or mucous membranes. These products contain an active drug that is incorporated into a vehicle (e.g., polyethylene glycol or petrolatum), which enables the drug to adhere to the tissue for a sufficient length of time to exert its effect. Lotions are liquid preparations often formulated as oil-in-water emulsions and are used to treat dermatologic conditions. Suppositories are products in which the drug is incorporated into a solid base that melts or dissolves at body temperature. Suppositories are used for rectal, vaginal, or urethral administration and may provide either localized or systemic drug therapy.

Figure 1–3. Mechanisms of sustained-release drug products. In the sustained-release tablet [A], water is attracted by an osmotic agent in the tablet, and this forces the drug out through a small orifice. In the transdermal skin patch (B), the drug diffuses through a rate-controlling membrane and is absorbed through the skin into the circulation.

ENTERAL ADMINISTRATION

Some routes of drug administration, such as the enteral and common parenteral routes compared in Table 1–2, are intended to elicit systemic effects and are therefore called systemic routes. Other routes of administration, such as the inhalation route, can elicit either localized effects or systemic effects, depending on the drug being administered.

**Enteral Administration**

The enteral routes of administration are those in which the drug is absorbed from the gastrointestinal tract. These include sublingual, buccal, oral, and rectal routes.

In **sublingual administration**, a drug product is placed under the tongue. In **buccal administration**, the drug is placed between the cheek and the gum. Both sublingual and buccal administrations enable the rapid absorption of certain drugs and are not affected by first-pass drug metabolism in the liver. Drugs for sublingual and buccal administration are given in a relatively low dosage and must have good solubility in water and lipid membranes. Larger doses might be irritating to the tissue and would likely be washed away by saliva before the drug would be absorbed. Two examples of drugs available for sublingual administration are **nitroglycerin** for treating ischemic heart disease and **hyoscyamine** for treating bowel cramps. Fentanyl, a potent opioid analgesic, is available in an oral transmucosal formulation (ACTIQ) like a lollypop for rapid absorption from the buccal mucosa in the treatment of breakthrough cancer pain.

In medical orders and prescriptions, **oral administration** is designated as *per os* (PO), which means to administer ‘by mouth’. The medication is swallowed, and the drug is absorbed from the stomach and small intestines. Because the oral route of administration is convenient and relatively safe and economical, it is the most commonly used route. It does have some disadvantages, however. Absorption of orally administered drugs can vary widely because of the interaction of drugs with food and gastric acid and the varying rates of gastric emptying, intestinal transit, and tablet disintegration and dissolution. Moreover, some drugs are inactivated by the liver following their absorption from the gut, called first-pass metabolism, and oral administration is not suitable for use by patients who are sedated, comatose, or suffering from nausea and vomiting.
Rectal administration of drugs in suppository form can result in either a localized effect or a systemic effect. Suppositories are useful when patients cannot take medications by mouth, such as in the treatment of nausea and vomiting. They can also be administered for localized conditions such as hemorrhoids. Drugs absorbed from the lower rectum undergo relatively little first-pass metabolism in the liver.

**Parenteral Administration**

Parenteral administration refers to drug administration with a needle and syringe, or with an intravenous infusion pump. The most commonly used parenteral routes are the intravenous, intramuscular, and subcutaneous routes.

Intravenous administration bypasses the process of drug absorption and provides the greatest reliability and control over the dose of drug reaching the general circulation. It is often preferred for administration of drugs with short half-lives and drugs whose dosage must be carefully titrated to the physiologic response, such as agents used to treat hypotension, shock, and acute heart failure. The intravenous route is widely used to administer antibiotics and anti-neoplastic drugs to critically ill patients, as well as to treat various types of medical emergencies. The intravenous route is potentially the most dangerous, because rapid administration of drugs by this route can cause serious toxicity.

Intramuscular and subcutaneous administration is suitable for treatment with drug solutions and particle suspensions. Solutions are absorbed more rapidly than particle suspensions, so suspensions are often used to extend the duration of action of a drug over many hours or days. Most drugs are absorbed more rapidly after intramuscular than after subcutaneous administration because of the greater circulation of blood to the muscle.

Intrathecal administration refers to injection of a drug through the thecal covering of the spinal cord and into the subarachnoid space. In cases of meningitis, the intrathecal route is useful in administering antibiotics that do not cross the blood-brain barrier. Epidural administration, common in labor and delivery, targets analgesics into the space above the dura membranes of the spinal cord.

Other less common parenteral routes include intrarticular administration of drugs used to treat arthritis, intradermal for allergy tests, and insufflation (intranasal) for sinus medications.

**Transdermal Administration**

Transdermal administration is the application of drugs to the skin for absorption into the circulation. Application can be via a skin patch or, less commonly, via an ointment. Transdermal administration, which bypasses first-pass metabolism, is a reliable route of administration for drugs that are effective when given in a relatively low dosage and that are highly soluble in lipid membranes. Transdermal skin patches slowly release medication for periods of time that typically range from one to seven days. Two examples of transdermal preparations are the skin patches called fentanyl transdermal (Duragesic) used to treat severe chronic pain, and nitroglycerin ointment that is used to treat heart failure and angina pectoris.

**Inhalational Administration**

Inhalational administration can be used to produce either a localized or a systemic drug effect. A localized effect on the respiratory tract is obtained with drugs used to treat asthma or rhinitis, whereas a systemic effect is observed when a general anesthetic, such as halothane, is inhaled.

**Topical Administration**

Topical administration refers to the application of drugs to the surface of the body to produce a localized effect. It is often used to treat disease and trauma of the skin, eyes, nose, mouth, throat, rectum, and vagina.

