A Review of Medication Dosage Forms, Drug Administration, Pharmacokinetics, and Abbreviations
A Knowledge Based Course For Technicians

By

Jeff Blackburn, MBA – Healthcare Administration, C.Ph.T.

ACPE No. 0096-9999-10-071-H04-T

Release Date: September 27, 2010
Expiration Date: September 27, 2013

Total number of pharmacy continuing education hours: 6 hours (0.6 CEU’s)

Course Cost: $19.00 (to be paid at time of testing)
Average time to Complete: Approximately Six hours including testing
Course Value: Six Contact Hours
Reading: 46 Pages
Final Exam: 50 Questions
Completion Requirements: Answer 70% of the questions correctly. Evaluation
Statement of Need

As a certified pharmacy technician, our number one goal is patient safety, and the number one weapon against medication errors is knowledge. While the information contained within this course should be familiar to every certified pharmacy technician, it is doubtful that you have given much thought to this area since your exam or last class. With that in mind the goal of this course is to refresh the memory of the technician in order to make them the best they can be at their jobs. While there may not be much new information, hopefully this will give you the opportunity to relearn some things you may have forgotten, which one of the main purposes of continuing education is.
Course Objectives

Upon successful completion of this course, the reader should be able to:

1. Identify most common medication dosage forms.

2. Describe the advantages and disadvantages of different medication dosage forms.

3. Understand the different routes of administration and the advantages of each.

4. Define pharmacokinetics.

5. Understand the way a drug is processed after it is administered.
Introduction

As a certified pharmacy technician, our number one goal is patient safety, and the number one weapon against medication errors is knowledge. While the information contained within this course should be familiar to every certified pharmacy technician, it is doubtful that you have given much thought to this area since your exam or last class. With that in mind the goal of this course is to refresh the memory of the technician in order to make them the best they can be at their jobs. While there may not be much new information, hopefully this will give you the opportunity to relearn some things you may have forgotten, which one of the main purposes of continuing education is.

The route of administration, in part, regulates drug action. Serious drug errors and death can result when a drug is delivered by the wrong route. Each member of the healthcare team involved in medication administration must be constantly vigilant to prevent errors and deliver quality patient care. The healthcare team must be familiar with many different forms of medications, as well as with their routes of administration, dosages, and strengths. A medication should never be given until its purpose, possible side effects, precautions, and recommended dosages are known.

When most people think of taking a medication, they think of swallowing a tablet or capsule. Although this is the most common way people take medications, other forms of administration are used to introduce medications into the body by routes other than the mouth. Solutions, suspensions, suppositories, and sprays may be sued to deliver medications into body areas such as the ear, nose, eye, rectum, or bloodstream.

A drug is defined as an agent intended for use in the diagnosis, mitigation, treatment, cure, or prevention of disease in humans or in other animals. One of the most astounding qualities of drugs is the diversity of their actions and effects on the body. This quality enables their selective use in the treatment of a range of common and rare conditions involving virtually every body organ, tissue, and cell.

Certainly the vast array of effective medicinal agents available today is one of our greatest scientific accomplishments. It is difficult to conceive our society without these remarkable and beneficial agents. Through their use, many of the diseases that have plagued humans throughout history, such as smallpox and poliomyelitis are now virtually extinct. Illnesses such as diabetes, hypertension, and mental depression are effectively controlled with modern drugs. Today’s surgical procedures would be virtually impossible without the benefit of anesthetics, analgesics, antibiotics, blood transfusions, and intravenous fluids.

The most effective routes of administration (e.g., oral, rectal, parenteral, topical) must be determined and guidelines for the dosages recommended for persons of varying ages (e.g., neonates, children, adults, geriatrics), weights, and states of illness have to be established. It has been said that the only difference between a drug and a poison is the dose.
This course describes common dosage forms and routes of administration. It is not intended to be all inclusive; other references are available that are more extensive and detailed.

**Medication Dosage Forms**

Drug dosage forms are classified according to their physical state and chemical composition. During manufacturing, the drug itself is mixed with other substances to create the form needed. The non-therapeutic substance is called the **vehicle**. This vehicle is the substance added to a drug to give the drug bulk or suitable consistency, and may be a solid, semisolid, liquid, or gas.

To ensure the stability of a drug in a formulation and the continued effectiveness of the drug product throughout its usual shelf life, the principles of chemistry, physical pharmacy, microbiology, and pharmaceutical technology must be applied. The formulation must be such that all components are physically and chemically compatible, including the active therapeutic agents, the pharmaceutical ingredients, and the packaging materials. The formulation must be preserved against decomposition due to chemical degradation and protected from microbial contamination and the destructive influences of excessive heat, light, and moisture. The therapeutic ingredients must be released from the dosage form in the proper quantity and in such a manner that the onset and duration of the drug’s action is that which is desired. The pharmaceutical product must lend itself to efficient administration and must possess attractive features of flavor, odor, color, and texture that enhance acceptance by the patient. Finally, the product must be effectively packaged and clearly and completely labeled according to legal regulations.

**Liquid Medication Dosage Forms**

Liquid preparations include drugs that have been dissolved or suspended. Examples of liquid drugs are syrups, spirits, elixirs, tinctures, fluidextracts, liniments, emulsions, solutions, mixtures, suspensions, aromatic waters, sprays, and aerosols. Liquid drugs may be administered systematically by mouth or injected, by using different techniques, into the skin, muscles, or veins.

Common vehicles are water, alcohol, and mineral oil. The medication may be dissolved in the vehicle or may be present as very fine solid particles suspended, or floating, in the vehicle. Liquid dosage forms may pour freely as water or have the thick consistency of syrup. They may be intended for oral consumption or for use in, or on, other parts of the body.

Liquid medication dosage forms have some advantages over other medication dosage forms:

1. Oral liquid dosage forms usually are faster acting than solid dosage forms. Medications are absorbed into the bloodstream in a dissolved state. The medication in a liquid dosage form is already dissolved or is present in small
particles so it can readily be absorbed. In contrast, tablets must dissolve before they can be absorbed so it takes more time for the medications to be absorbed.

2. For patients who have difficulty swallowing, oral liquid medications may be easier to take than an oral solid dosage form.

3. There is more flexibility in liquid doses than some other dosage forms because liquid medications are usually dispensed in bulk containers rather than distinct dosage units. For example, a liquid medication may contain 500 milligrams (mg) of a drug in 10 milliliters (ml) of liquid. The same medication is also available in 500mg tablets. To take a 600mg dose of the liquid medication, a patient would simply need to measure out 12ml of liquid. However, to take a 600mg dose of a tablet the patient would need to take 1.2 tablets, which would be difficult.

4. Liquid medications may be used where solid dosage forms are not practical to administer. For example, medications that need to be placed directly into the ear or eye may be more practically administered as a liquid rather than a solid.

Liquid dosage forms also have some disadvantages:

1. Often they have a shorter time to expiration than other dosage forms.

2. Most drugs have a bad taste as the drug dissolved or is chewed into small particles. Drug particles present in the oral liquid medications come in contact with the taste receptors on the tongue and leave a bad taste. Sweeteners and flavoring agents are necessary to make these liquid medications more palatable. Tablets, on the other hand, are often coated and swallowed quickly to avoid contact with the taste receptors.

3. Patients do not always find liquid medications convenient to take because they may be spilled, require careful measuring before administration, or have special storage or handling requirements such as refrigeration or shaking before use.

Liquid medication dosage forms are categorized based on several characteristics: they type of liquid medium (e.g., water or alcohol) in which the medication is delivered, whether the medication is dissolved or suspended as particles in the liquid, and the intended use of the medication.

**Solutions**

Solutions are evenly distributed, homogeneous mixtures of dissolved medication in a liquid vehicle. Molecules of a solid, liquid, or gaseous medication are equally distributed among the molecules of the liquid vehicle. Because the medication is already dissolved in the solution, it is absorbed from the stomach, skin, or other site of administration more quickly than other medication dosage forms.
Solutions may be subdivided based on characteristics of the vehicle:

- **Aqueous** and **viscous aqueous** solutions use purified water as the vehicle. Aqueous solutions may be ingested orally, applied topically, or injected into the bloodstream. Viscous aqueous solutions are sticky, thick, sweet solutions that are either liquid or semisolid.

- **Nonaqueous** solutions are those that utilize solvents, or dissolving liquids, in addition to or instead of water. Commonly used nonaqueous solvents include alcohol (ethyl alcohol or ethanol), glycerin, and propylene glycol. Nonaqueous solutions that employ alcohol and their solvent are called alcoholic solutions.

- **Hydroalcoholic** solutions are nonaqueous solutions that contain a mixture of alcohol and water.

- **Inhalants** and **liniments** do not fit neatly into any category and are classified as miscellaneous solutions.

**Aqueous Solutions**

**Douches** are solutions that are directed into a body cavity or against a part of the body to clean or disinfect. Douches are used to remove debris from the eyes, or to cleanse the nose, throat, or vagina.

