

# Introducing Pharmacology

For nursing and healthcare

Roger McFadden



# Introducing Pharmacology for Nursing and Healthcare

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Roger McFadden

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# Introduction

Welcome, reader, to the fascinating world of pharmacology.

You are probably reading this book because you have enrolled on a course of studies leading to a recognised clinical qualification such as Registered Nurse (RN) or Registered Midwife (RM). Alternatively, you may already be a registered practitioner but are returning to study in order to gain additional qualifications such as Nurse Independent Prescriber or Specialist Practitioner. Whatever your reason for studying the subject, you will find an understanding of pharmacology to be invaluable in your clinical practice. Therapeutic drugs are widely prescribed to patients in most branches of medicine and it is unlikely that any clinical practitioner will be working in an area where patients have not been prescribed some form of medication.

If you will be looking after patients who have been prescribed drugs, you need to understand the mechanism whereby those drugs work. For the patient, it will be sufficient to know that an analgesic drug relieves pain or an anxiolytic drug relieves anxiety but you, as a clinical practitioner, need to understand the action of the drugs at a much deeper level. You may have had the responsibility for the administration of a drug to a patient or perhaps you are looking after a patient who has been administered a drug by a clinical colleague. In either case, it is you who will be responsible for monitoring the patient's response to the drug, and not only must you ensure that the drug is working but also (and equally importantly) whether the drug is causing any unwanted side-effects. To do this effectively it is essential that you understand the drug's mechanism of action - how it produces its therapeutic effect. Increasingly, many non-medical practitioners, nurses, midwives, etc., are trained and licensed to prescribe independently, and a good understanding of pharmacology is absolutely essential.

The main problem associated with the study of pharmacology is that the subject makes little sense unless you also understand the related **anatomy**, **physiology** and **pathology** (disease). Let us explain further . . .

Pharmacology is the study of how drugs work in the human body and anyone who has ever opened a physiology textbook will know that the structure (anatomy) of the human body is rather complex and its workings (physiology) are even more complicated. Unfortunately, this means that the action of drugs on the body is equally complicated. Put simply, you cannot understand the pharmacology unless you first understand the anatomy and physiology. Visit your university or college library and you will find plenty of anatomy and physiology books, but most of them are fairly weighty and not particularly oriented to the study of pharmacology. Look on the adjacent shelves and you will find that there is no shortage of pharmacology books in the library. These will undoubtedly tell you all you need to know about pharmacology but they nearly all begin with the assumption that the

reader arrives at the subject with a good understanding of basic anatomy and physiology. Experience has shown that this is not always the case and even when students have some background in human anatomy and physiology they can struggle with the specialised cell biology and biochemistry that underpins the subject of pharmacology.

So, in order to understand pharmacology, you need to understand basic anatomy and physiology and you also need to understand pathologies.

Apart from a few exceptions such as oral contraceptives, drugs are not prescribed to healthy people; mostly they have some disease or are at risk of developing a disease or complication. This means that most drugs can only be understood in the context of pathologies as that is where they have their prime source of action. For example, common analgesics such as *ibuprofen* and *diclofenac* help to ease pain by reducing inflammation, so an understanding of inflammation is required before we can be confident that we know precisely how these drugs work. Again, there are plenty of (often very heavy) pathology books in the library but by now we have accumulated quite a pile of textbooks from which to study the subject of pharmacology. We have our anatomy and physiology textbook, our pathology textbook and finally our pharmacology textbook.

Do I really need all these textbooks?



Fortunately - no! *Introducing Pharmacology* has been specially written for the reader without a background in physiology, pathology and pharmacology. In its 11 chapters, *Introducing Pharmacology* covers most of the commonly prescribed drugs and explains their action relative to the physiology and pathology of the system concerned. Naturally, as you progress in your studies, you will need to refer to more advanced textbooks and journals but you should be able to obtain a sound understanding of the basics of the subject here.

