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MEDICINES MANAGEMENT *FOR* NURSING ASSOCIATES

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Contents

Chapter 3

Principles of pharmacology

NMC STANDARDS OF PROFICIENCY FOR NURSING ASSOCIATES

This chapter will address the following platforms and proficiencies:

Platform 3 Provide and monitor care

3.15 understand the principles of safe and effective administration and optimisation of medicines in accordance with local and national policies.

3.16 demonstrate the ability to recognise the effects of medicines, allergies, drug sensitivity, side effects, contraindications and adverse reactions.

3.17 recognise the different ways by which medicines can be prescribed.

Chapter aims

After reading this chapter, you will be able to:

- understand the pharmacological principles for medicines management;
- appreciate the science of pharmacokinetics and pharmacodynamics, how medications affect the body and what effect the body has on the medicine itself;
- understand why certain medicines are used to prevent and treat certain conditions.

Chapter 3

Introduction

Case study: Henry

Henry is an elderly gentleman who has learning difficulties, has type 2 diabetes and has taken medication to prevent epileptic seizures for many years. Recently, one of his medications has been changed to sodium valproate, but Henry does not remember the name of this new drug. He attends the A&E department with a painful and infected wound on his foot, having injured himself a few weeks ago. Henry informs the doctor of his previous anticonvulsant medicine, the name he is familiar with. The doctor prescribes the antibacterial ertapenem for the infection along with some painkillers. A few days later Henry has several epileptic fits.

Henry's case study is an example of the importance of understanding the basic principles of pharmacology, how medications work and possible interactions. In this fictitious scenario, Henry was unable to articulate what medications he takes and the doctor prescribed an antibiotic that reduces the plasma concentration of valproate and therefore increases the risk of therapeutic failure of the anti-convulsant medicine (BNF, 2023). In other words, the antibiotic rendered the anti-convulsant medication less effective. This raises several issues you may encounter in your practice – the need for thorough assessment and reliable communication – and underlines the necessity for examining how and why medicines work.

In Chapter 1, you were asked to consider the definition of a medicine, which was described as having properties that treat or prevent disease. In this chapter, we will examine this in more detail. We will determine the different medication forms and how this gives rise to their naming, then consider how the body acts on these chemicals via absorption, metabolism, distribution and elimination to allow safe usage and removal. Next, we will describe how these chemicals work to prevent disease or treat illnesses, and finally explore some of the factors that influence the therapeutic choice and effectiveness of medications.

In historical times, a variety of noxious substances were used as treatments. Arsenic was used for cosmetic purposes, for a paler complexion, as a stimulant and as a treatment for syphilis. In these cases, along with others, treatments were discontinued after evidence proved their harm or uselessness.

Pharmacology is the scientific study of the origin, nature, chemistry, effects and uses of medicines. These processes form the basis for why medicines are given in a particular way, why some may be given with food, why some are given more regularly than others and which medicine is the most appropriate in any given situation. This knowledge is essential to ensure accurate and safe **administration** of treatment regimens to your service users.

You may feel quite daunted when it comes to trying to remember the names of medicines and how they work, known as their mode of action, their usual dosages and possible side effects. This is a common fear among healthcare professionals, but it is neither necessary nor, in fact, possible as medications and treatment practices are constantly changing. What is important for your service users' safety is that you understand the pharmacological principles and are able to apply that knowledge within your sphere of practice. Therefore, while you do not need to memorise all drugs and their mechanisms, you do need pharmacological knowledge to look up and interpret information, and remember basic kinetics and dynamics to know how to apply the information.

Before we examine these principles in more detail, let us start with an activity to help you reflect on your current knowledge of the science of medications.

Activity 3.1 Reflection

Think of an example when you have observed, or been involved with, medicines administration at home or in a work capacity.

- What do you know about the different names given to medicines?
- What knowledge do you have about how medicines work and how they stop working within the body?
- Do you know how we group classes of medicines to describe their usage and give us some idea as to what their side effects may be?

As the answers are based on your own observation and reflection, there are no outline answers at the end of this chapter.

You may wish to discuss this reflection with colleagues and retain the information in a personal portfolio.

Having thought about your observations and prior knowledge, let us consider the science in more detail. There are three basic concepts of pharmacology. **Pharmacokinetics** explains the absorption, distribution, metabolism and excretion of medicines. This branch of pharmacology is also concerned with a drug's onset of action, peak concentration level and duration of action. **Pharmacodynamics** are the biochemical effects of the medicines, their mechanisms of action, and **pharmacotherapeutics** are the use of medicines to prevent and treat conditions. In addition, the science of pharmacology helps us to understand how medicines are derived and developed, named and classified, and chosen for administration.