**Irrigating solutions** are used to wash or cleanse part of the body such as the eyes, urinary bladder, open wounds, or abraded skin. They often contain medications such as antibiotics or other antimicrobial agents. Irrigating solutions may be used in surgical procedures to clear the surgical field of blood and surgical debris. While similar to douches, irrigating solutions usually are used in larger volumes and over larger areas of the body for more general cleansing than douches.

**Enemas** are solutions that are introduced into the rectum to empty the bowel or to treat diseases of the lower gastrointestinal tract. Enemas, such as Fleet enemas, are often given to relieve serious constipation or to cleanse the bowel before surgery.

**Gargles** are solutions that treat conditions of the throat. The gargle is held in the throat as the patient gurgles air through the solution. Although gargles are admitted into the mouth, they should not be swallowed. A familiar example of a gargle is Chloraseptic mouth rinse and gargle.

A **wash** is a solution that cleanses or bathe a body part, such as the eyes or mouth. A **mouth-wash** is a solution used to deodorize, refresh, or disinfect the mouth, primarily for cosmetic reasons. Although many people use mouthwashes as gargles, technically they are in different classes of solutions; gargles are used to treat throat conditions such as a sore throat, while mouthwashes are used to freshen the mouth. Like gargles,
mouthwashes should not be swallowed. Common mouthwashes include Scope and Listerine.

**Sprays** are solutions that are delivered as a mist against the mucous membranes of the nose and throat. Nasal decongestants and antiseptic throat solutions are common spray formulations.

**Viscous Aqueous Solutions**

A **syrup** is a concentrated mixture of sugar and purified water. The high sugar content distinguishes syrups from other types of solutions. Syrups may or may not contain medication or added flavoring agents. Syrups without a medication, but with a flavoring agent, are called non-medicated or flavored syrups. Flavored syrups are often used as vehicles for unpleasant tasting medications; the result is medicated syrup. The high amount of sugar present in syrups predisposes them to bacterial contamination, so they often contain a preservative.

The advantage of syrup is its ability to disguise the bad taste of medications. Syrups are thicker than aqueous solutions, therefore only a portion of the medication dissolved in the syrup comes in contact with the taste buds. The remainder of the medication is held above the tongue by the thick syrup so it is not tasted as it is swallowed. The high sugar content of syrups gives them a sweet taste that helps conceal the bad taste of the medicine. This is why syrups are commonly used for pediatric medications.

The thick character of syrups also has a soothing effect on irritated tissues of the throat, so syrups are often used for cough formulations. Robitussin and Triaminic Syrup are examples of two well-known cough and cold syrups.

**Jellies** are semisolid solutions that contain a high proportion of water. Jellies are used as lubricants for surgical glove and rectal thermometers. K-Y Jelly is an example of a commonly used biological lubricant. It may be used to aid in the insertion of rectal thermometers or other diagnostic probes into orifices, as a sexual lubricant, or to reduce surface friction during ultrasound procedures. Jellies are also used as vehicles for vaginal contraceptive agents.

**Mucilages** are thick, viscous, adhesive liquids. They are solutions of water containing the sticky, pulpy components of vegetable matter. Mucilages are useful dosage forms that prevent insoluble solid medication particles from settling to the bottom of liquids. Bulk-producing laxative/psyllium products such as Metamucil form mucilage when the powder is added to water or juice.

**Hydroalcoholic Solutions**

Hydroalcoholic solutions are nonaqueous and differ from aqueous solutions in that they contain alcohol in addition to water. Elixirs and spirits are examples of hydroalcoholic solutions.
**Elixirs** are clear, sweet, flavored water-and-alcohol mixtures intended for oral ingestion. The alcohol content in various elixirs varies greatly depending on the ability of the other ingredients in the elixir to dissolve in water. Many drugs do not dissolve easily in pure water but do so in a water-and-alcohol mixture. The alcohol in an elixir helps to dissolve these drugs. Some elixirs may have as little as 3% alcohol while others may contain almost 25% alcohol. The advantage of an elixir, its alcohol content, may also be a disadvantage or a contraindication in patients who should not or cannot ingest alcohol. In addition, alcohol can have undesired interactions with other medications the patient may be taking. Pediatric, elderly, and alcoholic patients should be made aware of the alcohol content of elixirs, because these patients may be especially sensitive to even a small amount of alcohol. Phenobarbital elixir and digoxin pediatric elixir are two widely prescribed medicated elixirs.

Aromatic and licorice elixirs are used as flavoring agents. An aromatic elixir is an unmedicated elixir commonly as a vehicle for other medications. “Simple elixir,” which contains orange, lemon, coriander, and anise oils in syrup, water, and alcohol, is such an example.

**Spirits**, or essences, are alcoholic or hydroalcoholic solutions that contain volatile, or easily evaporated, substances. Because the volatile substances dissolve most readily in alcohol, spirits can contain a greater concentration of these materials than water. Perhaps the most familiar spirits administered internally are the alcoholic beverages brandy (Spirits Vini Vitis) and whisky (Spiritus Frumenti). Other spirits may be inhaled (e.g., aromatic ammonia spirits, popularly known as smelling salts), while still others, such as peppermint spirits, are used as flavoring agents.

**Alcoholic Solutions**

Alcoholic solutions are nonaqueous solutions that contain alcohol but no water.

A **colloision** is a liquid preparation of pyroxylin (found in cotton fibers) dissolved in ethyl ether and ethanol. After application to the skin, the ether and ethanol evaporate and leave a pyroxylin film. Collodions that contain medication are useful in the treatment of corns and warts. Unmedicated collodions, such as liquid adhesive bandages (New-Skin), may be applied to the skin to protect and seal small wounds.

**Spirits** as mentioned above, may be either alcoholic or hydroalcoholic solutions.

**Glycerite Solutions**

Glycerites are nonaqueous solutions of medication dissolved in glycerin, a sweet oily fluid made from fats and oils. Glycerin can be used alone as a vehicle, in combination with water, alcohol, or both. Because glycerin easily mixes with water and alcohol, it can be used as a solvent for medications that do not dissolve in either alone. After dissolving a medication in glycerin, the medication/glycerin mixture can then be easily added to a
water and/or alcohol vehicle. Most glycerite solutions are very viscous, some to the point of being jelly-like. Glycerites are not commonly used today.

**Miscellaneous Solutions**

*Inhalants* are fine powders or solutions of drugs delivered as a mist through the mouth into the respiratory tract. Many drugs used to treat asthma are formulated as inhalants. The over-the-counter product Primatene Mist and the prescription drug Proventil are two examples.

**Emulsions**

Emulsions are mixtures of two liquids that normally do not mix. In an emulsion, one liquid is broken into small particles and evenly scattered throughout the other. The liquid present in small particles is referred to as the internal phase; the other liquid is called the external, or continuous, phase. To keep the liquids from separating, an emulsifying agent is added to the formulation. The emulsifying agent prevents the small particles of the internal phase from fusing together and eventually separating out from the external phase to form two distinct layers. Oil-and-vinegar salad dressing is a common household emulsion that is formed by shaking the two liquids together. Because no emulsifying agent is added, the oil and vinegar separate within seconds after shaking and the emulsion is broken.

In most emulsions, the two liquids are oil and water. An *oil-in-water* (O/W) emulsion consists of small oil globules dispersed throughout water; a *water-in-oil* (W/O) emulsion is the reverse; water droplets are distributed throughout the oil. Most emulsions intended for oral use are of the O/W type; those to be applied to the skin may be of either type.

**Oil-in-Water Emulsions**

The O/W emulsions are desirable for oral use for several reasons. Unpalatable oily medications are broken into small particles and dispersed throughout a sweetened, flavored aqueous vehicle. These small particles are then carried past the taste buds and swallowed without the patient tasting the oil medication. The small particle size increases medication absorption from the stomach into the bloodstream. Mineral oil and castor oil are available as emulsions that make them taste better.

**Water-in-Oil Emulsions**

Water-in-oil emulsions are often spread on unbroken skin. They spread more evenly than O/W emulsions since the natural oils on the skin readily mix with the external oil phase of the emulsion. They also soften the skin better because they retain moisture and are not readily washed off with water. However, they stain clothing and have a heavy, greasy feel. On the other hand, O/W emulsions may be more desirable in some cases since they are water washable and do not stain clothing. They feel lighter and non-greasy and are
particularly advantageous when the emulsion is to be applied to a hairy part of the body such as the scalp.

The choice of O/W or W/O emulsions for preparations applied to the skin depends on several factors. Medications that are irritating to the skin are better tolerated if they are applied to the skin as small particles present in the internal phase. The external phase keeps them from directly contacting and irritating the skin. Therefore, medications that dissolve more readily in oil are applied to the skin as O/W emulsions, in which the oil is the internal phase, while those that dissolve in water are applied as W/O emulsions, in which the water is the internal phase.

Some emulsions may also be injected into the bloodstream. Intravenous fat emulsion (Intralipid and Liposyn) is an example of a O/W emulsion that is infused into the bloodstream through a vein.

