PHARMACOLOGY
FOR HEALTH PROFESSIONALS
WORKBOOK

Kathleen Knights and John Miners
PHARMACOLOGY FOR HEALTH PROFESSIONALS WORKBOOK

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Preface

The ever-expanding number of drugs that are introduced annually into clinical practice makes it essential for you, as a student or as a practising health professional, to continually update your knowledge. This Pharmacology for Health Professionals Workbook has been designed to complement and enhance your knowledge of pharmacology. By using an integrated approach, we hope that completion of the various Workbook activities will not only help to reinforce the material contained in the text Pharmacology for Health Professionals but will also promote lifelong learning. To aid the learning process we have arranged each chapter of the Workbook so that it starts with simple activities that will enable you to grasp key concepts quickly without becoming overwhelmed. It is akin to climbing a ladder: the first steps are simple but, as the ladder becomes part of a scaffold, the concepts and ideas become more complex and interrelated. In-depth questioning will challenge your knowledge base and will stimulate those amongst you who seek thought-provoking and challenging explanations that will ultimately enable you to enjoy the wonders of pharmacology. To this end, many principles that underpin drug therapy are explored as we seek to encourage in-depth understanding rather than superficial rote memorisation.

We appreciate that mastering the knowledge of pharmacology is a formidable task and recalling information instantly in a clinical setting is often difficult, especially with the added pressure of ‘getting it right’. As developments in pharmacology, physiology and medicine lead to an improved understanding of disease processes, this in turn leads to a greater appreciation of the mechanisms of drug action and their relationships to rational drug therapy. To enhance your learning numerous aspects of the pharmacology contained within the Workbook are contextualised into the clinical arena giving meaning to the concept of ‘needing to know’.

Our primary aim in writing the Pharmacology for Health Professionals Workbook was to provide those who use it with a clear understanding, through an in-depth knowledge of pharmacology, of safe and efficacious drug use that maximises benefits and minimises harm. We hope this Workbook provides you with a challenging journey that is both worthwhile and enjoyable.

Kathleen M Knights
John O Miners
About the authors

KATHLEEN KNIGHTS
Kathie obtained her PhD from Flinders University in 1984 and a Graduate Certificate in Tertiary Education in 1997. She has held the position of Professor in Clinical Pharmacology at Flinders University since 2008 and is a member of the Flinders College of Distinguished Educators. In 2007 she was awarded an Australian Carrick Citation for Outstanding Contributions to Student Learning for the development of an e-learning pharmacology package for Masters students in urban, rural and remote areas of Australia. In 2010 she received, from the Australasian Society of Clinical and Experimental Pharmacologists and Toxicologists (ASCEPT), the ASCEPT Teaching Excellence Award. She is passionate about the discipline of pharmacology and her teaching crosses discipline boundaries, covering medicine, nursing, nutrition and dietetics and paramedic sciences. She is co-author of the highly successful text *Pharmacology for Health Professionals*. A member of ASCEPT since 1980 she has served as ASCEPT President (2008–2009). Currently, she is a member of the British Pharmacological Society (BPS), the International Society for the Study of Xenobiotics (ISSX) and the Drug Metabolism Section of the International Union of Basic and Clinical Pharmacology (IUPHAR).

Kathie’s research interests centre on drug metabolism, specifically the metabolism of non-steroidal anti-inflammatory drugs, and the mechanisms of renal toxicity of NSAIDs. An invited speaker at national and international conferences, she has published over 70 research articles and reviews in peer-reviewed international journals and five book chapters.

JOHN MINERS
John completed BSc, MSc and PhD degrees at the Victoria University of Wellington (New Zealand). Following a period of postdoctoral research at the University of Oxford he took up an appointment in the joint Flinders Medical Centre—Flinders University Department of Clinical Pharmacology, becoming Professor in 1992 and serving as Head of Department from 2003 to 2013. John is currently Matthew Flinders Distinguished Professor in the Department of Clinical Pharmacology.

John has over 30 years of experience in the teaching of pharmacology and therapeutics across a range of disciplines that include medicine, medical science, nursing, paramedic science and optometry. He is recognised nationally and internationally for his research on drug and chemical metabolism and disposition in humans, particularly sources of variability in drug elimination and its pharmacokinetic and therapeutic consequences. John has published 260 research articles (papers, reviews and book chapters) in this area. His research achievements have been recognised by the award of a DSc from Flinders University, the Rand Medal of the Australasian Society of Clinical and Experimental Pharmacologists and Toxicologists (ASCEPT) and a Scientific Achievement Award from the International Society for the Study of Xenobiotics (ISSX), along with election to Honorary Fellowship of the Royal Society of New Zealand and Fellowship of the Australian Academy of Science.

He has additionally served as President of several pharmacology-related societies (ASCEPT, ISSX and the Asia-Pacific Federation of Pharmacologists) and as a member of the Executive Committee of the International Union of Basic and Clinical Pharmacology.
How to use this workbook

The Workbook is divided into 51 chapters that cover, in sequential order, the content of the text Pharmacology for Health Professionals. We advise starting with Chapters 1–10 as these provide the foundations of pharmacology that you may find useful for completing activities in subsequent chapters. Chapters 11–48 review systems pharmacology while Chapters 49–51 look at drugs in sport, obesity and envenomation. To facilitate your learning each chapter has been divided into smaller sections that transition your learning from simple concepts through to more complex problems, which are generally based around therapeutics.