Naming medicines: Nomenclature

Have you wondered why, when you are uncertain of a drug and you look it up in the *British National Formulary* (BNF), that there are several names for the same medication? This is because the medicine will have a **chemical name** describing its chemical composition and molecular structure, a **generic name**, which indicates the active ingredient of the medicine, and its **proprietary name**. This trade name is the drug title which can only be used by the patent owner, which is usually the manufacturer. So, for example, isobutylphenylpropionic acid as a chemical name indicates the non-proprietary drug ibuprofen, which is the term you should see on the prescription as it denotes the medication class. Nurofen is a proprietary trade or brand name registered by the drug manufacturer. Another example is N-acetyl-para-aminophenol, the chemical name of paracetamol, with Panadol being a brand-specific medication available to buy. This variety occurs as initially a drug company will invest large amounts of money developing a new medicine, discussed further in Chapter 7. The patent for this product usually lasts for 20 years; after this, other drug companies can produce their version of this medicine, usually a lot cheaper as they have not had the research and preclinical trial testing costs. They will use this chemical compound, and therefore generic active ingredient, but formulate their product in a slightly different way and give it a unique name.

The European Union requires manufacturers to use the **recommended International Nonproprietary Name** (rINN) for all medicines, which in many cases are identical to the British approved name. Where they had a different name, the rINN has been adopted in UK healthcare, and this is the naming you will find in the BNF. The use of the non-proprietary name on the prescription allows for the most cost-effective drug to be administered. If a brand name is used, then the brand drug must be given. Brand-specific drugs may be required if there is an established difference between a patient's response to a certain brand or if there is a requirement for slow, modified or controlled release, which may only be available in one brand.

Medicines that share similar characteristics can additionally be grouped together as a pharmacological class. Antihypertensive treatments are an example of this. To help with our understanding of the functions of these drugs, **suffixes**, or common endings, are used. Some examples include -olol for beta-blockers like propanolol and bisoprolol, -pril for angiotensin-converting enzyme inhibitors like ramipril and lisinopril. In addition, medicines can be classed or grouped dependent on their therapeutic use. So, anti-epileptics, analgesics, anti-hypertensives and anti-psychotics are all examples of therapeutic class. Now you have discovered that medications have different names and means of classification, complete Activity 3.2 in order to test your understanding.

Activity 3.2 Critical thinking

You are asked by a friend for some advice regarding an advert he has seen for a medication to relieve flu symptoms. He purchased Anadin®, which he saw advertised on television, but when he gets it home, he realises that it does not look the same as the medication he saw advertised and it does not state the same symptom relief on the box. He asks you to explain his mistake.

An outline answer is given at the end of this chapter.

Hopefully, due to your understanding of the different naming of medications and the use of brand labels, you would have been able to answer your friend's question. You may have used several sources of drug information to assist you. For example, perhaps the box label, the inserted information leaflet or you may have accessed the internet as a source of advice. As a nursing associate, you will be aware that caution is needed as the information online is not peer reviewed and accuracy cannot be assured. Finally, and most reassuringly, would be the use of the BNF as an up-to-date, comprehensive guide to medicines management, and you can access this in either book or online format. The BNF would have informed you of indications, contraindications, cautions, interactions and side effects, and it is where this information comes from that we need to explore next.

Medicines uses

Medicines may be used to prevent or treat disease, but we need to know what the indications for a specific medicine are. The **prophylactic** administration of a medicine describes the use of the drug to prevent disease, examples being a vaccine given to induce resistance, an antifibrinolytic after surgery to prevent clot formation and deep vein

thrombosis or embolus or a drug given to reduce cholesterol and thus reduce the likelihood of heart disease or stroke. The **therapeutic** administration of a medicine describes the use of a drug either to treat a condition, control the disease progression or to reduce unpleasant symptoms, and you will have observed many different examples of these. Medicines may also be used to aid diagnosis – for example, fluorescein sodium is an eye drop which, although yellow in colour, when a fluorescent light is shone at it, makes lesions and foreign bodies on the cornea show up clearly with a blue glow. This, along with other eyedrops, like mydriatics that dilate the pupil, make eye examination easier. Clearly, therefore, knowing what we need the medicine to achieve aids the prescriber to choose, but it is not as simple as that. The prescriber will also need to understand in what format this medicine can be given and how it is going to work in order to predict the contraindications, cautions, interactions and side effects. We will examine these next.

Pharmacokinetics: What the body does to the medicine

Derived from the Greek words *pharmakon*, meaning drug, and *kinetics*, meaning motion, pharmacokinetics describes what the body does to a medication. In other words, once administered through any route, which is explored in Chapter 4, it describes the effect the various bodily functions have on the chemical. It explores how the body allows and influences the absorption, how the chemical is distributed around the body, how it is broken down, known as metabolism, and how it is removed from the body or excreted. We will examine each of these in turn.