**Suspensions**

Suspensions are mixtures of fine particles of an undissolved solid distributed through gas, liquid, or solid. Most suspensions are solids dispersed in liquids. The difference between a solution and a suspension is that in a solution the particles are dissolved where in a suspension they are not. Suspensions are useful for administering a large amount of solid medication that would be inconvenient to take as a tablet or capsule. The fine particles dissolve more quickly in the stomach and thus are absorbed into the bloodstream more quickly than the medication of a solid tablet or capsule. Usually suspensions need to be shaken before use to redistribute particles that may have settled to the bottom or risen to the top of the container during storage.

Most suspensions are intended for oral use, but some may be administered by other routes such as the rectal, otic, ophthalmic, or parenteral routes. Orally administered suspensions usually use water as the vehicle; some given by parenteral routes, such as the intramuscular route, use an oil as the vehicle.

**Lotions** are suspensions intended for external applications. They contain finely powdered medications, and they cool, soothe, dry, or protect the skin. Lotions are usually applied without rubbing and work easily into large areas of the skin without leaving a greasy or oily feeling. Calamine lotion is a commonplace example of a protective lotion.

**Magmas** and **milk** are thick, viscous suspensions of undissolved drugs in water. Milk of magnesia may be the most familiar examples of a magma. Magmas and milks are usually intended for oral administration and should be shaken well before each use.

**Gels** are similar to magmas and milks except that the suspended particle size in gels is smaller. Gels, too, are often intended for oral administration.
Extractions are concentrated preparations of active components obtained from plant or animal tissue. The crude drug is extracted, or withdrawn, from the dried plant or animal tissue by soaking it in a solvent. The solvent is then evaporated, leaving the active component behind. Tinctures, fluidextracts, and extracts are examples of formulations prepared in this manner. They differ only in their potency.

Tinctures are alcoholic or hydroalcoholic solutions whose potency is adjusted so that each milliliter of tincture contains the equivalent potency of 100mg of crude drug. Iodine tincture and paregoric tincture are common examples.

Fluidextracts are more potent than tinctures; each milliliter of fluidextract contains the equivalent of 1000mg of crude drug. Cascara sagrada fluidextract and senna fluidextract are commonly used to clear bowels.

Extracts are prepared in the same manner as tinctures and fluidextracts but two to six times as potent as the crude drug. Vanilla, almond, peppermint extracts are examples of extracts.

Solid Medication Dosage Forms

Medications are widely available as solid dosage forms; in fact, most medications are available as a solid form (as well as a liquid form). There are different factors to be reviewed when deciding if a solid dosage form is an appropriate choice for a patient. Solid medications may be administered by different routes of administration, such as orally, rectally, vaginally, or topically.

Solid medications have several advantages and disadvantages compared with other forms of medication. Following are some of the common advantages of solid medications:

- Patients are able to self-administer solid medications more easily.
- Solid medications usually have a longer shelf life before expiring.
- Solid medications are easier to package, distribute, ship, and store.
- The dosing is more accurate with solid dosage forms, since the medication is already in a distinctive unit/measure.
- Solid dosage forms have been created to release the medication over a longer period of time in the patient’s body – extended release medications. This allows the patient to take fewer doses, while still getting the same desired effects.
There are also several disadvantages of solid medications:

- Some patients may have difficulty swallowing large tablets or capsules.
- Solid medications are not an appropriate choice for patients who are unconscious or have nasal/mouth breathing tubes for ventilation.
- Solid medications take longer to be absorbed, broken down, and distributed in the body. The stomach has to metabolize the medication before it can take effect.
- Solid medications are not fast enough for immediate action treatments. When immediate action treatments are required, liquids or injectable medications are more appropriate.

**Tablets**

Tablets are solid medications that are compacted into small, formed shapes. Tablets are usually taken by the mouth for oral administration. Tablets consist of several components. These components work together to ensure that the tablet is properly digested in the body, is easy to swallow, has flavorings or sweeteners for taste, and controls the timed release of the drug to produce the desired effect. All of the ingredients except the active drug are called inactive or inert ingredients.

Tablets are classified by the way they are made. The two most common classifications are molded tablets and compressed tablets. *Molded tablets* are made from wet materials placed in molds. *Compressed tablets* are formed by die punch compression of powdered, crystalline, or granular substances.

Other ingredients that have no medicinal activity may be included in a compressed tablet. These inactive, or inert, ingredients (e.g., binders, lubricants, diluents, colorants) are necessary for the manufacturing process or to make the tablet more effective (e.g., disintegrators). Binders help keep the compressed tablet from crumbling and hold it together. Diluents are fillers that are added to the active medication to make the tablet a practical size, and lubricants ease removal of the tablet from the die. Colorants add color to the product, and disintegrators are included to help the tablet dissolve in the stomach or elsewhere in the body.

Compressed tablets may have a sugar, film, or enteric coating on the outside. Sugar coating or film coating may be used to mask noxious-tasting or -smelling drugs, to add color to the tablet, or to protect the drug from exposure to the air and humidity. A film coating also coats the tablet with a hard shell to make it more durable and easier to swallow.

Enteric-coated oral tablets have a coating that protects the tablet from stomach acid and protects the lining of the gastrointestinal tract from irritation by the drug. Enteric-coating is also a technique used in making sustained-release tablets.
There are five common types of tablets that you need to understand. Each one has unique characteristics and uses.

**Chewable** tablets are tablets that can be chewed instead of swallowed. Chewable tablets should be chewed, and not swallowed, in order to achieve the desired results. Chewable tablets are most common in pediatric medications, since small children have a difficult time swallowing tablets. Chewable tablets are also known to have sweeteners and flavorings to mask the bad taste and make the medication easier to take. Some adult medications are also chewable, such as antacids and aspirin.

**Effervescent** tablets are dissolved into a liquid before administration. These tablets contain special ingredients that release the active chemical ingredient by bubbling and fizzing once placed in the liquid. Effervescent tablets have the advantage of being completely dissolved in the liquid before the patient takes the medication. This allows for quicker absorption in the body than a solid tablet.

**Sublingual** tablets are also quickly absorbed and disintegrated, once placed under the patient’s tongue. These tablets are absorbed through the lining of the mouth into the bloodstream. Medications that are destroyed by stomach acid or are poorly absorbed into the bloodstream may be formulated as either of these types of tablets.

**Buccal** tablets are similar to sublingual, except that they are disintegrated in the mouth in the lining of the cheek and then absorbed into the bloodstream.

**Vaginal** tablets are solid dosage forms that are administered through the vagina. These tablets are dissolved and absorbed through the mucous lining of the vagina. These are useful if immediate treatment and medication is needed in the walls of the vagina.

**Capsules**

Capsules are solid medication forms in which the drug is contained in an outer coating. Both the active and inactive ingredients are held together by the coating. The most common type of coating is a gelatin shell. The gelatin shells are made of protein from animals. The smooth surface of the gelatin shells allow for easier swallowing.

**Gelatin shells** are classified into two types: hard and soft. Soft gelatin shells have had ingredients added to the shell to give it a soft, elastic consistency. This allows the capsule to be flexible during administration. The two halves of the soft capsules are sealed together and cannot be broken apart. The shape of soft capsules can vary from round to oblong. They are filled with powdered, pasty, or liquid medications. The soft gelatin capsule is broken apart in the body during absorption to allow the medication to be distributed to the body.

Hard gelatin capsules are characterized by two oblong halves joined together. These capsules are filled with a powdered substance and often intended for oral administration.
They are to be swallowed whole. One advantage of a hard gelatin capsule is that it can be broken open and its contents sprinkled over a food substance or into water before administration. This is helpful for patients who are not able to swallow a whole capsule. The ingredients will be dissolved more quickly outside the gelatin shell.

**Lozenges**

Lozenges are solid dosage forms also known as pastilles or troches. These medications are hard, disk-shaped forms that contain a sugar base. Lozenges are used to deliver a variety of therapeutic remedies to the patient’s mouth and throat. Among these remedies are antiseptic, analgesic, anesthetic, antibiotic, decongestant, astringent, and antitussive agents. The lozenge remains in the patient’s mouth until it has completely dissolved and released the medication.

**Extended-Release Dosage Forms**

In some instances, it is desirable to have a medication dosage form that slowly and consistently releases the drug over an extended period of time – instead of all at once. These medication dosage forms are called extended-release, sustained-release, long-acting, or controlled-release. While the exact meaning of these terms differs in some respects, each of these terms implies a gradual release of medication over a longer period of time than standard dosage forms. Oral tablets and capsules are the most common dosage forms that are formulated as extended-release. There are other dosage forms, such as implants and some intramuscular injections; that are also extended release.

Extended-release dosage forms may be advantageous in several ways:

- They deliver medication in a slow, controlled and consistent manner so that the patient is absorbing the same amount of medication throughout the given time period.

- The risk of drug side effects is reduced because the medication is delivered over an extended period of time.

- The patient may need to take the medication less frequently during the day, often only once or twice.

- Patients are more likely to take their medications properly if they have to take them less often and are less likely to experience side effects.

