INTRODUCTION

Pharmacology is the study of drugs or chemicals used to treat and cure disease and their interactions in the body. Within the study of pharmacology there are a number of separate areas to consider, but for nurses the most important aspects are pharmacokinetics (PK) and pharmacodynamics (PD). Pharmacokinetics describes what the body does to a drug through the movement and distribution of that drug around the body. This is important because to be therapeutically useful, drugs must be absorbed into the body and transported to the desired site for action. Drugs will be therapeutically ineffective if they do not reach the target organ (site) to exert their activity. Pharmacodynamics considers what a drug does to the body – that is, the mechanism of drug action in the body. It describes the biochemical and physical effects of a drug and how it interacts with its desired target (such as a cell surface receptor, enzyme or DNA).

Nurses should understand the PK/PD principles of the drugs they are administering to patients. This includes the mode of action of drugs, dose responses, and potential interactions with other treatments (pharmacological or non-pharmacological) that the patient may be undergoing. Serious and adverse side-effects can arise from drug treatment (sometimes very quickly) and it is essential that the nurse can recognize these and act quickly to minimize their potential life-threatening effects.

Useful resources

Nurses! Test Yourself in Essential Calculation Skills
Chapters 1 and 2

Nurses! Test Yourself in Anatomy and Physiology
Chapters 1 and 2

Nurses! Test Yourself in Non-Medical Prescribing
Chapters 4 and 6
LABELLING EXERCISE

Identify the routes of administration in Figures 1.1 and 1.2 using the terms provided in the box below:

- intramuscular
- oral
- topical
- rectal
- subcutaneous
- inhalation
- intradermal
- intravenous
- transdermal

Figure 1.1 Common routes for the administration of medicines
Figure 1.2 Position of the needle for common injection routes
TRUE OR FALSE?

Are the following statements true or false?

10. In pharmacology, the word ‘agonist’ describes a drug that binds or interacts with its biological receptor but produces no effect.

11. An antagonist may be described as competitive or non-competitive.

12. The pharmacological action of a drug varies significantly among individuals.

13. A pro-drug describes a drug that is pharmacologically inactive until it reaches the liver and is metabolized.

14. Drugs administered intravenously (IV) are considered to have 100% absorption into the systemic circulation.

15. Free, unbound drug molecules cannot exert a pharmacological effect.

16. Most drugs are excreted in the urine.
MULTIPLE CHOICE

Identify one correct answer for each of the following.

17. The time required for the onset of a drug’s action depends on its delivery to the site of action. Which of the following is not an important consideration in drug delivery?
   a) route of administration
   b) rate of absorption
   c) rate of elimination
   d) distribution of drug

18. How many factors are associated with a drug’s distribution?
   a) 1
   b) 2
   c) 3
   d) 4

19. Which of the following describes the amount of drug absorbed by the body and distributed systemically?
   a) bioavailability
   b) first-pass metabolism
   c) biotransformation
   d) pharmacokinetics

20. Most drugs and drug molecules are excreted by the:
   a) liver
   b) kidneys
   c) gall bladder
   d) lungs
**QUESTIONS**

**21** The ability of the kidneys to excrete drugs is called:

- a) renal excretion
- b) renal filtration
- c) renal secretion
- d) renal clearance

**22** The time taken for the concentration of a drug to fall to half its original level is called:

- a) half-life
- b) steady state
- c) elimination
- d) clearance

**23** When the amount of drug excreted equals the amount being absorbed, the condition is called:

- a) toxicity
- b) half-life
- c) therapeutic limit
- d) steady state

**24** Sometimes drug metabolism processes become more effective, which can lead to:

- a) drug toxicity
- b) drug tolerance
- c) drug overdose
- d) liver failure
FILL IN THE BLANKS

Fill in the blanks in each statement using the options in the box below. Not all of them are required, so choose carefully!

<table>
<thead>
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<td>second-pass metabolism</td>
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25. Drug __________ describes how well a drug binds to its specific target.

26. The ability of drugs to cross cell membranes depends on their __________ __________.

27. Tissue __________ has a significant role in the initial distribution of a drug.

28. The physical and chemical composition of a drug is called its __________.
Drugs direct their effects at molecular targets within the body. The four most common molecular targets are: _______, _______, and _______.

The products of biliary excretion are eliminated from the body via the ______.

Some drugs undergo ___________ _____________, which prolongs their effect.