*Introducing Pharmacology* is divided into two parts:

In **Part 1** we look at the fundamentals of pharmacology, taking you down among the cells to the (mainly) protein structures targeted by drugs. We also look at how the body processes and eliminates the drugs that have been administered; this will help you to understand why some drugs can be given in tablet form while others need to be injected. You are no doubt aware that most drugs have the potential to cause side-effects or to interact with other drugs, and in Part 1 we explore how this happens.

In **Part 2**, when you have read Part 1 and have a good grasp of the fundamentals of pharmacology, we can then proceed to learn how individual drugs produce their therapeutic (and sometimes unwanted) effects on the body. We have divided Part 2 into chapters that are devoted to the major drug groups as used for specific organ systems - circulatory, respiratory, digestive system, etc. These chapters will follow a common format that will, firstly, examine the basic anatomy and physiology of the organ system. Secondly, the chapter will look at key pathologies that affect the system - for example, asthma in the respiratory system and high blood pressure in the circulatory system. Finally, when you are sure that you understand the physiology and pathology, we will examine the key drugs used to treat those pathologies.

As *Introducing Pharmacology* is an introductory textbook, it covers primarily those drugs that you will encounter regularly in general clinical practice. Some drugs are rarely found outside specialist areas such as operating theatres or cancer wards, and to keep the book to its remit of *introducing pharmacology*, these more specialist drugs have been omitted. However, all drugs have similarities in their modes of action, so by reading this book and understanding the basic principles of pharmacology, you should have the knowledge necessary to access more advanced publications dealing with these specialist drugs.

As you read each chapter, you will find a few special features that help to keep you involved in the learning process and also ensure that you have understood what you have just read.



### WHERE ARE WE STARTING FROM?

This provides a few short questions to test your background knowledge before you start a chapter. Answers are provided at the end of the chapter.



### ONE SMALL QUESTION

This character pops up frequently and asks those awkward questions that keep us on our toes.



### DID YOU KNOW

These are interesting snippets of information relating to the text that may broaden your understanding of a particular topic.



### IN PRACTICE

These are notes that help you to apply your understanding of pharmacology to clinical practice.



### REALITY CHECK

It is easy to read something and think that it makes sense, but have you really understood it? This feature prompts you to stop for a second and consider.



### KEY FACT

Highlights important concepts or ideas.



### ANOTHER WAY TO PICTURE THIS

Sometimes pharmacological concepts can be quite difficult to grasp, but by using an analogy from everyday experience they can make more sense.



### CASE STUDY

These mini case studies appear in Part 2 and relate to the drugs and diseases you are exploring in that chapter. You are encouraged to think about what you have learned and apply that knowledge to practice.



### A QUICK RECAP

Highlights the key concepts and ideas that you have been reading about over the previous few pages.



### RUNNING WORDS

At the end of each chapter there is a list of all of the technical terms that have appeared in that chapter. Check them one by one and tick them off when you are certain you understand them.



### YOUR TURN TO TRY

Now you have finished the chapter, you can test yourself with these mini-quizzes to find out how much you have learned and remembered. Answers are provided at the end of the book.

This book has been written primarily for the reader with little or no previous knowledge of the subject of pharmacology and perhaps may not have studied anatomy and physiology in any great depth. Hopefully, you should find *Introducing Pharmacology* accessible and understandable. The book has been written in an informal manner but without sacrificing scientific accuracy. In a society where the text message and e-mail are the preferred methods of communication, many readers are put off by a formal, dry academic style of writing that is the norm in many textbooks, but there is no reason why science cannot be communicated effectively in a language that everyone understands. Of course there are long words and technical terms that have to be learned because those are the words and terms that are used and understood by fellow professionals. This does not mean that we cannot communicate in plain English without resorting to jargon or 'in-house' acronyms that are only understood by the initiated few. In *Introducing Pharmacology* you will find plenty of case studies, clinical notes and self-test questions that break up the narrative into manageable sections. When you have finished working through the book you should have a good grasp of the basics of the subject, the key specialist terms used in pharmacology and be ready to move onto the next stage of applying what you have learned to your clinical practice.