- The daily medication cost to the patient may be decreased. While extended-release products may be more expensive on a per-dose basis, the total daily cost may be less since the patient may need to take only one or two doses a day rather than three or four.
Several technologies are available to give medication dosage forms extended-release properties. Many small beads of medication in varying sizes may have varying thicknesses of a coating material. These beads are then put in a hard gelatin capsule. In the stomach, the gelatin capsule quickly dissolves and releases the small beads, which then dissolve and release medication at varying rates over a long period of time.

Other extended-release products use a slowly eroding matrix to provide the extended-release characteristics. In this situation, a portion of the medication is treated and made into special granules. Those granules are then combined with untreated portion of the medication granules and made into a tablet or capsule. The untreated granules immediately release the drug in the stomach while the treated ones slowly erode to provide the prolong effect.

Some extended-release products are formulated in two or more layers. One layer immediately dissolves to produce an immediate effect while the remaining layers dissolve and release the drug gradually.

Other products, such as Procanbid, embed the drug in an inert plastic or wax matrix. The drug is then released into the body as it slowly leaches from the matrix. The matrix does not dissolve and is passed through the gastrointestinal tract and excreted in the feces.

A very sophisticated extended-release system uses an osmotic pump to slowly deliver medication over time. This system utilizes the principle of osmosis, which states that fluids tend to flow from areas with a low concentration of a substance to areas with a high concentration. The pump system is composed of a special membrane surrounding a core of medication. As fluid in the stomach passes through the membrane, the drug core inside swells and forces medication out of a small hole drilled in the membrane.

**Miscellaneous Dosage Forms**

A number of medication dosage forms do not fit neatly into a specific category. They may be either unique in and of themselves, or may be a combination of medication dosage forms.

**Powders**

Powders as a medication dosage form can be used externally or internally. Externally powders, or dusting powders, are finely ground mixtures of dry drugs and inactive ingredients that are sprinkled or dusted on the area to be medicated. An example is Mycostatin powder, which is often used to treat fungal infections of the skin. Internal powders are meant to be dissolved in a liquid prior to ingestion. Many potassium products are available as powders intended to be dissolved in water or juice. Some powders, such as powdered toothpaste, are mixed with water and used in the wetted state.

Powders are packaged in bulk containers or, when the amount delivered must be accurate, in powder papers. Powder papers are envelopes of folded papers that contain
enough powder for one dose or application. BC powder and Arthritis Strength BC Powder are analgesic powder packaged in powder paper.

**Granules**

When powders are wetted, allowed to dry, and ground into coarse pieces, the resulting medication dosage form is called a granule.

Granules differ from powders in that the particle size is larger and usually more stable. Many antibiotics are formulated as granules. The pharmacist or technician adds water to form a solution or suspension at the time of dispensing. Senokot Granules, a common laxative, is added to water before administration.

**Aerosols**

Aerosols are suspensions of very fine liquid or solid particles distributed in a gas and packaged under pressure. Medication is released from the container in a spray, foam, or solid. Aerosols are conveniently packaged and easy to use.

Aerosols may be used to deliver medications to internal and external sites. Aerosols inhaled internally, such as Proventil and Ventolin, are used to treat conditions such as asthma. The aerosol delivers the drug directly to the lungs, where it begins acting immediately. The drug does not first have to be dissolved in the stomach and absorbed into the bloodstream as it would if it were formulated as a tablet or capsule. External aerosols, such as Tinactin and Bactine Antiseptic Anesthetic sprays, may be applied topically (externally) for skin conditions. An external aerosol can deliver medications to a hard-to-reach area of the skin and can be applied to inflamed or irritated skin with little or no further irritation.

**Ointments**

Ointments are semisolid medication dosage forms intended to be applied to the skin or mucous membranes. They are used to lubricate and soften or as a base (a vehicle that contains a drug) for drug delivery. However, ointments do not always contain a drug. Ointments are categorized on the basis of their characteristics. The primary types are oleaginous, anhydrous, emulsion, and water soluble.

*Oleaginous, or hydrocarbon, bases* are emollients that soothe the skin or mucous membrane. They are occlusive and protect the skin or mucous membrane from the air. They are hydrophobic, or repel water, and therefore do not wash off with water. They feel greasy to the touch. Oleaginous bases are used primarily for their lubricating effect because they do not allow moisture to escape from the skin, do not dry out, and remain on the skin for a long time. Vaseline petroleum jelly is an example of an oleaginous base.
Anhydrous, or absorption, bases contain no water and are similar to oleaginous bases but differ, in that instead of repelling water, they absorb it. They also soften skin but not to the same degree as the oleaginous bases. Anhydrous bases are used to absorb an aqueous, water-based, drug into an ointment base. They do not contain water as part of their formula but as they absorb water, a water-in-oil (W/O) emulsion is formed. Anhydrous lanolin and cold cream are widely used anhydrous bases.

Emulsion bases may be W/O or O/W. The W/O types are also emollient, occlusive, and greasy. They contain water and some may be able to absorb additional water. Lanolin, mentioned above as a hydrinous base, and cold cream are considered to be W/O emulsions when water is added to them.

Emulsion bases of the O/W type, or water-washable bases, are quite different. They are non-greasy and readily wash off with water. They are non-occlusive and may be diluted, or thinned with the addition of water. They are often used to absorb watery discharge in certain skin conditions or may be used to help the skin absorb certain medications. Hydrophilic Ointment is an O/W ointment base.

Water-soluble bases are non-greasy, non-occlusive, and water-washable. They do not contain any fats and usually do not contain any water. Nonaqueous or solid medications are added to this type of ointment base. Polyethylene glycol ointment is one such base.

Ointment bases are chosen primarily on the basis of the characteristics described above. A W/O emulsion base may be used if a liquid medication is to be added to the ointment. Some medications may be more stable or more readily absorbed by the skin when delivered in some types of ointment bases over others. However, the softening or drying characteristics of the ointment base may also influence the choice of a base. For instance, a non-greasy ointment base may be chosen if the ointment is to be applied to the face since a greasy base may leave an unpleasant feeling.

Creams

Creams are semisolid O/W or W/O emulsions that may or may not contain medication. They are easily worked into the skin and feel lighter than ointments. They too serve to soften the skin. Creams may be preferred over ointments because they are easier to spread, have a cooling effect on the skin, and (in the case of O/W creams) are easier to wash off with water. Many products are available as creams or ointments to cater to the preferences of patients and physicians. Creams are also widely used in many cosmetic products.
Drug Administration and Pharmacokinetics

Drug administration is the giving of a drug by one of several means (routes). Drug kinetics (pharmacokinetics) involves what the body does to a drug, including the processes of absorption, distribution, metabolism, and elimination, and how long these processes take.

Drug treatment requires getting a drug to its target site or sites—specific sites in tissues where the drug performs its action. Typically, the drug is introduced (the process of administration) into the body far from this site. The drug must move into the bloodstream (the process of absorption) and be transported to the target sites where the drug is needed (the process of distribution). Some drugs are chemically altered (the process of metabolism) by the body before they perform their action; others are metabolized afterward; and still others are not metabolized at all. The final step is the removal of the drug and its metabolites from the body (the process of elimination).

Routes of Administration

Drugs are introduced into the body by several routes. They may be taken by mouth (orally); given by injection into a vein (intravenously), into a muscle (intramuscularly), into the space around the spinal cord (intrathecally), or beneath the skin (subcutaneously); placed under the tongue (sublingually); inserted in the rectum (rectally) or vagina (vaginally); instilled in the eye (by the ocular route); sprayed into the nose and absorbed through the nasal membranes (nasally); breathed into the lungs, usually through the mouth (by inhalation); applied to the skin (cutaneously) for a local (topical) or bodywide (systemic) effect; or delivered through the skin by a patch (transdermally) for a systemic effect. Each route has specific purposes, advantages, and disadvantages.

Oral Route

Because the oral route is the most convenient and usually the safest and least expensive, it is the one most often used. However, it has limitations because of the way a drug typically moves through the digestive tract. For drugs administered orally, absorption may begin in the mouth and stomach. Usually, however, most of the drug is absorbed from the small intestine. The drug passes through the intestinal wall and travels to the liver before it is transported via the bloodstream to its target site. The intestinal wall and liver chemically alter (metabolize) many drugs, decreasing the amount of drug reaching the bloodstream. Consequently, these drugs are often given in smaller doses when injected intravenously to produce the same effect.

When a drug is taken orally, food and other drugs in the digestive tract may affect how much of and how fast the drug is absorbed. Thus, some drugs should be taken on an empty stomach, others should be taken with food, others should not be taken with certain other drugs, and still others cannot be taken orally at all.
Some orally administered drugs irritate the digestive tract. For example, aspirin and most other nonsteroidal anti-inflammatory drugs can harm the lining of the stomach and small intestine and can cause or aggravate preexisting ulcers. Other drugs are absorbed poorly or erratically in the digestive tract or are destroyed by the acid and digestive enzymes in the stomach.

Other routes of administration may be required when the oral route cannot be used: for example, when a person cannot take anything by mouth, when a drug must be administered rapidly or in a precise or very high dose, or when a drug is poorly or erratically absorbed from the digestive tract.