______ – _______ _____________ occurs in the liver.

Sustained release drugs are delivered _____________ into the blood.
ANSWERS

LABELLING EXERCISE

Figure 1.3 Common routes for the administration of medicines

1. Inhalation
2. Oral
3. Transdermal
4. Rectal
5. Topical
6. Intravenous
**Inhalation:** drugs targeting the respiratory tract may be inhaled to produce a rapid, local effect on the respiratory system. Drugs that are absorbed by the lungs to produce a general effect may also be administered by inhalation (for example, some general anaesthetics).

**Oral:** this is the most common route of administration because it is the easiest for both the patient and the person administrating the medicine. There are many formulations available for the oral administration of drugs, including tablets, capsules, caplets, elixirs, linctus, lozenges, oral powders, and suspensions. The absorption of orally administered medicines is affected by several factors, including:
- the drug formulation
- the presence of food in the stomach
- the rate of gastric emptying
- possible drug interactions (especially if drugs are administered together).

The formulation of tablets, capsules, and caplets affects the absorption of drugs; for example, many enteric-coated tablets are now available to
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protect the lining of the stomach by preventing the release of the active ingredient until it reaches the duodenum. Sublingual tablets are placed under the tongue for absorption, while buccal tablets are administered between the cheek and gum. Like tablets, capsules and caplets deliver a measured dose of medication (for example 250 mg), although capsules and caplets are generally considered easier to swallow than tablets. They differ in their shape and rate of absorption of the medicine each contains. A capsule has a cylindrical-shaped shell (often made of gelatine), while a caplet is an oval (or capsule)-shaped tablet. Elixirs are alcohol-based solutions. A lozenge is designed to dissolve slowly in the mouth, since it is absorbed here it generally has a local effect. A linctus is a sweet, sucrose syrup often prescribed when administering drugs to children who may find it difficult to swallow tablets; a sugar-free formulation is preferable when available. An oral powder is usually dissolved in juice or water before administration, while an oral suspension is mixed with, but not completely dissolved in, a liquid. It must be shaken before administration to distribute and suspend the drug particles equally. A disadvantage of liquid preparations over solid dosage forms is that liquid preparations rely on the patient, carer or other administrator to measure the dose accurately and subsequently could result in the incorrect dose being given.

3 **Transdermal:** active drug ingredients may be delivered via the skin for systemic distribution, often using a transdermal patch. For example, nicotine patches are used in nicotine replacement therapy as a smoking cessation aid. A transdermal analgesic patch (such as buprenorphine or fentanyl) may be applied to the skin to relieve moderate to severe pain.

4 **Rectal:** certain drugs may be absorbed from the rectum and may be administered as a suppository or enema. A suppository is a bullet-shaped formulation that melts at body temperature, dispersing the drug. The drug in an enema is suspended in a solution and infused into the rectum. This route is useful to avoid first-pass metabolism (see Answer 19).

5 **Topical (local):** drugs may be applied topically (locally) to the skin, mucous membranes or surface wounds, usually in the form of creams, ointments or gels. Topically applied medicines are primarily active at the site of application, although some drugs (for example, non-steroidal anti-inflammatory drugs (NSAIDs)) are also absorbed into the systemic circulation and can therefore cause side-effects.

6 **Intravenous (IV):** this route has the most rapid action since the drug is applied directly into the bloodstream and has a bioavailability of 100% (see Answers 14 and 19). It may be used for drugs that are too irritating to be administered intramuscularly. This procedure is technically quite difficult and the nurse must be careful not to inadvertently inject into an artery, which can lead to arterial spasm and tissue damage.

7 **Intramuscular (IM):** this route is easier than the intravenous one but can be quite painful, so the maximum volume for delivery depends on
the muscle being injected. Some common muscles should only receive 1mL intramuscular injection. Higher volumes may be injected depending on muscle size and its capacity to cope with the volume being injected. Absorption from the site is variable and depends on the blood flow but can be increased by exercise and rubbing the injection site. Usually absorption is greatest from the deltoid muscle and least from the buttock.

8 **Subcutaneous (SC)**: this route is widely used. The common areas for subcutaneous injections are the forearm, outer aspect of the thigh or the abdominal wall. Absorption is slower than with an intramuscular injection (see Figure 1.5) and the area should not be massaged after administration. When a local effect is required (for example, with a local anaesthetic), a vasoconstrictor may be added to the injection to narrow the blood vessels and prevent the drug being distributed away from the site of injection.