So, find a nice new pad of A4 paper, sharpen your pencil and get ready for some interesting (if occasionally challenging) pharmacology.

### A brief note about the drug names used in this book

The drugs in *Introducing Pharmacology* use the Recommended International Non-proprietary Names (rINN) from the European Pharmacopoeia which are replacing the British Approved Names (BAN). Some of these might be slightly different from what you currently encounter in clinical practice so, for example, **phenobarbital** replaces **phenobarbitone**, **furosemide** replaces **frusemide** and **lidocaine** replaces **lignocaine**. The rINN names are the names that appear in the *British National Formulary* (BNF) and are becoming the accepted form in UK practice.

As is standard for most pharmacology books, *Introducing Pharmacology* uses the generic (rINN) names for drugs rather than the proprietary or trade names. The generic names refer to a standardised formula for that particular drug, whereas the manufacturer's proprietary or trade name describes the formulation of the drug supplied by that particular manufacturer. For example, **fluoxetine** is the generic name of Prozac<sup>®</sup> which is the name given to **fluoxetine** by its manufacturer - Eli Lilly & Co Ltd. **Salbutamol** is the generic name for Ventolin<sup>®</sup> produced by GlaxoSmithKline plc. Although some proprietary names may be better known than the generic names, *Introducing Pharmacology* generally uses the generic names because some drugs, especially those that are out of copyright, may have many proprietary versions produced by various manufacturers and it would be impossible to use them all or decide which among them was the best-known name. In *Introducing Pharmacology*, the generic name is indicated by the name being highlighted in **italicised bold** letters.

### **Introducing Pharmacology and clinical practice**

While you will find the study of pharmacology very useful and relevant to your clinical practice, it is not strictly a clinical subject and *Introducing Pharmacology* will not be imparting clinical advice. Case studies are included in Part 2 of this book solely to demonstrate the relevance of pharmacology to practice. The decision about which drug to administer to which patient at which dose, at which time and by which route is a clinical decision that requires expertise acquired in clinical practice and clinical training.

*Roger McFadden*

# Acknowledgements

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# Part 1

## Principles of pharmacology

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# Chapter 1

## Let's start at basics: Cells and how they work

### AIMS

By the time you have finished the chapter you should be able to understand:

- 1 The structure and function of cells (cells are the prime target for most drugs)
- 2 Some basic biochemistry (drugs mostly target biochemical processes in cells).

### CONTENTS

Introduction

Where are we starting from?

- 1.1 **Levels of organisation: from cells to systems**
- 1.2 **A brief introduction to cells**  
Cells and cell components
- 1.3 **A brief introduction to (basic) biochemistry**  
Protein and protein synthesis  
How cells make proteins  
Lipids  
Carbohydrates and sugars  
Cellular respiration and the production of ATP

Running words

References and further recommended reading

Your turn to try

## Introduction

Pharmacology can be quite daunting to the student approaching the subject for the first time. The reason for this is that most pharmacological activity takes place at a cellular or biochemical level and relatively few people are really comfortable down among the cells and molecules. However, this is the level where we need to be, not only to understand the subject of pharmacology but also to understand the literature relating to the subject. This literature is not just textbooks on pharmacology but the clinical reference books such as the **British National Formulary** (BNF) that you will find in daily use in every UK hospital ward and GP surgery. The BNF appears in an updated edition at six-monthly intervals and is published jointly by the British Medical Association and the Royal Pharmaceutical Society of Great Britain. Clinical practitioners use this standard reference book on licensed drugs to ensure that the drug they are prescribing is suitable for the patient, that the patient is being prescribed the correct dose and that the drug will not interact with other drugs. However, a look at the contents page of the BNF will quickly convince you that you need to have some understanding of pharmacology, just to access and use this book. Here is a short sample of the section headings relating to various classes of drugs contained in the BNF:

- Calcium channel blockers
- Selective beta-2 agonists
- Angiotensin-converting enzyme inhibitors
- Alpha-adrenoceptor blocking drugs
- Non-steroidal anti-inflammatory drugs
- H<sub>2</sub> receptor antagonists
- Selective serotonin re-uptake inhibitors
- Cyclo-oxygenase-2 inhibitors

If you already understand these terms then you can probably progress quickly to a more advanced pharmacology book. However, if you do not understand the terms then you will need to learn them - especially if you are going to be involved either in the prescribing or the administration of drugs to patients. You not only need to be familiar with the terms but you also need to know what the terms mean - which is a fundamental requirement to ensure patient safety. Nursing staff who administer drugs to patients are responsible for the safe administration of those drugs. This means that those staff must be familiar with those drugs, how they work in the body, how they may cause side-effects and possibly interact with other drugs. The classes of drugs mentioned above are in fact the clinical names of some of the most common drug groups that include **antihypertensives, analgesics, bronchodilators** and **antidepressants**.

One of the key aims of *Introducing Pharmacology* is to familiarise you with the language of pharmacology, the names of drugs and the terms that you will find

on every packet of drugs and in every publication dealing with the clinical use of those drugs. You will need this language not only to study and understand pharmacology but also to discuss drugs and their effects with patients and fellow professionals.



### WHERE ARE WE STARTING FROM?

Normally at this point - at the beginning of a chapter - we start with a short quiz to see how much you already know about a particular topic. However, as this is the first chapter of *Introducing Pharmacology*, we will assume that your knowledge of the subject is limited to what you read about drugs in the newspaper and hear about them on the radio and TV. For some future chapters you will need to do some background reading, but at this stage we are assuming that you are entirely new to the subject. We will therefore start at the best place - the beginning!

## 1.1 Levels of organisation: from cells to systems

Drugs are chemicals that are introduced into the human body to treat or prevent disease. Drugs can relieve symptoms such as pain and swelling, resolve problems such as indigestion and anxiety or manage problems such as heart disease. There are hundreds of different types of drugs designed to treat hundreds of disorders and each type of drug works by a unique action of its own. The way that some drugs work is relatively straightforward while others have quite complex actions. Ultimately, however, if we are going to understand how any of these drugs work, we need to transport ourselves to the level at which most drugs work - the cell.

What exactly is a cell?



Good question - we will examine cells in some detail later in this chapter. At the moment you just need to know that cells are very small structures that form the building blocks of tissues and organs.

Now, although the basic action of most drugs can be explained at a cellular level, they eventually have an effect on organs and systems that can be observed either by the clinical practitioner or by the patient. This means that to really understand the action of drugs you have to be able to connect their action at cellular level with their effect on organs and systems. Let us illustrate this by looking at some common drugs and drug groups with which you are probably familiar (or at least have heard of) - see Table 1.1. All of these drugs act on specific cells of the body but have an effect above cellular level.