**Parenteral or Injection Routes**

Administration by injection (parenteral administration) includes the subcutaneous, intramuscular, intravenous, and intrathecal routes. A drug product can be prepared or manufactured in ways that prolong drug absorption from the injection site for hours, days, or longer. Such products do not need to be administered as often as drug products with more rapid absorption.

**Subcutaneous**

For the subcutaneous route, a needle is inserted into fatty tissue just beneath the skin. The drug is injected, then moves into small blood vessels (capillaries) and is carried away by the bloodstream or reaches the bloodstream through the lymphatic vessels. Protein drugs that are large in size, such as insulin, usually reach the bloodstream through the lymphatic vessels because these drugs move slowly from the tissues into capillaries. The subcutaneous route is used for many protein drugs because such drugs would be digested in the digestive tract if they were taken orally.

Certain drugs (such as progestin, used for birth control may be given by inserting plastic capsules under the skin (subcutaneously). This route of administration is rarely used.

**Intramuscular**

The intramuscular route is preferred to the subcutaneous route when larger volumes of a drug product are needed. Because the muscles lie below the skin and fatty tissues, a longer needle is used. Drugs are usually injected into the muscle of the upper arm, thigh, or buttock. How quickly the drug is absorbed into the bloodstream depends, in part, on the blood supply to the muscle: The sparser the blood supply, the longer it takes for the drug to be absorbed.

**Intravenous**

For the intravenous route, a needle is inserted directly into a vein. A solution containing the drug may be given in a single dose or by continuous infusion. For infusion, the solution is moved by gravity (from a collapsible plastic bag) or by an infusion pump
through thin flexible tubing to a tube (catheter) inserted in a vein, usually in the forearm. Intravenous administration is the best way to deliver a precise dose quickly and in a well-controlled manner throughout the body. It is also used for irritating solutions, which would cause pain and damage tissues if given by subcutaneous or intramuscular injection. An intravenous injection can be more difficult to administer than a subcutaneous or intramuscular injection, because inserting a needle or catheter into a vein may be difficult, especially if the person is obese.

When given intravenously, a drug is immediately delivered to the bloodstream and tends to take effect more quickly than when given by any other route. Consequently, health care practitioners closely monitor patients who receive an intravenous injection for signs that the drug is working or is causing undesired side effects. Also, the effect of a drug given by this route tends to last for a shorter time. Therefore, some drugs must be given by continuous infusion to keep their effect constant.

**Intrathecal**

For the intrathecal route, a needle is inserted between two vertebrae in the lower spine and into the space around the spinal cord. The drug is then injected into the spinal canal. A small amount of local anesthetic is often used to numb the injection site. This route is used when a drug is needed to produce rapid or local effects on the brain, spinal cord, or the layers of tissue covering them (meninges)—for example, to treat infections of these structures. Anesthetics and analgesics (such as morphine) are sometimes given this way.

**Sublingual Route**

A few drugs are placed under the tongue (taken sublingually) so that they can be absorbed directly into the small blood vessels that lie beneath the tongue. The sublingual route is especially good for nitroglycerin—which is used to relieve angina (chest pain caused by an inadequate blood supply to the heart muscle)—because absorption is rapid and the drug immediately enters the bloodstream without first passing through the intestinal wall and liver. However, most drugs cannot be taken this way because they may be absorbed incompletely or erratically.

**Rectal Route**

Many drugs that are administered orally can also be administered rectally as a suppository. In this form, a drug is mixed with a waxy substance that dissolves or liquefies after it is inserted into the rectum. Because the rectum's wall is thin and its blood supply rich, the drug is readily absorbed. A suppository is prescribed for people who cannot take a drug orally because they have nausea, cannot swallow, or have restrictions on eating, as is required after many surgical operations. Drugs that are irritating in suppository form may have to be given by injection.
**Vaginal Route**

Some drugs may be administered vaginally to women as a solution, tablet, cream, gel, suppository, or ring. The drug is slowly absorbed through the vaginal wall. This route is often used to give estrogen to women at menopause, because the drug helps prevent thinning of the vaginal wall, an effect of menopause.

**Ocular Route**

Drugs used to treat eye disorders (such as glaucoma, conjunctivitis, and injuries) can be mixed with inactive substances to make a liquid, gel, or ointment, so that they can be applied to the eye. Liquid eye drops are relatively easy to use but may run off the eye too quickly to be absorbed well. Gel and ointment formulations keep the drug in contact with the eye surface longer. Solid inserts, which release the drug continuously and in slow amounts, are also available, but they may be hard to put in and keep in place. Ocular drugs are almost always used for their local effects. For example, artificial tears are used to relieve dry eyes. Other drugs (for example, those used to treat glaucoma, such as acetazolamide and betaxolol and those used to dilate pupils, such as phenylephrine and tropicamide) produce a local effect after they are absorbed through the cornea and conjunctiva. Some of these drugs then enter the bloodstream and may have unwanted effects on other parts of the body.

**Nasal Route**

If a drug is to be breathed in and absorbed through the thin mucous membrane that lines the nasal passages, it must be transformed into tiny droplets in air (atomized). Once absorbed, the drug enters the bloodstream. Drugs administered by this route generally work quickly. Some of them irritate the nasal passages. Drugs that can be administered by the nasal route include nicotine (for smoking cessation), calcitonin (for osteoporosis), sumatriptan (for migraine headaches), and corticosteroids (for allergies).

**Inhalation**

Drugs administered by inhalation through the mouth must be atomized into smaller particles than those administered by the nasal route, so that the drug can pass through the windpipe (trachea) and into the lungs. How deeply into the lungs they go depends on the size of the droplets. Smaller droplets go deeper, which increases the amount of drug absorbed. Inside the lungs, they are absorbed into the bloodstream.

Relatively few drugs are administered this way because inhalation must be carefully monitored to ensure that a person receives the right amount of drug within a specified time. Usually, this method is used to administer drugs that act on the lungs, such as aerosolized antiasthmatic drugs in metered-dose containers, and to administer gases used for general anesthesia.
Cutaneous Route

Drugs applied to the skin are usually used for their local effects and thus are most commonly used to treat superficial skin disorders, such as psoriasis, eczema, skin infections (viral, bacterial, and fungal), itching, and dry skin. The drug is mixed with inactive substances. Depending on the consistency of the inactive substances, the formulation may be an ointment, a cream, a lotion, a solution, a powder, or a gel.

Transdermal Route

The transdermal, or percutaneous, route of medication administration delivers drugs across the skin.

Some drugs are delivered bodywide through a patch on the skin. These drugs, sometimes mixed with a chemical (such as alcohol) that enhances penetration of the skin, pass through the skin to the bloodstream without injection. Through a patch, the drug can be delivered slowly and continuously for many hours or days or even longer. As a result, levels of a drug in the blood can be kept relatively constant. Patches are particularly useful for drugs that are quickly eliminated from the body because such drugs, if taken in other forms, would have to be taken frequently. However, patches may irritate the skin of some people. In addition, patches are limited by how quickly the drug can penetrate the skin. Only drugs to be given in relatively small daily doses can be given through patches. Examples of such drugs include nitroglycerin (for chest pain), scopolamine (for motion sickness), nicotine (for smoking cessation), clonidine (for high blood pressure), and fentanyl (for pain relief).

Transdermal patches are formulated in one of two ways. One type of patch is formulated so that the patch itself controls the rate of delivery of drug to the skin. A special membrane in the patch is in contact with the skin. The membrane controls the amount of drug delivered from a drug reservoir contained in the patch, through the membrane and skin, and into the bloodstream. The second type of transdermal patch is designed so that the skin itself controls the rate of drug delivery. The drug moves from an area of high concentration (the drug reservoir) into an area of low concentration (the skin and bloodstream). The disadvantage to this type of patch is that the release of drug is less controlled and a large amount of drug could suddenly be released from the patch into the bloodstream.

Topical

The topical route of administering medication refers to the application of medications to the surface of the skin or mucous membranes. Medications administered topically include antibiotics, antiseptics, astringents, emollients, and corticosteroids. Topical medication dosage forms include creams, ointments, lotions, sprays, and aerosols. In most cases, the skin or mucous membrane acts as a barrier to prevent the medication from entering the bloodstream. As a result, drugs used for treating diseases of the skin and
mucous membranes can be applied in higher concentrations than drugs administered internally.

Some ointments and crèmes (e.g., topical corticosteroid ointments) are formulated to deliver a drug into the skin to treat a condition of the deeper skin layers. Sometimes creams or ointments may be designed so that the drug diffuses through the skin into the bloodstream. The drug is then available to the whole body. This is called systemic absorption. Nitroglycerin ointment used to treat chest pain in an example.

In some cases, systemic absorption is not desired and may result in unwanted side effects. For example, when topical corticosteroids are absorbed systemically over prolonged periods of time, the patient may develop cataracts or glaucoma. Penetration of topical medications into the bloodstream is more likely when the skin is not intact (e.g., when it is inflamed or burned).