Absorption in pharmacology is the movement of a drug from the site of administration to the bloodstream. Since medicines can be given through a variety of routes, this will have the initial effect on how the medicinal chemical is absorbed. Most medicines in common use are swallowed and are therefore absorbed by passing from the stomach into the intestines, passing through the liver, and from there into the bloodstream, or circulatory system (see Chapter 2). Medicines given by other routes enter the blood directly from the site of administration. Intramuscularly and subcutaneously, through the capillary blood supply of the muscle and skin, and topically through the mucosal membrane at the site where the medication is deposited – for example, the rectum, vagina and nasal passages. Medicines administered by inhalation are atomised into droplets and nebulised medicines are aerosolised. They are then absorbed into the pulmonary circulatory system.

In order to pass into the circulatory system, the medicinal chemical needs to pass across cell membranes and it does this by passive diffusion, facilitated diffusion or active transport. **Passive diffusion**, as the name suggests, occurs passively without the requirement for any energy or effort. One side of the cell membrane will have a greater concentration of the substance and the molecules will move along the **concentration gradient** to the area where there is a lesser concentration, as a way of evening out the substance on both sides. The word 'diffusion' derives from the Latin word to spread out.

Facilitated diffusion, as the name suggests, requires something to facilitate or allow this process to happen. Carrier proteins are required to move the substance, in this case the medicinal chemical, across the cell membrane from the area of high to low concentration, and they do this by binding to the drug chemical.

Active transport requires energy. Our body's energy is in the form of adenosine triphosphate (ATP) to move the medicine molecules across the cell membrane, because they are either being moved against a concentration gradient or because the molecules are so large (Figure 3.1).

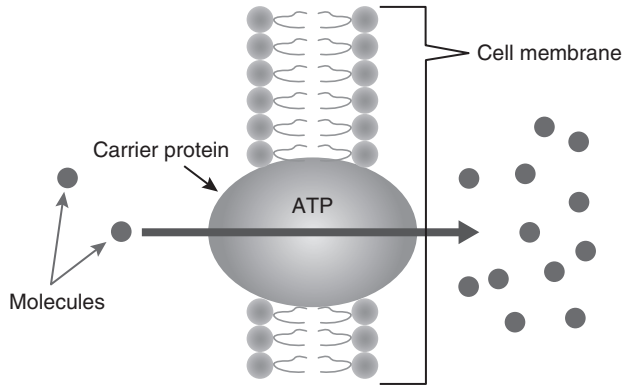

Figure 3.1 Passive and facilitated diffusion and active transport

Source: Cook et al. (2021).

Most medicines are absorbed by diffusion through the wall of the intestine into the circulatory system, and this process will occur more quickly if the medicine molecules are small and lipid-soluble, drugs are usually manufactured to make them as lipid-soluble as possible. It is also worth noting here that non-ionised molecules are more lipid-soluble than ionised molecules. Any molecule, medicines included, consists of two or more **atoms**. Atoms are electrically neutral, consisting of a balance of positively charged **protons** and negatively charged **electrons**. When they lose or gain an electrical charge, they become **ions** and thus we describe these as ionised. Some medicines are deliberately formulated or manufactured as less lipid-soluble, however, to allow them to reach the colon largely unabsorbed – for example, aminosalicylates which are used in the treatment of ulcerative colitis.

Fewer drugs are absorbed by active transport and some examples include levodopa, iron and fluorouracil, as well as electrolytes, such as sodium and potassium. A unique form of active transport called **pinocytosis** occurs when a cell engulfs a drug molecule; the fat-soluble vitamins, A, D, E and K, are absorbed in this manner.

Absorption rate describes the time from when the medicine is administered to its entry into the bloodstream and thus will be affected by several factors. The fewer cells separating the medicine from the bloodstream and the larger the surface area, the quicker the absorption; sublingual and inhalatory medications are absorbed quickly. The more complex membrane system of the gut mucosa, muscles and skin result in slower medicine absorption. In addition, medicines absorbed from the gastrointestinal tract will enter the **portal** circulation, which will transport the drug directly to the liver, where some are extensively broken down as they pass through, known as **first-pass metabolism**. In other words, the liver metabolises much of the drug before it reaches the general or systemic circulation. This means that only a proportion of the medicine absorbed will reach the general circulation and be carried to the site of action, known as the **bioavailability**. Glyceryl trinitrate (GTN) as an example shows a very significant first-pass effect, and as such is given sublingually for the treatment of angina. Other medicines that show significant first-pass effect may still be given orally, but the dosage will need to reflect this in order to ensure a therapeutic effect. The greater the blood flow to the absorption site, the quicker absorption may happen, and thus the onset of the medicinal action. Hot and cold environments, the general health of the individual and choice of administration site will have an impact. Pain, stress, malnutrition, general malaise and stomach contents may also slow medication absorption, as will the individual's characteristics. These characteristics, such as their age and ethnicity will be explored in more detail later. The formulation, or type of the medicine, will additionally have an impact. Liquid medicines are readily absorbed, whereas

enteric-coated drugs are specifically formulated so that they do not dissolve immediately in the stomach, but rather release the active ingredient in the small intestine.