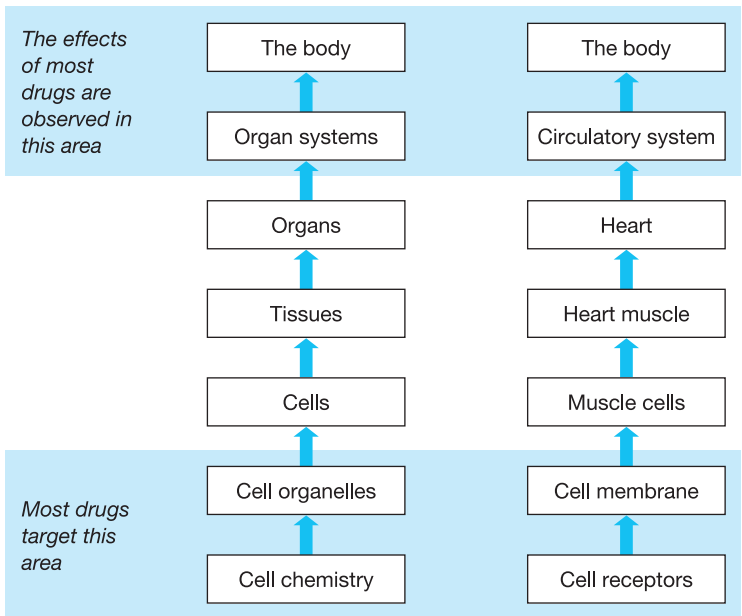
The gap between target cell and the effect the drug has on the body is highlighted in the table by an arrow and this is largely what pharmacology is about - explaining how a drug that targets a particular cell produces its therapeutic effect on the body. To understand this, you need to appreciate that the body has various levels of organisation.

**Table 1.1** Some common drugs, their cellular targets and their effects

Drug	Cell target	Mechanism	Therapeutic effects
Beta-blockers	Heart cells	————→	Prevents an increase in heart rate
Local anaesthetics	Nerve cells	————→	Prevents pain in minor surgery
Analgesics	Immune cells	————→	Reduces inflammatory pain
Antidepressants	Nerve cells	————→	Relieves depression
Statins	Liver cells	————→	Reduces blood cholesterol levels

We divide the human body into levels of organisation for much the same reason as we divide a book into sections and chapters - it helps us to understand the structure better. Figure 1.1 shows a simplified hierarchy of structures, starting with cell chemistry and moving upwards to the whole body. As an example of this hierarchy we have used the circulatory system, but bear in mind that this simplified diagram does not imply that the heart is made up of only one type of tissue. There may be only one heart but it is made up of several different types of tissue and these tissues are made up of their own specialised types of cells.

Most drugs interact initially with the first two categories, cell **organelles** and their components, the chemicals of which they are made. However, the effects of drugs are generally observed on the body as a whole or the organ systems. For example, the anti-angina drug *glyceryl trinitrate* (GTN) targets the cells of



**Figure 1.1** Levels of organisation within the human body. The hierarchy of organisation of the heart and circulatory system is given as an example.

various blood vessels, including those of the heart itself, but the effect observed by the patient is the lessening of his or her chest pain. Another example is the antihypertensive drug *verapamil*, which reduces blood pressure by targeting the cell membrane of heart muscle cells. Here the effect is on the circulatory system where you will observe a fall in blood pressure.

In Part 2 of *Introducing Pharmacology* we will be following the stories of most of our major drug groups from their interaction with cells right through to their therapeutic effect on organs systems. You will see that when we take each stage a step at a time, then pharmacology is actually quite a straightforward subject and is nowhere near as daunting as it may at first seem. But first things first - we need to familiarise ourselves with cells and some of the basic biochemistry that takes place in those cells.