**Pharmacokinetics**

**Absorption**

Drug absorption is the movement of a drug into the bloodstream.

Absorption affects bioavailability—how quickly and how much of a drug reaches its intended target (site) of action. Factors that affect absorption (and therefore bioavailability) include the way a drug product is designed and manufactured, its physical and chemical properties, and the physiologic characteristics of the person taking the drug. Physiologic characteristics that may affect the absorption of drugs taken by mouth include how long the stomach takes to empty, what the acidity (pH) of the stomach is, and how quickly the drug is moved through the digestive tract.

A drug product is the actual dosage form of a drug—a tablet, capsule, suppository, transdermal patch, or solution. It consists of the drug (active ingredient) and additives (inactive ingredients). For example, tablets are a mixture of drug and diluents, stabilizers, disintegrates, and lubricants. The mixture is granulated and compressed into a tablet. The type and amount of additives and the degree of compression affect how quickly the tablet disintegrates and how quickly the drug is absorbed. Drug manufacturers adjust these variables to optimize absorption.

If a tablet releases the drug too quickly, the blood level of the drug may become too high, causing an excessive response. If the tablet does not release the drug quickly enough, much of the drug may be eliminated in the feces without being absorbed, and blood levels may be too low. Drug manufacturers formulate the tablet to release the drug at the desired speed.

Capsules consist of drugs and additives within a gelatin shell. The shell swells and releases its contents when it becomes wet, usually eroding quickly. The size of the drug particles and the properties of the additives affect how quickly the drug dissolves and is
absorbed. Drugs tend to be absorbed more quickly from capsules filled with liquid than from those filled with solid particles.

Because drug products that contain the same drug (active ingredient) may have different inactive ingredients, absorption of the drug from different products may vary. Thus, a drug's effects, even at the same dose, may vary from one drug product to another. Drug products that not only contain the same active ingredient but also produce virtually the same blood levels at the same points in time are considered bioequivalent. Bioequivalence ensures therapeutic equivalence (that is, production of the same medicinal effect), and bioequivalent products are interchangeable.

If an orally administered drug can harm the stomach lining or decomposes in the acidic environment of the stomach, a tablet or capsule of the drug can be coated with a substance intended to prevent it from dissolving until it reaches the small intestine. These protective coatings are described as enteric, which refers to the small intestine. For the coatings to dissolve, they must come in contact with the less acidic environment of the small intestine or with the digestive enzymes there. However, the coatings do not always dissolve as intended. The tablet or capsule may be passed intact in the feces, especially in older people.

Some drug products are specially formulated to release their active ingredients slowly or in repeated small amounts over time—usually for a period of 12 hours or more. This dosage form is called modified-release, controlled-release, sustained-release, or extended-release.

Food, other drugs, and digestive disorders can affect drug absorption and bioavailability. For example, high-fiber foods may bind with a drug and prevent it from being absorbed. Laxatives and diarrhea, which speed up the passage of substances through the digestive tract, may reduce drug absorption. Surgical removal of parts of the digestive tract (such as the stomach or colon) may also affect drug absorption.

Where and how long a drug product is stored can affect drug bioavailability. The drug in some products deteriorates and becomes ineffective or harmful if stored improperly or kept too long. Some products must be stored in the refrigerator or in a cool, dry, or dark place. Storage directions should be followed, and expiration dates should be observed.

**Distribution**

Drug distribution refers to the movement of drug to and from the blood and various tissues of the body (for example, fat, muscle, and brain tissue) and the relative proportions of drug in the tissues.

After a drug is absorbed into the bloodstream, it rapidly circulates through the body. The average circulation time of blood is 1 minute. As the blood circulates, the drug moves from the bloodstream into the body's tissues.
Once absorbed, most drugs do not spread evenly throughout the body. Drugs that
dissolve in water (water-soluble drugs), such as the antihypertensive drug atenolol, tend
to stay within the blood and the fluid that surrounds cells (interstitial space). Drugs that
dissolve in fat (fat-soluble drugs), such as the anesthetic drug halothane, tend to
concentrate in fatty tissues. Other drugs concentrate mainly in only one small part of
the body (for example, iodine concentrates mainly in the thyroid gland), because the tissues
there have a special attraction for (affinity) and ability to retain the drug.

Drugs penetrate different tissues at different speeds, depending on the drug's ability to
cross membranes. For example, the anesthetic thiopental, a highly fat-soluble drug,
rapidly enters the brain, but the antibiotic penicillin, a water-soluble drug, does not. In
general, fat-soluble drugs can cross cell membranes more quickly than water-soluble
drugs can. For some drugs, transport mechanisms aid movement into or out of the tissues.

Some drugs leave the bloodstream very slowly, because they bind tightly to proteins
circulating in the blood. Others quickly leave the bloodstream and enter other tissues,
because they are less tightly bound to blood proteins. Some or virtually all molecules of a
drug in the blood may be bound to blood proteins. The protein-bound part is generally
inactive. As unbound drug is distributed to tissues and its level in the bloodstream
decreases, blood proteins gradually release the drug bound to them. Thus, the bound drug
in the bloodstream may act as a reservoir for the drug.

Some drugs accumulate in certain tissues, which can also act as reservoirs of extra drugs.
These tissues slowly release the drug into the bloodstream, keeping blood levels of the
drug from decreasing rapidly and thereby prolonging the effect of the drug. Some drugs,
such as those that accumulate in fatty tissues, leave the tissues so slowly that they
circulate in the bloodstream for days after a person has stopped taking the drug.

Distribution of a given drug may also vary from person to person. For instance, obese
people may store large amounts of fat-soluble drugs, whereas very thin people may store
relatively little. Older people, even when thin, may store large amounts of fat-soluble
drugs because the proportion of body fat increases with aging.

Elimination

Drug elimination is the removal of drugs from the body.

All drugs are eventually eliminated from the body. They may be eliminated after being
chemically altered (metabolized), or they may be eliminated intact. Most drugs,
particularly water-soluble drugs and their metabolites, are eliminated largely by the
kidneys in urine. Some drugs are eliminated by excretion in the bile (a greenish yellow
fluid secreted by the liver and stored in the gallbladder).

Elimination in the Urine: Several factors, including certain characteristics of the drug,
 affect the kidneys' ability to excrete drugs. To be extensively excreted in urine, a drug or
metabolite must be water soluble and must not be bound too tightly to proteins in the
bloodstream. The acidity of urine, which is affected by diet, drugs, and kidney disorders, can affect the rate at which the kidneys excrete some drugs. In the treatment of poisoning with some drugs, the acidity of the urine is changed by giving antacids (such as sodium bicarbonate) or acidic substances (such as ammonium chloride) orally to speed up the excretion of the drug.

The kidneys' ability to excrete drugs also depends on urine flow, blood flow through the kidneys, and the condition of the kidneys. Kidney function can be impaired by many disorders (especially high blood pressure, diabetes, and recurring kidney infections), by exposure to high levels of toxic chemicals, and by age-related changes. As people age, kidney function slowly declines. For example, the kidneys of an 85-year-old person excrete drugs only about half as efficiently as those of a 35-year-old person.

In people whose kidney function has declined, the “normal” dosage of a drug that is eliminated primarily through the kidneys may be too much and may cause side effects. Therefore, health care practitioners sometimes must adjust the drug dosage based on the amount of decline in the person's kidney function. Health care practitioners have several ways to estimate the decline in kidney function. Sometimes they base an estimate solely on the person's age. However, they can get a more accurate estimate of kidney function by using the results of tests that measure the level of creatinine (a waste product) in the blood and sometimes also the urine. They use these results to calculate how effectively creatinine is removed from the body (called creatinine clearance), which reflects how well the kidneys are functioning.

Elimination in the Bile: Some drugs pass through the liver unchanged and are excreted in the bile. The bile then enters the digestive tract. From there, drugs are either eliminated in feces or reabsorbed into the bloodstream and thus recycled. Other drugs are converted to metabolites in the liver and excreted in the bile. These metabolites may be excreted in the feces or can be converted back to the drug, which is then reabsorbed into the bloodstream and recycled.

If the liver is not functioning normally, the dosage of a drug that is eliminated primarily by metabolism in the liver may need to be adjusted. However, there are no simple ways to estimate liver function quantitatively for drug metabolism comparable to those for kidney function.

Other Forms of Elimination: Some drugs are excreted in saliva, sweat, breast milk, and even exhaled air. Most are excreted in small amounts. The excretion of drugs in breast milk is significant only because the drug may affect the breastfeeding infant. Excretion in exhaled air is the main way that inhaled anesthetics are eliminated.
Metabolism

Drug metabolism is the chemical alteration of a drug by the body.

Some drugs are chemically altered by the body (metabolized). The substances that result from metabolism (metabolites) may be inactive, or they may be similar to or different from the original drug in therapeutic activity or toxicity. Some drugs, called prodrugs, are administered in an inactive form, which is metabolized into an active form. The resulting metabolites produce the desired therapeutic effects. Metabolites may be metabolized further instead of being excreted from the body. The subsequent metabolites are then excreted.