![](image)

**Figure 1.5 The effect of route of administration on plasma concentrations of drug after one dose**

9 **Intradermal (ID)**: this is the route often used when administering immunizations. A very small volume is injected at an angle, just under the skin in the dermis, commonly in the upper arm. The injection site should not be massaged when the needle is removed.
In pharmacology, the word ‘agonist’ describes a drug that binds or interacts with its biological receptor but produces no effect.

An agonist is a drug that binds to, or interacts with, its specific biological receptor (such as a cell surface receptor, an enzyme or a section of DNA), stimulating the receptor to trigger a response by the cell. The response is produced in a similar manner to that of the natural physiological ligand (or chemical), such as a hormone or neurotransmitter – that is, the action of an agonist mimics that of the receptor’s natural ligand (see Figure 1.6). For example, a beta₂ (β₂) agonist drug (such as salbutamol) mimics the action of the natural ligand for the β₂ adrenergic receptors (for example adrenaline) on the muscles surrounding the airways. Activation of β₂ adrenergic receptors relaxes the muscles surrounding the airways, causing bronchodilation, which opens the airways. Dilation of the airways helps to relieve the symptoms of dyspnoea (shortness of breath).

Figure 1.6 Mechanism of ligand/agonist–receptor binding

![Diagram of ligand/agonist–receptor binding](image-url)
An antagonist may be described as competitive or non-competitive.  
An antagonist drug may compete with the natural ligand to bind with the cell surface receptor. When it binds with the natural ligand an antagonist will not produce a cellular response, thus an antagonist inhibits the action of the natural ligand. Sometimes the inhibition of the cellular response is desirable in therapeutics and many drugs utilize this mode of action. For example, the cells of some breast cancer patients possess many receptors that will bind to the natural oestrogen hormone circulating in the body. Since oestrogen stimulates breast cancer cells to grow, the continued binding of oestrogen to these receptors will allow the cancerous cells to multiply rapidly, enabling the malignant tumour to grow and spread. Competitive antagonists work by competing with the natural oestrogen ligand to bind with the receptor and once bound they inhibit the cellular response. When the competitive antagonist drug is bound to the receptor, it effectively blocks the oestrogen receptors on the cell surface, which prevents the natural oestrogen ligands from binding to the same receptors and hence tumour cell growth is prohibited. This is how a ‘competitive antagonist’ works. Tamoxifen is an example of a competitive antagonist used in the treatment of breast cancer.

The pharmacological action of a drug varies significantly among individuals.  
Generally, the body’s response to the pharmacological action of a certain drug does not vary significantly among individuals; however, the intensity and duration of the drug response may vary considerably. This is due to two main factors: (1) the bioavailability of the drug (plasma concentration of the absorbed drug) within the body may vary significantly, and (2) the sensitivity and responsiveness of the necessary cell surface receptors may differ. Usually these individual differences are not significant enough to cause concern, although some drugs have a narrow margin between therapeutic effect and toxicity and with these it is important for the nurse to consider the factors that may modify an individual’s response to specific drugs.

A pro-drug describes a drug that is pharmacologically inactive until it reaches the liver and is metabolized.  
A pro-drug may be used if the bioavailability of the orally administered drug is quite poor. It may also be used to increase the selectivity of the drug for its intended target. Pro-drugs only become active when they have undergone metabolism in the liver. Many chemotherapy treatments utilize pro-drugs to specifically target malignant cells and reduce the adverse effects of the treatment.

Drugs administered intravenously (IV) are considered to have 100% absorption into the systemic circulation.  
Drugs administered intravenously are considered to have 100% absorption because they are delivered directly into the bloodstream. The blood plasma concentration of orally administered drugs is compared
against the concentration of the same IV-administered drug to determine the bioavailability of the oral dosage.

15 **Free, unbound drug molecules cannot exert a pharmacological effect.**

Drugs are considered free and unbound when they are not bound to plasma proteins in the blood. Only free drug molecules, which are not bound to plasma proteins, can leave the bloodstream and enter the interstitial (tissue) fluid to exert a pharmacological effect. While bound to plasma proteins such as albumin, drug molecules cannot leave the blood and therefore remain pharmacologically unreactive (inert).