Distribution, as the name suggests, is how the medicine is distributed around the body where it must then penetrate the body tissues to cause an effect, as relatively few medicines exert their pharmacological action in the blood itself. Most medicines therefore need to move from the blood into the interstitial fluid, which surrounds the cell, to interact with the cell membrane target proteins, examined further when we discover how medicines act on the body. As with absorption, distribution is affected by blood flow or tissue perfusion; those organs with a large blood supply, including the heart, liver and kidneys, will receive the medicinal product quicker than other internal organs. The size, solubility, polarity and the acidity of the medicine in solution will additionally affect its distribution. Lipid-soluble drugs easily cross cell membranes, whereas water-soluble medicines cannot. Finally, the affinity or how avidly a drug can bind to plasma proteins will affect distribution. Many medicinal molecules do not dissolve in the blood, but are bound to plasma proteins such as albumin. The drug binds to these proteins, but it is only the unbound chemical that will have a medicinal effect. Thus, it is important to remember conditions that reduce the amount of plasma protein or albumin, like malnutrition or severe burns, will leave more of the free unbound medicine in the bloodstream able to exert a medicinal effect. This may result in a greater response to the medication and additionally greater susceptibility to unwanted effects. Some medicines have a higher affinity for plasma proteins and as such may take longer to move from the blood to the target cell. Warfarin is an example: it has a long **half-life.** This is the time it takes for the plasma concentration of the medicine to fall by half of its original value. This therefore causes a prolonged anticoagulant effect, taking many days for its pharmacological effects to stop after the administration has been stopped. In addition, some medicines will have an affinity for the same plasma protein. Warfarin and aspirin are good examples, competing to bind to the same protein. If administered together, aspirin will bind to the plasma protein, displacing the warfarin and as such making the free warfarin able to exert its anticoagulant effect to a greater degree.

Distribution will also be affected if there are barriers that medicines cannot penetrate. One such example is the membrane barrier that separates the circulating blood and the cerebral spinal fluid. Known as the **blood–brain barrier**, this membrane, which is designed to protect the brain from harmful substances such as bacteria, also prevents the movement of all but the very small medicinal molecules. This can make administering medicines to have a therapeutic effect on the brain difficult. Some molecules do pass this barrier easily, however – for example, alcohol and diazepam. There are also variations in the ability for medicines to pass across the **placenta** from mother to unborn child. Lipid-soluble drugs will cross much easier than water-soluble ones, but once the medication has crossed, its elimination is slow. Medicines may also be from mother to infant through breast milk. Antidepressants as an example, pre and postnatally, require careful prescribing weighting up risks and benefits for mother and baby. In addition, prescribers will need to be aware that physiological changes that occur during pregnancy will have implications for medicine distribution. The concentration of albumin, one of the plasma proteins, is reduced due to the increase in circulatory volume during pregnancy, which will increase the amount of free and active medicine molecules in the blood.

Metabolism is the term used to describe the body's ability to change the medicine molecule from its dosage form to a more water-soluble form to allow it to be removed from the body. This metabolism is also known as **biotransformation**, where the medicine is converted or transformed into inactive components or metabolites. However, some medicines are formulated so that they are inactive until they are altered or metabolised by the body, known as prodrugs. In this way, they only become active and cause a medicinal effect once they are metabolised or biotransformed. An example of this is valaciclovir, the prodrug for aciclovir.

Most medicines are metabolised by enzymes in the liver, although metabolism may also occur in the plasma, kidneys and intestinal membranes. Those metabolised in the wall of the

gut have a clinical significance if food substances such as grapefruit juice, which can inhibit gut enzyme function, are present. Other factors will affect the body's ability to metabolise medicines. If the same enzymes are required – for example, to break down two or more medicines – then this competition will allow for the accumulation of one of the drugs, increasing the potential for toxicity or an adverse reaction. Some disease processes will affect metabolism, including cirrhosis of the liver and heart failure, which may reduce the circulation to the liver. Genetics and a person's age may play a part. Some people are better able to metabolise drugs, and developmental changes, including small, under-developed livers in infants and declining liver size and function in old age, will affect biotransformation. Additionally, some environmental factors such as stress, anxiety or smoking can slow medicine metabolism.

Excretion refers to the elimination of the medicine from the body. Most medicines are excreted by the kidneys and the inactive components or metabolites leave the body in the urine. Thus, it is important to consider the impact of kidney disease on this process. Care is required for medicines management for those with kidney impairment. Drugs may also be excreted through the lungs, in expired breaths, through exocrine glands, through the intestinal tract into the faeces and through the skin, secreted in sweat. Amiodarone, rifampicin and vecuronium – medicines with large molecular weight – are examples of drugs eliminated by the liver in bile and excreted in faeces.