**DRUG NAMES**

A drug often has several names, including a chemical name, a nonproprietary (generic) name, and a proprietary name (or trade or brand name).

The chemical name, which specifies the chemical structure of the drug, uses standard chemical nomenclature. Some chemical names are short and easily pronounceable, for example the chemical name of aspirin is acetylsalicylic acid. Others are long and hard to pronounce due to the size and complexity of the drug molecule. For most drugs, the chemical name is used primarily by medicinal chemists. [AQ1]

The nonproprietary name, or generic name, is the type of drug name most suitable for use by health care
professionals. In the United States, the preferred nonproprietary names are the United States Adopted Names (USAN) designations. These designations, which are often derived from the chemical names of drugs, provide some indication of the class to which a particular drug belongs. For example, oxacillin can be easily recognized as a type of penicillin. The designations are selected by the USAN Council, which is a nomenclature committee representing the medical and pharmacy professions and the United States Pharmacopeia (see Chapter 4), with advisory input from the US Food and Drug Administration. The USAN is often the same as the International Nonproprietary Name and the British Approved Name. International generic names for drugs can vary with the language in which they are used.

The proprietary name, trade name, or brand name for a drug is the registered trademark belonging to a particular drug manufacturer and used to designate a drug product marketed by that manufacturer. Many drugs are marketed under two or more brand names, especially after the manufacturer loses patent exclusivity. For example, ibuprofen (generic name) is marketed in the United States with the brand name ADVIL, and its brand name(s) in SMALL CAPS font.

SUMMARY OF IMPORTANT POINTS

- The development of pharmacology was made possible by important advances in chemistry and physiology that enabled scientists to isolate and synthesize pure chemical compounds (drugs) and to design methods for identifying and quantifying the physiologic actions of the compounds.
- Pharmacology has two main subdivisions. Pharmacodynamics is concerned with the mechanisms of drug action and the dose-response relationship, whereas pharmacokinetics is concerned with the relationship between the drug dose and the plasma drug concentration over time.
- The sources of drugs are natural products (including plants, microbes, animal tissues, and minerals) and chemical synthesis. Drugs can exist as crude drug preparations, pure drug compounds, or pharmaceutical preparations used to administer a specific dose to a patient.
- The primary routes of administration are enteral (e.g., oral ingestion), parenteral (e.g., intravenous, intramuscular, and subcutaneous injection), transdermal, inhalational, and topical. Most routes produce systemic effects. Topical administration produces a localized effect at the site of administration.

All drugs (pure compounds) have a nonproprietary name (or generic name, such as a USAN designation) as well as a chemical name. Some drugs also have one or more proprietary names (trade names or brand names) under which they are marketed by their manufacturer.

**Review Questions**

1. Which route of drug administration is used with potent and lipophilic drugs in a patch formulation and avoids first-pass metabolism?
   (A) topical  
   (B) sublingual  
   (C) rectal  
   (D) oral  
   (E) transdermal

2. Which one of the following routes of administration does not have an absorption phase?
   (A) subcutaneous  
   (B) intramuscular  
   (C) intravenous  
   (D) sublingual  
   (E) inhalation

3. Which of the following correctly describes the intramuscular route of parenteral drug administration?
   (A) drug absorption is erratic and unpredictable  
   (B) used to administer drug suspensions that are slowly absorbed  
   (C) bypasses the process of drug absorption to give an immediate effect  
   (D) cannot be used for drugs that undergo a high degree of first-pass metabolism  
   (E) poses more risks than intravenous administration

4. An elderly patient has problems remembering to take her medication three times a day. Which one of the drug formulations might be particularly useful in this case?
   (A) extended-release  
   (B) suspension  
   (C) suppository  
   (D) skin-patch  
   (E) enteric-coated

5. Which form of a drug name is most likely known by patients from exposure to drug advertisements?
   (A) nonproprietary name  
   (B) British Approved Name  
   (C) chemical name  
   (D) generic name  
   (E) proprietary name

**Answer and Explanations**

1. **The answer is E:** transdermal. The topical, sublingual, rectal (suppositories), and transdermal routes of administration all avoid first-pass hepatic drug metabolism; however, only the transdermal formulation uses a patch with potent and lipophilic drugs. Orally administered drugs have the highest exposure to first-pass metabolism.
2. **The answer is C**: intravenous administration. Drug absorption refers to the process by which drugs get into the bloodstream. With subcutaneous, intramuscular, sublingual, and inhalation routes of administration, drug molecules have to cross membranes to get into the blood. Direct delivery of drug into the blood by intravenous administration therefore has no absorption phase.

3. **The answer is B**: used to administer drug suspensions that are slowly absorbed. After intramuscular injection of a suspension of drug particles, the particles slowly dissolve in interstitial fluid to provide sustained drug absorption over many hours or days. When a drug solution is injected intramuscularly, the drug is usually absorbed rapidly and completely.

4. **The answer is A**: extended-release. Using an extended-release tablet or capsule, the patient could most likely reduce the schedule of medication from three times a day to once a day. A suspension, for oral administration, would not likely reduce the schedule; a suppository would be difficult and reduce patient compliance; and a skin-patch for transdermal administration would only work in a few cases with potent and highly lipophilic drugs. Enteric-coated may help absorption or drug stability but would not reduce the schedule of medication.

5. **The answer is E**: proprietary name. The proprietary name, also known as the trade name or the brand name, is the name trademarked by the manufacturer and promoted on television, radio, and print ads. The chemical name is rarely seen, being tedious and descriptive only to chemists, whereas the generic name may be seen in the fine print of the ad but is not usually promoted as highly as the proprietary name. The nonproprietary name is the same thing as the generic name, and the British Approved Name is an official name that is usually the same as the generic name.

**SELECTED READINGS**