16 **Most drugs are excreted in the urine.**

Most drugs are excreted in the urine either unchanged or as a metabolite. Three renal processes are involved in excretion of drugs. In the first stage, glomerular filtration, small drug molecules are forced across the membrane of the glomerulus by the high pressure in the renal arteries and enter the filtrate in the renal tubule at a concentration equal to that of the blood plasma. Drugs bound to plasma proteins are not filtered. As water is reabsorbed from the filtrate, the concentration of drug in the urine increases. Drug molecules that are not filtered out of the blood in the glomerulus are secreted into the filtrate in the proximal convoluted tubule. The process of secretion is highly effective and can remove most of the drug from the blood in just one passage through the kidneys. Other routes of excretion include the lungs and biliary excretion.

**MULTIPLE CHOICE**

**Correct answers identified in bold italics.**

17 **The time required for the onset of a drug’s action depends on its delivery to the site of action. Which of the following is not an important consideration in drug delivery?**

a) route of administration  
b) rate of absorption  
c) rate of elimination  
d) distribution of drug

For many drugs, the time taken for the onset of drug action is an important consideration because its desired effect is required within a certain timeframe. The time to the onset of drug action can be modified in a number of ways. For example, if drug action is required quickly an intramuscular or intravenous route of administration may be taken. For patients who suffer chronic pain, analgesia (pain relief) may be administered through a transdermal patch which provides a more continuous plasma drug level to control the pain and reduce the amount of oral medication required; this is particularly important in older adults and patients who may have difficulty swallowing tablets or capsules. The
rate of drug elimination will determine the duration of the drug effect: the quicker the drug is removed from its target site, the shorter the drug’s therapeutic effect.

18 How many factors are associated with a drug’s distribution?
a) 1 b) 2 c) 3 d) 4
Once a drug has been administered and absorbed by the body, it must be distributed to the correct site of action. For some drugs the desired site of action is known (thus a drug may be administered locally at the site) but when the site of action is unknown, drugs must be distributed systemically (throughout the body) to ensure they reach the necessary target. Four factors need to be considered regarding drug distribution in the body: (1) distribution into the body fluids; (2) uptake of drugs by body tissues (organs); (3) the extent of plasma protein binding; and (4) passage through barriers (such as the blood–brain barrier).

19 Which of the following describes the amount of drug absorbed by the body and distributed systemically?
a) bioavailability b) first-pass metabolism
c) biotransformation d) pharmacokinetics
Bioavailability refers to the quantity of the administered drug that is absorbed into the body and distributed by the systemic blood circulation. Bioavailability is affected by incomplete absorption and first-pass metabolism, so the route of administration is significant in determining the bioavailability of a drug. For example, drugs that are administered orally may not be fully absorbed from the stomach or intestinal tract (if there is a lot of food present or there is GI disturbance), which will reduce the amount of drug entering the bloodstream. Some drugs are significantly metabolized in their first transit through the liver (first-pass metabolism), which also reduces bioavailability (see Answer 32). Drugs administered intravenously are considered to have 100% absorption (because they are delivered directly into the bloodstream) and so the blood plasma concentration of orally administered drugs is compared against the concentration of IV-administered drugs to determine the bioavailability of the oral dosage. Biotransformation describes the metabolism of drugs in the body. It mainly occurs in the liver. Pharmacokinetics describes what the body does to drugs from administration to excretion.

20 Most drugs and drug molecules are excreted by the:
a) liver b) kidneys c) gall bladder d) lungs
Excretion of drugs occurs primarily through the kidneys, although small quantities of drug may be detected in the faeces. Drugs that are detected in the faeces are eliminated from the body through the bile. Drugs may also be detected in sweat, saliva, hair, tears, and exhaled air, although these are not considered routes of excretion since the quantities usually detectable are very low.
21 The ability of the kidneys to excrete drugs is called:
   a) renal excretion  b) renal filtration
   c) renal secretion  d) renal clearance

Renal clearance is determined by dividing the amount of drug excreted in the urine by the plasma concentration of the drug. In a healthy adult, the kidneys filter 120 mL of plasma every minute. Based on this figure, if a drug has a renal clearance value considerably lower than 120 mL per minute, it means the drug is either (1) not well filtered as it passes through the glomeruli of the kidneys or (2) the drug is filtered and then mostly reabsorbed into the plasma at the kidney tubules. Renal clearance values of more than 120 mL per minute indicate that the drug is filtered by the glomeruli and actively secreted by the tubules. Drugs with high renal clearance values rely on the healthy functioning kidneys to eliminate them from the body, otherwise the drug will accumulate in the body – this is particularly important when prescribing such drugs to patients with kidney disease or individuals at risk of renal complications from other illnesses (such as diabetes). Drugs with low renal clearance rates rely on other elimination mechanisms, usually by the liver with bile. Doses of drugs with low renal clearance need not be modified for patients with kidney disease. The renal clearance rate in newborn babies and older adults is significantly lower and these patients need to receive lower drug doses (see Chapter 12).