For manufacturers and those prescribing, it is important to understand how long a medicine remains in the body and able to exert an effect, so that it is possible to determine how often a medicine needs to be taken. To aid with this, the half-life of the drug is determined, identifying how long it takes for half of the administered drug to be eliminated. This time will be affected by the rates of absorption, distribution, metabolism and excretion. In addition, three other factors determine how long a medicine can exert an effect; the **onset of action** refers to the time taken for the medicine to start working once it has been administered. **Peak concentration** describes the point when the absorption rate equals the elimination rate and thus there is a peak amount of the drug available. **Duration of action** is the time the medicine continues to produce its therapeutic, diagnostic or preventative effect.

So, having explored and understood what the body will do to our medicine, and therefore what format and how often we may need to deliver our chemical to allow it to have an effect, we need to consider how these medicine molecules produce the effects they do.

Pharmacodynamics: What the medicine does to the body

Pharmacodynamics is the study of the various mechanisms that produce the physiological or biochemical effect. It is the study of the body's reactions to the medicinal molecules.

Medicine as a replacement: in certain cases, the medicine will bring about a normal physiological response as a replacement or substitute for a deficiency – for example, synthetic insulins for service users with diabetes mellitus, ferrous sulphate for iron-deficiency anaemias and levothyroxine for service users with under-active thyroids.

Most medicines, however, produce their biochemical effect in cells and do this by targeting key cell membrane proteins, which can be divided into four categories: receptors, enzymes, ion channels and carrier proteins.

Receptors: receptor proteins on the cell membrane usually respond to the body's natural chemicals, transmitter substances, mediators or hormones. The medicines therefore can mimic the body's natural chemical and activate the receptor, these are called **agonists**. It does this as the medicine's molecular structure is similar in shape to the body's natural chemical – think of

it as a specific key to open a specific lock. Alternatively, the medicine can combine with the receptor and not activate it; these are known as **antagonists**. This time the key fits but does not open the lock. These antagonists may either bind with the receptor and block it so that the body's normal chemicals cannot activate it or simply reduce the function of the receptor. Naloxone is an example of an opioid antagonist. The **affinity** the medicine has for the receptor describes the strength of the bond between the two. In addition, the ability the medicine has to bind or combine with one particular type of receptor describes its **specificity**. In other words, the medicine is quite selective to one receptor. No medicines are truly specific, however, and thus can not only produce a therapeutic effect but also can produce additional unwanted effects, known as side effects. The relationship between a medicine's desired effect and the adverse effects is called the **therapeutic index**, also known as the **margin of safety**. In other words, a medicine may have a very narrow range of safety between an effective dose and a lethal one (Figure 3.2).

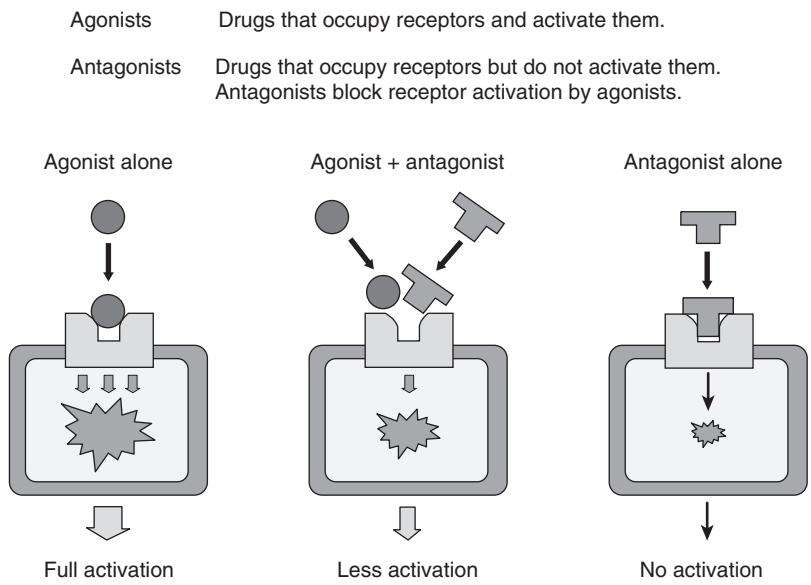

Figure 3.2 Agonists and antagonists

Source: Ashelford et al. (2024)

Enzyme inhibitors: medicines may interact with the body's enzymes which are responsible for promoting or accelerating normal biochemical reactions. Within each cell there are thousands of tiny biochemical reactions that require enzymes as catalysts or required substance to allow the reaction to happen. Medicines are formulated to inhibit or prevent them from performing their role. This inhibition is caused by the medicine binding to the active site of the enzyme where it would usually allow the conversion of one substance into another by being formulated to have a similar molecular shape – the key blocking the lock again. Ibuprofen, a non-steroidal anti-inflammatory (NSAID), is an example of a cyclooxygenase (COX) enzyme inhibitor. The enzyme cyclooxygenase is required to facilitate the production of prostaglandins, chemicals that promote inflammation, pain and fever. NSAIDs work by reducing the production of prostaglandins and thus reducing these symptoms. Further examples include the monoamine oxidase inhibitors, which are anti-depressants, carbonic anhydrase inhibitors, which are diuretics, and statins such as pravastatin and atorvastatin which block the enzyme pathway that produces cholesterol in the liver.