A vast majority of drugs must pass through the liver, which is the site of most drug metabolism. Once in the liver, enzymes convert prodrugs to active metabolites or convert active drugs to inactive forms. The liver's primary mechanism for metabolizing drugs is via a specific group of cytochrome P-450 enzymes. The level of these cytochrome P-450 enzymes controls the rate at which many drugs are metabolized. The capacity of the enzymes to metabolize is limited, so they can become overloaded when blood levels of a drug are high.

Because metabolic enzyme systems are only partially developed at birth, newborns have difficulty metabolizing certain drugs. As people age, enzymatic activity decreases, so that older people, like newborns, cannot metabolize drugs as well as younger adults and children do. Consequently, newborns and older people often need smaller doses per pound of body weight than do young or middle-aged adults.

Conclusion

Drugs can be administered by several different routes. Although the oral route is most common, it may not always be the most convenient or practical. Drugs may be administered via any body orifice, through the skin, or an artificially made opening.
Appendix A

List of Codes and Abbreviations for Routes of Administration

<table>
<thead>
<tr>
<th>ROUTE OF ADMINISTRATION</th>
<th>CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLOCK INFILTRATION</td>
<td>BIN</td>
</tr>
<tr>
<td>BUCCAL</td>
<td>BUC</td>
</tr>
<tr>
<td>CAUDAL BLOCK</td>
<td>CAU</td>
</tr>
<tr>
<td>CYSTOURE THROGRAPHY</td>
<td>CGY</td>
</tr>
<tr>
<td>DENTAL</td>
<td>DEN</td>
</tr>
<tr>
<td>DISINFECTANT BARN</td>
<td>DBR</td>
</tr>
<tr>
<td>DISINFECTANT CONTACT LENS</td>
<td>DCL</td>
</tr>
<tr>
<td>DIINFECTION DOMESTIC</td>
<td>DDC</td>
</tr>
<tr>
<td>DISINFECTANT FOOD PREMISES</td>
<td>DFP</td>
</tr>
<tr>
<td>DISINFECTANT HOSPITAL AREA</td>
<td>DHO</td>
</tr>
<tr>
<td>DISINFECTANT INSTITUTIONAL INDUSTRIAL</td>
<td>DII</td>
</tr>
<tr>
<td>DISINFECTANT MEDICAL INSTRUMENTS</td>
<td>DMI</td>
</tr>
<tr>
<td>HEMODIALYSIS</td>
<td>DIS</td>
</tr>
<tr>
<td>EPIDURAL</td>
<td>EPD</td>
</tr>
<tr>
<td>EXTRACORPOREAL</td>
<td>ECP</td>
</tr>
<tr>
<td>ROUTE OF ADMINISTRATION</td>
<td>CODE</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------</td>
</tr>
<tr>
<td>EXTRADURAL INFUSION</td>
<td>EXT</td>
</tr>
<tr>
<td>EX VIVO</td>
<td>EXM</td>
</tr>
<tr>
<td>INHALATION</td>
<td>INH</td>
</tr>
<tr>
<td>INSTILLATION</td>
<td>ISL</td>
</tr>
<tr>
<td>INTERVERTEBRAL</td>
<td>IND</td>
</tr>
<tr>
<td>INTRA AMINOTIC</td>
<td>IAM</td>
</tr>
<tr>
<td>INTRA ARTERAL</td>
<td>IAR</td>
</tr>
<tr>
<td>INTRA ARTICULAR</td>
<td>IA</td>
</tr>
<tr>
<td>INTRA BRONCHIAL</td>
<td>IBR</td>
</tr>
<tr>
<td>INTRABURSAL</td>
<td>IBU</td>
</tr>
<tr>
<td>INTRACARDIAC</td>
<td>ICD</td>
</tr>
<tr>
<td>INTRACAVERNOSAL</td>
<td>ICN</td>
</tr>
<tr>
<td>INTRACAUDAL</td>
<td>ICA</td>
</tr>
<tr>
<td>INTRACEREBRAL</td>
<td>ICE</td>
</tr>
<tr>
<td>INTRACERVICAL</td>
<td>ITC</td>
</tr>
<tr>
<td>INTRACORNEAL</td>
<td>ICN</td>
</tr>
<tr>
<td>INTRACORONARY</td>
<td>ICO</td>
</tr>
<tr>
<td>INTRACRANIAL</td>
<td>ICR</td>
</tr>
<tr>
<td>INTRACUTANEOUS</td>
<td>ICU</td>
</tr>
<tr>
<td>ROUTE OF ADMINISTRATION</td>
<td>CODE</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------</td>
</tr>
<tr>
<td>INTRACAVITY</td>
<td>ICV</td>
</tr>
<tr>
<td>INTRADERMAL</td>
<td>ID</td>
</tr>
<tr>
<td>INTRADISCAL</td>
<td>IDI</td>
</tr>
<tr>
<td>INTRAFOLLICULAR</td>
<td>INF</td>
</tr>
<tr>
<td>INTRAGANGLIONAL</td>
<td>IGA</td>
</tr>
<tr>
<td>INTRAGASTRIC</td>
<td>ITG</td>
</tr>
<tr>
<td>INTRALESIONAL</td>
<td>IL</td>
</tr>
<tr>
<td>INTRAMUSCULAR</td>
<td>IM</td>
</tr>
<tr>
<td>INTRAMAMMARY</td>
<td>IMM</td>
</tr>
<tr>
<td>INTRAMYOCARDIAL</td>
<td>ITM</td>
</tr>
<tr>
<td>INTRAMURAL</td>
<td>INMU</td>
</tr>
<tr>
<td>INTRANASAL</td>
<td>ITN</td>
</tr>
<tr>
<td>INTRANODAL</td>
<td>ITNO</td>
</tr>
<tr>
<td>INTRAOCULAR</td>
<td>IO</td>
</tr>
<tr>
<td>INTRAPERITONEAL</td>
<td>IP</td>
</tr>
<tr>
<td>INTRAPLEURAL</td>
<td>IPI</td>
</tr>
<tr>
<td>INTRAPROSTATIC</td>
<td>INP</td>
</tr>
<tr>
<td>INTRAPULMONARY</td>
<td>IPU</td>
</tr>
<tr>
<td>INTRAPUTAMINAL</td>
<td>IPUT</td>
</tr>
<tr>
<td>ROUTE OF ADMINISTRATION</td>
<td>CODE</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>INTRATUMINAL</td>
<td>IRU</td>
</tr>
<tr>
<td>INTRASINAL</td>
<td>ISI</td>
</tr>
<tr>
<td>INTRASPINAL</td>
<td>ISP</td>
</tr>
<tr>
<td>INTRASYNOVIAL</td>
<td>ISY</td>
</tr>
<tr>
<td>INTRATENDINOUS</td>
<td>ITE</td>
</tr>
<tr>
<td>INTRATESTICULAR</td>
<td>ITS</td>
</tr>
<tr>
<td>INTRATHECAL</td>
<td>INT</td>
</tr>
<tr>
<td>INTRATHORACIC</td>
<td>IT</td>
</tr>
<tr>
<td>INTRATRACHEAL</td>
<td>ITR</td>
</tr>
<tr>
<td>INTRATUMOR</td>
<td>ITU</td>
</tr>
<tr>
<td>INTRAUTERINE</td>
<td>IU</td>
</tr>
<tr>
<td>INTRAVESICULAR</td>
<td>ITV</td>
</tr>
<tr>
<td>INTRAVENOUS</td>
<td>IV</td>
</tr>
<tr>
<td>INTRAVESICAL</td>
<td>IVA</td>
</tr>
<tr>
<td>INTRAVERTEBRAL</td>
<td>IVE</td>
</tr>
<tr>
<td>INTRAVITREAL</td>
<td>IVL</td>
</tr>
<tr>
<td>INTRAVENTRICULAR</td>
<td>IVR</td>
</tr>
<tr>
<td>IRRIGATION</td>
<td>IR</td>
</tr>
<tr>
<td>MISCELLANEOUS</td>
<td>MIS</td>
</tr>
<tr>
<td>ROUTE OF ADMINISTRATION</td>
<td>CODE</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>NASAL</td>
<td>NAS</td>
</tr>
<tr>
<td>NEBULIZER</td>
<td>NEB</td>
</tr>
<tr>
<td>OPTHALMIC</td>
<td>OPH</td>
</tr>
<tr>
<td>ORAL</td>
<td>ORL</td>
</tr>
<tr>
<td>OTIC (AURICULAR)</td>
<td>OT</td>
</tr>
<tr>
<td>PERCUTANEOUS</td>
<td>PCU</td>
</tr>
<tr>
<td>PERIBULBAR BLOCK</td>
<td>PRB</td>
</tr>
<tr>
<td>PERIOSTEAL</td>
<td>PRS</td>
</tr>
<tr>
<td>PARENTERAL UNSPECIFIED</td>
<td>PRT</td>
</tr>
<tr>
<td>RETROBULBAR</td>
<td>RB</td>
</tr>
<tr>
<td>RECTAL</td>
<td>RT</td>
</tr>
<tr>
<td>SOFT TISSUE</td>
<td>ST</td>
</tr>
<tr>
<td>SUBARACHNOIDIAL</td>
<td>SAR</td>
</tr>
<tr>
<td>SUBCUTANEOUS</td>
<td>SC</td>
</tr>
<tr>
<td>SUBGINGIVAL</td>
<td>SGV</td>
</tr>
<tr>
<td>SUBLINGUAL</td>
<td>SLG</td>
</tr>
<tr>
<td>TEAT DIP</td>
<td>TDP</td>
</tr>
<tr>
<td>TOPICAL</td>
<td>TOP</td>
</tr>
<tr>
<td>TRANSDERMAL</td>
<td>TRD</td>
</tr>
<tr>
<td>ROUTE OF ADMINISTRATION</td>
<td>CODE</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------</td>
</tr>
<tr>
<td>TRANSURETHRAL</td>
<td>TRU</td>
</tr>
<tr>
<td>UNASSIGNED</td>
<td>UNS</td>
</tr>
<tr>
<td>URETHRAL</td>
<td>URH</td>
</tr>
<tr>
<td>UDDER WASH</td>
<td>UWH</td>
</tr>
<tr>
<td>VAGINAL</td>
<td>VAG</td>
</tr>
</tbody>
</table>
Final Exam