22 The time taken for the concentration of a drug to fall to half its original level is called:
   a) half-life  b) steady state  c) elimination  d) clearance

The half-life (or elimination half-life) of a drug is the time taken for the plasma concentration of a drug to decrease by half. The half-life indicates the speed of elimination of a drug and therefore implies the duration of action of a drug. The faster the elimination of a drug, the shorter its half-life will be because plasma concentrations will decrease relatively quickly (see Figure 1.7). When the half-life of a drug is known, it can be used to help determine the intervals between drug doses in patients.

23 When the amount of drug excreted equals the amount being absorbed, the condition is called:
   a) toxicity  b) half-life  c) therapeutic limit  d) steady state

Ideally a therapeutic effective concentration of a drug (or steady state) would be achieved and maintained with a single dose. Unfortunately this is rarely possible so to maintain a steady state, doses have to be administered at intervals. A steady state may be reached quickly by initially administering a higher dose of the drug – known as a loading dose – followed by a maintenance dose. Some antibiotics are administered using this loading–maintenance dose regimen to rapidly attack bacteria and produce desired levels of the drug in the body immediately to combat infection. Rapidly excreted drugs (with relatively short half-lives) require frequent administration or a continuous infusion to maintain a reasonably steady state in the body (see Figure 1.8).
Figure 1.7 The half-life of a drug after one IV injection

![Graph showing the half-life of a drug after one IV injection.]

Figure 1.8 Influence of excretion on achieving a steady-state blood concentration of a drug

![Graph showing the influence of excretion on achieving a steady-state blood concentration of a drug.]

- Slowly excreted drug takes longer to reach a steady state
- Initial large dose followed by smaller maintenance dose
- Rapidly excreted drug quickly achieves a steady state
24 Sometimes drug metabolism processes become more effective, which can lead to:

a) drug toxicity  
b) drug tolerance  
c) drug overdose  
d) liver failure

Drug tolerance may develop when the metabolic processes become more effective. In this situation, repeatedly larger doses of the drug will be required to produce the same therapeutic effect. Patients taking anti-epileptic drugs can sometimes develop drug tolerance, so their initial prescriptions should be as low a dose as necessary to control seizures and still allow for an increased dose in the future.

25 **FILL IN THE BLANKS**

Drug *affinity* describes how well a drug binds to its specific target.

Drugs with a high affinity bind preferentially to their specific physiological target compared with other drug molecules that may be present. The higher the affinity, the tighter the drug will bind to its target. Even low concentrations of very high affinity drugs will bind to their targets preferentially, which can be useful with drugs that are toxic at higher doses.

26 The ability of drugs to cross cell membranes depends on their *lipid solubility*.

Lipid-soluble drugs can easily enter cells from the interstitial tissue fluid by crossing the cell membranes. This is due to the phospholipid nature of cell membranes, which separates the intracellular and extracellular fluid compartments and facilitates the movement of lipids through the cell membrane. Water-soluble drugs will not cross cell membranes as easily. Due to their relatively favourable solubility, lipid-soluble drugs (such as warfarin) will be widely distributed throughout the body fluids and compartments, whereas the distribution of water-soluble drugs tends to be restricted to the extracellular fluid compartments of the plasma and interstitial fluid.

27 Tissue *perfusion* has a significant role in the initial distribution of a drug.

Organs and tissues that are richly perfused with blood will initially receive more drug molecules than regions that do not have a rich blood supply. This is because the drug molecules are transported around the body in the blood, so that areas such as the brain, heart, and kidneys, which receive a rich supply of blood, will initially receive more drug molecules quickly. Bone and adipose (fat) tissue are less well perfused and therefore receive less drug during the initial distribution; even very lipid-soluble drugs will not initially be detected in significant quantities in adipose tissue. After
initial distribution, drugs become redistributed to the tissues for which they have highest affinity.