Affecting transport processes: these medicines, as the name suggests, act on the movement of molecules. **Ion channels** are selective pores in the membrane of the cell which allow the transfer of ions. Think of them like tunnels with barriers that allow atoms which have lost or gained an electrical charge to pass along. These pores, or barriers, are opened or closed either by electrical means with the charged potential of the membrane or by chemical transmitter substances. Thus, medicines formulated to act on these channels do so either by inserting themselves in the channel, blocking it and preventing ion movement, or by modulating or changing how the ion channel behaves, enhancing or inhibiting their action. Some examples of these medicines that will act on these pores or openings are calcium-channel blockers, widely used in the treatment of angina; local anaesthetics which block the sodium channels in nerves; anxiolytics which reduce anxiety, like diazepam; antihypertensives like verapamil and some anticonvulsants.

Carrier proteins additionally affect the movement of molecules and are divided into two main categories. In the first group, some proteins will transport ions across the cell membrane using ATP as the energy source in the form of ion pumps, which can be found in various parts of the body. Frusemide is an example of a diuretic that inhibits an ion carrier in the loop of Henle in the kidney, causing an increase in urine production. The second group of carrier proteins are neurotransmitter transporters affecting the junctions between neurons. Fluoxetine and paroxetine, as anti-depressants, are examples of medicines that block the carrier proteins for the neurotransmitter serotonin, although why increased synaptic serotonin levels reduce depressive symptoms is not well understood.

Understanding the theory: Pharmacokinetics and pharmacodynamics

At the beginning of this chapter we stated that it is important for your service users' safety that you understand the pharmacological principles of medicines and that you should be able to apply that knowledge within your sphere of practice. It may seem like there has been a lot of theory here for you to read and understand. We know that this theory can seem complex and daunting; however, let us think of how you are already putting this theory into practice. Think of an occasion when you have taken, or observed someone else take, a mild painkiller to relieve a lower back pain or other soft tissue injury. You will be aware of how quickly the symptoms went away, the painkiller's onset of action and then when the pain started to reoccur, the duration of action, when there was a need to take a further dose to be comfortable again as the rate of elimination was higher than the absorption rate and the peak concentration had lowered. Now think of a time when you or a friend may have taken a strong painkiller, or maybe consumed a little too much alcohol, and the effect it had. Did one of you seem to suffer the sedation effects quicker because you had not eaten, the rate of absorption being quicker due to an empty stomach? Was one of you more affected because of age, ethnicity, sex or a health condition – all of the things that can affect distribution and metabolism? Later that day, did you have to increase your trips to the toilet as your body attempted to eliminate the foreign chemical in your urine – in this case, alcohol or painkiller? Finally, were you concerned about driving home or even driving the next day due to an awareness of how long the alcohol, or analgesic with its sedative effect, was in your system waiting to be completely eliminated? An awareness of how substances, like commonly taken medications or dietary molecules such as alcohol, affect us all will help to put the theory into practice.

Factors influencing medicinal effects

In discussing the pharmacokinetics and dynamics of medicines, we have begun to explore some of the factors that will influence the choice of medication for a service user. We have discovered what happens to the medicine when it enters the body and what effects the medicine exerts. No two people are the same, however, and most drug trials are usually undertaken with healthy, young individuals. The clinical setting and therapeutic use may vary considerably. As a nursing associate, part of the healthcare team responsible for medicines management, you will want to consider several factors before administering any medicine and we will give some thought to those now.

Weight: the recommended dose of a medicine is usually based on evaluation studies from an 'average' weight individual, usually estimated to be around 70 kg. Thus, your service users who are much heavier or indeed lighter than this 'average' person may require adjusted doses to achieve the required therapeutic response or avoid toxic effects.

Gender: physiological differences exist between the sexes. Women have more adipose, or fat cells, than men and so medicines deposited in fat may be released slower and have a prolonged duration of action. For example, inhalation anaesthetics given for surgery have an affinity for depositing in fat and thus may have a prolonged sedative effect in female patients.