1. Serious drug errors and death can result when a drug is delivered by the *wrong* route of administration.
   a. True
   b. False

2. Drug dosage forms are classified according to their:
   a. Physical state
   b. Chemical composition
   c. Both A and B
   d. None of the above

3. To ensure the stability of a drug in a formulation and the continued effectiveness of the drug product, the principles of ____________ must be applied.
   a. Chemistry
   b. Physical pharmacy
   c. Microbiology
   d. Pharmaceutical technology
   e. All of the above

4. Liquid preparations include drugs that have been dissolved or suspended.
   a. True
   b. False
Final Exam

5. Which of the following is NOT a common vehicle of liquid medications?
   a. Water
   b. Kerosene
   c. Alcohol
   d. Mineral oil

6. Oral liquid dosage forms usually are slower acting than solid dosage forms.
   a. True
   b. False

7. ___________ are evenly distributed, homogenous mixtures of dissolved medications in a liquid vehicle.
   a. Solutions
   b. Emulsions
   c. Suspensions
   d. All of the above

8. _____________ use purified water as the vehicle.
   a. Aqueous and viscous aqueous solutions
   b. Nonaqueous solutions
   c. Hydroalcoholic solutions
   d. Inhalants and liniments

9. _____________ are those that utilize solvents, or dissolving liquids, in addition to or instead of water.
   a. Aqueous and viscous aqueous solutions
   b. Nonaqueous solutions
c. Hydroalcoholic solutions

d. Inhalants and liniments

10. __________________ do not fit neatly into any category and are classified as miscellaneous solutions.
    
    a. Aqueous and viscous aqueous solutions
    b. Nonaqueous solutions
    c. Hydroalcoholic solutions
    d. Inhalants and liniments

11. ______________ are solutions that are nonaqueous solutions that contain a mixture of alcohol and water.
    
    a. Emulsions
    b. Suspensions
    c. Hydroalcoholic solutions
    d. Inhalants and liniments

12. __________ are solutions that treat conditions of the throat.
    
    a. Douches
    b. Irrigating solutions
    c. Enemas
    d. Gargles
Final Exam

13. _______________ are solutions that are introduced into the rectum to empty the bowel or to treat diseases of the lower gastrointestinal tract.
   a. Douches
   b. Irrigating solutions
   c. Enemas
   d. Gargles

14. The advantage of a syrup is its ability to disguise the bad taste of medications.
   a. True
   b. False

15. _______________ are thick, viscous, adhesive liquids
   a. Syrup
   b. Jellies
   c. Mucilages
   d. Washes

16. _______________ is a concentrated mixture of sugar and purified water.
   a. Syrup
   b. Jellies
   c. Mucilages
   d. Washes
Final Exam

17. __________ are semisolid solutions that contain a high proportion of water.
   a. Syrup
   b. Jellies
   c. Mucilages
   d. Washes

18. __________ are nonaqueous solutions of medication dissolved in glycerin, a sweet oily fluid made from fats and oils.
   a. Elixirs
   b. Spirits
   c. Collodion
   d. Glycerite

19. __________ or essences, are alcoholic or hydroalcoholic solutions that contain volatile, or easily evaporated, substances.
   a. Elixirs
   b. Spirits
   c. Collodion
   d. Glycerite

20. ____________ is a liquid preparation of pyroxylin dissolved in ethyl ether and ethanol.
   a. Elixir
   b. Spirits
   c. Collodion
   d. Glycerite
Final Exam

21. Inhalants are a mixture of two liquids that normally do not mix.
   
   a. True
   
   b. False

22. In most emulsions, the two liquids are:
   
   a. Water and alcohol
   
   b. Water and ether
   
   c. Water and oil
   
   d. Oil and alcohol

23. Most emulsions intended for oral use are of the _________ type.

   a. Oil-in-water
   
   b. Water-in-oil

24. Some emulsions may also be injected into the bloodstream.

   a. True
   
   b. False

25. Suspensions are mixtures of fine particles of an undissolved solid distributed through:

   a. Gas
   
   b. Liquid
   
   c. Solid
   
   d. All of the above
   
   e. None of the above
Final Exam

26. ___________ are suspensions intended for external applications.
   a. Lotions
   b. Magmas and milk
   c. Gels
   d. None of the above

27. ___________________ are thick, viscous suspensions of undissolved drugs in water
   a. Lotions
   b. Magmas and milk
   c. Gels
   d. None of the above

28. ___________ are concentrated preparations of active components obtained from plant or animal tissue.
   a. Solutions
   b. Suspensions
   c. Extractives
   d. Emulsions

29. Which of the following is NOT typically a route of administration for a solid dosage form?
   a. Parenteral
   b. Oral
   c. Vaginal
   d. Rectal
30. The dosing is more accurate with a solid dosage form since the medication is already in a distinctive unit/measure.
   a. True  
   b. False 

31. Solid medications are a good choice for immediate action treatments.
   a. True  
   b. False 

32. __________ tablets are formed by die punch compression of powdered, crystalline, or granular substances.
   a. Molded  
   b. Compressed  
   c. Both A & B  
   d. None of the above 

33. __________ tablets are dissolved into a liquid before administration.
   a. Chewable  
   b. Effervescent  
   c. Sublingual  
   d. Buccal  
   e. Vaginal 

34. One advantage of a soft gelatin capsule is that it can be broken open and its contents sprinkled over a food substance.
   a. True  
   b. False
35. __________ are solid dosage forms also known as pastilles or trouches.
   a. Tablets
   b. Capsules
   c. Lozenges
   d. None of the above

36. __________ describes a medication dosage form that slowly and consistently releases the drug over an extended period of time – instead of all at once.
   a. Extended-release
   b. Sustained-release
   c. Long-acting
   d. Controlled-release
   e. All of the above

37. A number of medication dosage forms do not fit neatly into a specific category because they are a combination of medication dosage forms.
   a. True
   b. False

38. When powders are wetted, allowed to dry, and ground into coarse pieces, the resulting medication dosage form is called __________.
   a. Cream
   b. Aerosols
   c. Granules
   d. Ointments
Final Exam

39. __________ are suspensions of very fine liquid or solid particles distributed in a gas and packaged under pressure.
   a. Cream
   b. Aerosols
   c. Granules
   d. Ointments

40. A hydrophobic substance:
   a. Repels water
   b. Absorbs water
   c. Both A&B
   d. None of the above

41. Anhydrous bases contain no water.
   a. True
   b. False

42. The ______ route of administration is the most convenient and usually the safest and least expensive.
   a. Oral
   b. Parenteral
   c. Rectal
   d. Vaginal

43. The intramuscular route is preferred to the subcutaneous route when larger volumes of a drug product are needed.
   a. True
   b. False
Final Exam

44. For the _________ route, a needle is inserted directly into the vein.

   a. Subcutaneous
   b. Intravenous
   c. Intramuscular
   d. Intrathecal

45. Most drugs can be taken sublingually.

   a. True
   b. False

46. The _________, or percutaneous, route of medication administration delivers drugs across the skin.

   a. Nasal route
   b. Inhalation
   c. Ocular
   d. Transdermal

47. The topical route of administration allows drugs used for treating diseases of the skin and mucous membranes to be applied in higher concentrations than drugs administered internally.

   a. True
   b. False

48. Drug _______ is the movement of a drug into the bloodstream.

   a. Distribution
   b. Absorption
   c. Metabolism
   d. All of the above
49. ________________ refers to the movement of drugs to and from the blood and various tissues of the body.
   a. Distribution
   b. Absorption
   c. Metabolism
   d. All of the above.

50. Drug ________________ is the chemical alteration of a drug by the body.
   a. Distribution
   b. Absorption
   c. Metabolism
   d. All of the above