28 The physical and chemical composition of a drug is called its formulation.

The formulation of a drug describes all physical and chemical aspects of a medicine, including the active ingredients and any excipients (inactive substances that serve as the vehicle or medium for a drug). Excipients can be responsible for adverse drug reactions and may vary between brands, therefore the rate of release of the active ingredient may be different.

29 Drugs direct their effects at molecular targets within the body. The four most common molecular targets are: receptors, enzymes, carriers, and ion channels.

Many drugs target and bind to protein molecules located on cell membranes. The phospholipid bilayer of the cell membrane is selectively permeable and has protein molecule receptors embedded throughout the surface that facilitate the movement of substances in and out of the cell. Certain molecules called ligands bind to specific receptors and produce a response. Drugs may bind to receptors agonistically to mimic the response of a natural ligand or antagonistically to inhibit the natural response. Salbutamol and morphine are examples of common drugs that interact with receptors. Many drugs act by targeting natural enzymes and inhibiting their activity. For example, angiotensin converting enzyme (ACE) inhibitor drugs reduce blood pressure by preventing the action of angiotensin converting enzyme which converts angiotensin I to angiotensin II. In the absence of angiotensin II, blood pressure falls. Carrier proteins (or transport systems) may be targeted by drugs to prevent the normal physiological recycling of certain chemical transmitters. An example is the inhibition of the re-uptake of the neurotransmitter serotonin by certain antidepressant drugs, causing an accumulation of serotonin at the synapse, which enhances mood. Ion channels in the cell membrane may be targeted by drugs in two ways: (1) channels are blocked, as in calcium channel blockers, which block the entry of calcium into cells, or (2) channels may be regulated by drugs that bind to the channel, altering the channel’s response to its normal target.

30 The products of bilary excretion are eliminated from the body via the faeces.

Drugs are often broken down or combined with other chemicals by enzymes in the liver making them inactive. These metabolites then pass out of the liver, mix with the bile, and enter the gastrointestinal (GI) tract. They pass through the GI tract with other unwanted products and are eventually eliminated from the body in the faeces.
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**31 Some drugs undergo enterohepatic recirculation, which prolongs their effect.**

During biliary excretion, some drugs are reabsorbed from the GI tract back into the blood and travel to the liver again where they are further metabolized. This helps to maintain constant circulating levels of the drug, which prolongs the drug’s effect until the next dose is administered. The combined oral contraceptive pill (COCP) is an example of a drug that undergoes this process; this enables the COCP to maintain constant high levels of the hormones required to prevent fertilization of the egg or implantation of a fertilized egg, thus preventing pregnancy. It is also the reason why the COCP should be taken at the same time each day.

**32 First-pass metabolism occurs in the liver.**

The first-pass metabolism (or effect) describes the breakdown (metabolism) of drugs by enzymes in the liver before the drug has entered the general circulation. After an oral drug is absorbed in the digestive tract, it passes to the liver via the hepatic portal vein. A family of enzymes in the liver, known as cytochrome P450 (or microsomal) enzymes, specialize in metabolism and certain enzymes within the family target drugs for metabolism. Each time a drug passes through the liver, it undergoes a certain amount of metabolism, which varies depending on the drug. The amount of metabolism the drug undergoes during its first passage through the liver will determine how much of the drug actually enters the circulation (known as the drug’s bioavailability). If a drug undergoes extensive first-pass metabolism in the liver, very little of the drug will remain when it is released into the circulation, which will limit its therapeutic efficacy. The anti-angina medicine, glyceryl trinitrate (GTN), is a drug that undergoes almost complete first-pass metabolism, which is why it is usually administered sublingually. From this site, it is directly absorbed into the blood, which gives it sufficient time to exert its therapeutic effect before it is metabolized in the liver. Each time a drug passes through the liver, it undergoes further metabolism by the cytochrome P450 enzymes. Some drugs induce certain cytochrome P450 enzymes, which increases their metabolic activity; while other drugs inhibit specific cytochrome P450 enzymes, which reduces their metabolic activity. This is the basis for many drug interactions (see Chapter 13).

**33 Sustained release drugs are delivered slowly into the blood.**

Sustained (prolonged) release formulations are delivered slowly, but at a steady rate, into the blood. This maintains a prolonged therapeutic action. It usually means a patient requires fewer tablets (if the drug is in tablets form) and side-effects may be reduced because peak plasma levels of the drug are reduced.