## 1.2 A brief introduction to cells

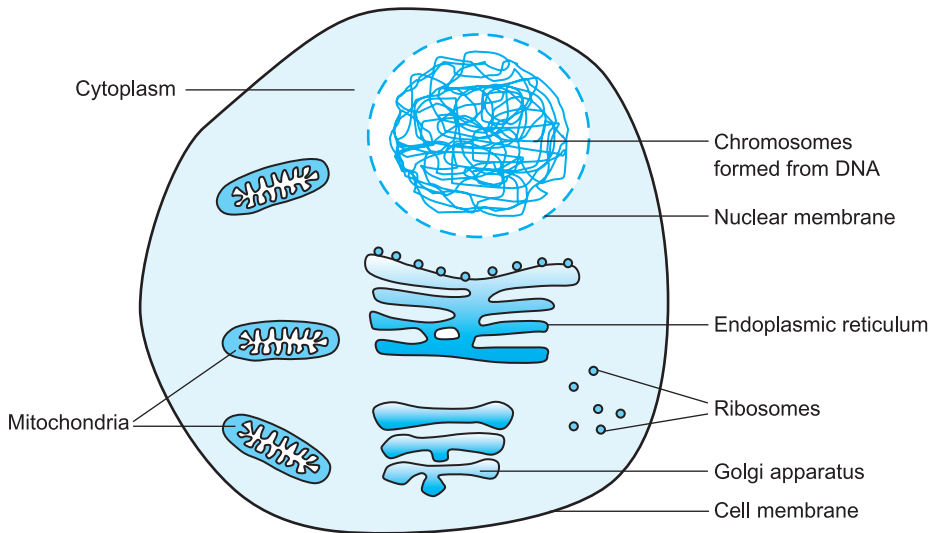
Most drugs bind to proteins and most of these proteins are found in and on cells. Those proteins that form the targets for drugs are explored in more detail in Chapter 2, but in the meantime we need to find out a bit more about cells and the proteins they produce.

### Cells and cell components

Cells are the building blocks that make up most tissues and our bodies contain trillions of cells. Most cells are specialised to a particular task. For example, muscle cells contract, nerve cells conduct nervous impulses and glandular cells secrete hormones. Drugs interact with these specialised cells and the effects of these interactions will be discussed in detail in the second part of *Introducing Pharmacology* when we look at the major drug groups. However, although these cells may look very different on the outside and each may have its own specialised function, inside they are fairly similar. A few cells such as muscle cells contain special proteins that enable them to contract, but otherwise cells have many internal features in common. To understand the principles of how drugs work on cells, it is necessary to have a basic understanding of cells, their structure and what goes on inside them. Figure 1.2 is a diagram of a typical cell.

### The components of cells: organelles

It is important that we do not think of cells simply as the building blocks of tissues because in reality they are miniature wonderlands of biochemical activity. Every second in every cell there are thousands upon thousands of biochemical reactions taking place to maintain the cell and also to enable it to perform its task as part of a community of cells that makes up our tissues and organs. If you look at a cell through a good-quality, high-powered microscope, you can see that



**Figure 1.2** A typical human cell showing the principal organelles.

it contains many small structures. These are called the **organelles** (literally small organs) and are common to all cells. Each organelle has a specific function.

Several organelles are involved in the production of proteins. These are the **nucleus**, the **endoplasmic reticulum**, the **Golgi apparatus** and the **ribosomes**. Tens of thousands of different proteins are made by cells and, as mentioned previously, proteins are the main target for drugs. **Mitochondria** are small, bean-shaped organelles that produce most of the energy for the cell. They use the energy from fuel such as glucose and lipid to produce **adenosine triphosphate (ATP)**, a small packet of energy that powers most of the cell's biochemical processes. You will need to understand more about ATP because some drugs target structures and mechanisms that use ATP. The process whereby our cells make ATP is quite complex, but we need to have a basic knowledge of the process because some diseases such as angina affect energy production and some drugs such as **glyceryl trinitrate** help to maintain the body's ability to make ATP. This process is called **cellular respiration** and we will examine it in more detail later in this chapter.

- **Cytoplasm.** This is basically the contents of the cell. It is composed of the organelles and the **cytosol**, a semitransparent solution of enzymes, nutrients and electrolytes, necessary for the myriad of processes that take place continuously in each cell.
- **Cell membrane.** This important structure is a thin membrane that encloses the contents of our cells and separates them from the **extracellular fluid** outside the cell. The cell membrane regulates what goes into and out of the cell. It is composed mainly of a **phospholipid bilayer** interspersed with **cholesterol** and it is incredibly thin, around 7 nanometres (1 nanometre is 1,000,000th of 1 millimetre). The components of the bilayer are arranged as shown in Figure 1.3.