Genetics can explain varying responses to medicines, usually related to underactive or overactive enzyme metabolism. It is difficult to predict how an individual from any race may react to a medicine, but **pharmacogenomics** – the study that explores unique differences to medicines based on genetic make-up –to predict this with more certainty. Currently in the UK we have one class of medication with ethnically derived guidelines. The ACE (angiotension-converting-enzyme) inhibitors – captopril, enalapril and ramipril – are not recommended as first-line antihypertensive therapy for those from an Afro-Caribbean origin due to their naturally lower circulating renin levels. ACE inhibitors act on the renin–angiotensin system. Precision medicine, where medications are tailored to individual's genetic make-up is a growing phenomenon with exciting prospects for future treatment regimens, particularly in the field of oncology.

Age: service users at the two ends of the age continuum present concerns for medicines management. Infants and children metabolise medicines differently from adults, due to immature body systems. The rate at which they metabolise and eliminate medicines may be slower for some medicines, but faster than adults for others. It is not possible to generalise and while dosage is often calculated based on the child's weight, the safest option is to prescribe and administer as few medicines as possible to children. Specialist publications like the *BNF for Children* will assist you in caring for these service users. Older adults conversely may undergo physical changes associated with the ageing process (see Chapter 2), with the resultant effect on the pharmacokinetics of medicines. However, it is not possible to generalise. The variations in lived experience, health conditions and the ageing process will make this group particularly challenging for medicines management. Declining liver and kidney function will affect the pharmacokinetics, as will the prescribing of multiple medicines for a variety of conditions. A decline in the function of one body system may result in the decline of another and so on, resulting in the need for a variety of medicines to maintain homoeostasis.

Polypharmacy is the term given to the prescribing of more than four different medicines to one individual (RPS, 2023) and it is a challenge in the older population. The potential for interactions increases with the number of medicines being taken. Further

concerns include the potential for side effects to be mistaken for the normal ageing processes, and the co-morbidities of poor eyesight, cognitive function and physical abilities affecting the ability to adhere to treatment regimens.

Psychological attitudes to treatments will influence the effectiveness of a medicine. Known as the **placebo effect**, an individual's belief in the value of the medicine has been shown to affect how the drug works. A positive belief in the medicine has been shown to increase the likelihood not only of the success of the treatment regimen but also of the individual's commitment to the process. As a nursing associate, you can influence this positivity by ensuring that service users have all the information they require regarding their medication.

Tolerance: some service users may become tolerant to a medicine over time. This may occur due to increased rate of metabolism, increased resistance to the effects or other pharmacokinetic factors. As the medicine no longer produces the desired effect, a review of the therapy is required. As a nursing associate, you will be well placed to observe and respond to such situations and relay information to the prescriber. An example of medication tolerance occurs with the opioid analgesics. Service users may find previous satisfaction with a dose of painkiller is no longer true. The longer morphine as an opioid is taken, the more tolerant the body becomes to it and the analgesic effect decreases. This becomes a challenge in clinical practice for those service users with chronic pain conditions with prescribed regimens, in addition to those service users who may have taken this class of medication illicitly.

Accumulation can occur if the service user takes successive doses of a medicine more frequently than advised. This may be due to cognitive impairment, causing a lack of understanding, or forgetting that medicines have already been taken, or a lack of compliance as it may be easier to take all medicines at once. Accumulation may also occur if the body is unable to eliminate or excrete the medicine adequately. Again, in these situations as a nursing associate you will be well placed to intervene.

Environment can affect the success of medicine therapy. As discussed earlier, temperature may affect the circulatory system of your service user and consequently affect tissue perfusion, and medicine absorption and distribution. In addition, environmental factors like the products of smoking in the air and stressful situations can affect medicine metabolism.

Immunological: service users can develop an allergy to a medicine; after exposure to the chemical, a person may develop antibodies as part of the body's natural defence against the unknown. This can result in a sensitivity to the medicine with resultant unpleasant symptoms or a life-threatening anaphylaxis, discussed in more detail in Chapter 4.

Pathology/medical conditions: disease can change the chemical reactions within the body, as well as affect the pharmacokinetics. Disease processes may influence tissue perfusion, reduce circulatory flow, affect renal function, reduce metabolism due to liver disease or speed up metabolism due to infection. In addition, the presence of disease and symptom management increases the chances of polypharmacy and interactions, as well as symptoms such as diarrhoea, vomiting and pain, affecting absorption and distribution of medicines.

Nutritional status, including anorexia, obesity and poor lifestyle choices can affect how a medicine is absorbed. Service users with greater fat deposits may suffer the prolonged duration of the action of medicines which are deposited in lipids. Service users with less body mass will have less muscle and fat mass, and fewer circulating plasma proteins necessary for the pharmacokinetics and dynamics of medicines management.

Now that you have read this chapter and have explored the pharmacological principles associated with medicines management, take some time to reflect on what you have learnt, which will allow you to apply it to your practice. Activity 3.3 will help you with this.

Activity 3.3 Critical thinking

Reviewing the case study at the beginning of this chapter, consider Henry's situation. Complete the following activity to demonstrate your understanding of the pharmacological considerations discussed in this chapter.

Henry is an elderly gentleman who has learning difficulties, is diabetic and has taken medication to prevent epileptic seizures for many years. Recently, one of his medications has been changed to sodium valproate, but Henry does not remember the name of this new drug. He attends the A&E department with a painful and infected wound on his foot, having injured himself a few weeks ago. Henry informs the doctor of his previous anticonvulsant medicine, the name he is familiar with. The doctor prescribes the antibacterial ertapenem for the infection along with some painkillers. A few days later, Henry has several epileptic fits.

Henry took his Epilim®, his anti-convulsant medication, after his breakfast in the morning prior to attending A&E. He knows he needs to take his next dose after his evening meal. The A&E team assessed Henry's condition, including an exploration of what they believed was his current medication and then administered the antibiotic ertapenem into a venous cannula once that day for the infection.

- Why are there three different names or descriptions within this chapter for Henry's medicine?
- What are the pharmacokinetic effects to be considered in this case?
- What are the pharmacodynamic effects to be considered in this case?
- What are the person-centred care issues to be considered in this case?

An outline answer is given at the end of this chapter.

You have now had the chance to reflect on the contents of this chapter and, as you can see from the summary below, that you have, in fact, explored a large amount of theory and been able to link this to your own practice.

Chapter summary

This chapter has covered the basic principles of pharmacology. You should now understand not only how medicines affect the body, known as the pharmacodynamics, but what effect the body has on the medicine, known as the pharmacokinetics. You have explored factors that may affect these processes, which will allow you to safely administer medicines to your service users. This knowledge will help you to understand the therapeutic usages of groups of medicines and to predict the side effects. Through undertaking the activities, you have been able to demonstrate your understanding and show how you can put the theory into practice. Any areas you were not sure about you can develop by rereading the appropriate section in the book or by seeking out further explanation from the suggested further reading and websites included below.

Activities: Brief outline answers

Activity 3.2: Critical thinking (page 42)

Anadin® is a brand or trade name and not a specific chemical formula or class of medication. Anadin® for symptom relief can be bought as Anadin® extra, which contains aspirin, paracetamol and caffeine, as Anadin® original, which contains aspirin and caffeine, or as Anadin® paracetamol, which just contains the chemical N-acetyl-para-aminophenol. Due to the medications contained within, they will provide different therapeutic responses and potential side effects.

Activity 3.3: Critical thinking (page 50)

Henry's medication Epilim® is the brand name, sodium valproate the recommended international non-proprietary name and anti-convulsant the therapeutic class of the drug. The fact that Henry took his sodium valproate after his breakfast in the morning tells us that this oral medicine can be absorbed through the gut mucosa and that it has a moderate onset of action, the time taken for the medicine to start working. It has a moderate duration of action time, as it only needs to be taken twice a day. That the medication is taken after food suggests that this will slow down the absorption rate, as potentially will the pain, stress and general malaise that Henry may be suffering due to the wound in his foot. The antibiotic ertapenem was given intravenously, so administered directly into the circulatory system for the quickest distribution to the site required; thus, it has not been subject to first-pass metabolism as it has not entered the general circulation via the portal system. We do not know Henry's weight, genetic make-up, age or whether he has a positive attitude to his medicine, but we do know that this may influence the effectiveness of this drug. We also know that Henry has another medical condition, diabetes, and this may affect his nutritional status, and that he is elderly, both of which can influence the effect of medication. On assessment, the A&E team did not indicate that he had either a tolerance, accumulation or immunological response to the medication as this would have caused them to review the treatment regimen. We know that Henry had a cognitive impairment which led him to fail to remember that his medication had been changed recently, which ultimately led to the pharmacodynamic effects, the reduction in plasma concentration of the valproate responsible for the adverse reaction he suffered a few days later and the return of his seizures.

Further reading

To better understand the pharmacological principles for medicines management and the science of pharmacokinetics and pharmacodynamics, as well as why certain medicines are used to prevent and treat certain conditions, the following titles may be helpful.

Ashelford, S, Raynsford, J and Taylor, V (2024) *Pathophysiology and Pharmacology for Nursing Students* (3rd edn). London: SAGE.

Barber, P and Robertson, D (2020) *Essentials of Pharmacology for Nurses* (4th edn). Maidenhead: Open University Press.

McFadden, R (2019) *Introducing Pharmacology for Nursing and Healthcare* (3rd edn). Abingdon: Routledge.

Neal, MJ (2020) *Medical Pharmacology at a Glance* (9th edn). Chichester: Wiley Blackwell.

Spires, A and O'Brien, M. (2011) *Introduction to Medicines Management in Nursing*. Exeter: Learning Matters.

Useful websites

The following websites are useful resources to aid your understanding.

British National Formulary: www.bnf.org

This website allows you to search for specific pharmacological information.

EMC: www.medicines.org.uk

This website provides up-to-date, approved and regulated prescribing and patient information for licensed medicines.