LEARNING OUTCOMES

At the beginning of each chapter are the Learning Outcomes. These are the goal posts against which you can assess your learning and they will allow you to judge, on completion of the Workbook activities in each chapter, whether you have mastered the material. An easy way to do this when revising the material is to start each Learning Outcome with the words ‘Can I’.

KEY CONCEPTS

These have been constructed as a tool to reinforce those concepts that you ‘need to know’ and to provide a user-friendly format to aid revision. Rather than rote memorising try putting difficult concepts in your own words and check to see if you understand them.

REVIEW QUESTIONS

These activities have been designed to scaffold your learning by increasing the complexity of the pharmacology and integrating your knowledge. It is a little like trying to connect the dots. If you have difficulty in some Review Questions with ‘connecting the dots’, go back and relook at the Key Concepts and try to broaden your knowledge by seeking the answer through self-directed learning.

MULTIPLE CHOICE QUESTIONS (MCQs)

Multiple choice questions are also referred to as Objective Questions. MCQs test factual material and the understanding of concepts—they aren’t about guessing the answer but are a tool for reinforcing your learning. The majority of MCQs we have constructed have multiple correct answers.

CRITICAL THINKING SCENARIOS

The majority of the critical thinking scenarios contextualise pharmacology by moving your learning to ‘real world’ therapeutic situations. These scenarios emphasise the basic science underlying the mechanisms and relate the relevant pharmacology to the therapeutic situation. Your answers will be dependent on not only your knowledge of pharmacology but also your ability to relate concepts in order to solve the problem. For some Critical Thinking Scenarios you may need to broaden your sources of drug information.

ANSWERS

Answers to all the Workbook activities can be found on the companion Evolve website. The package comprising the text Pharmacology for Health Professionals and the accompanying Workbook has been designed to complement and extend your pharmacology knowledge by promoting critical thinking and the desire for lifelong learning.

ACKNOWLEDGEMENTS

The authors thank all the reviewers who provided helpful and constructive comments, which we have addressed in this Workbook.

CONTRIBUTORS

The authors thank and acknowledge the invaluable assistance of Dr Tilenka Thynne (Consultant Clinical Pharmacologist/Endocrinologist), Professor Arduino Mangoni (Consultant General Physician/Clinical Pharmacologist), Dr Matthew Doogue (Consultant Physician/Clinical Pharmacologist), Mr Cameron Phillips (Clinical Pharmacist) and Dr Ganessan Kichenadasse (Consultant Oncologist) whose time and expertise contributed to the accuracy and clarity of some of the Critical Thinking Scenarios.
Chapter 25
Drugs affecting the kidney and bladder

LEARNING OUTCOMES

On completion of Chapter 25 and the workbook you should be able to:

1. Describe the structure of a nephron.
2. Discuss the role of the kidney in the maintenance of fluid and electrolyte balance.
3. Discuss the various transfer processes that occur throughout the nephron.
4. Name one drug from each of the three major classes of diuretics and identify their primary sites of action in the nephron.
5. Discuss the three main types of urinary incontinence.
6. Identify the neurotransmitters and receptors involved in bladder function.

KEY CONCEPTS

To enhance your learning complete the following sentences:

1. The major anatomical structures of the nephron are ________________________________

2. Glomerular filtration is the initial step in urine formation and involves ________________________________

3. The main transfer processes that occur throughout the nephron include: ________________________________

4. Diuresis is defined as ________________________________

5. Chronic kidney disease is defined as ________________________________
6 Urinary incontinence can be categorised into __________________________.

**REVIEW QUESTIONS**

1. On the diagram label the following sites:
   a. Afferent arteriole
   b. Collecting duct
   c. Distal convoluted tubule
   d. Efferent arteriole
   e. Glomerulus
   f. Loop of Henle
   g. Proximal convoluted tubule


2. On the diagram indicate the site of action of:
   a. Amiloride
   b. Hydrochlorothiazide
   c. Indapamide
   d. Frusemide
   e. Spironolactone

3 Match the term in column 1 with the description in column 2.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 mL/min</td>
<td>Volume of filtrate reabsorbed per day</td>
</tr>
<tr>
<td>120 mL/min</td>
<td>Tubular transport maximum for glucose</td>
</tr>
<tr>
<td>178 L</td>
<td>Renal blood flow</td>
</tr>
<tr>
<td>32 mg/min</td>
<td>Glomerular filtration rate</td>
</tr>
</tbody>
</table>

4 Match each individual drug with its drug group.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Drug group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfuzosin</td>
<td>Thiazide diuretic</td>
</tr>
<tr>
<td>Amiloride</td>
<td>$\alpha_1$-Adrenoceptor antagonist</td>
</tr>
<tr>
<td>Bumetanide</td>
<td>Potassium-sparing diuretic</td>
</tr>
<tr>
<td>Darifenacin</td>
<td>Loop diuretic</td>
</tr>
<tr>
<td>Frusemide</td>
<td>Anticholinergic (muscarinic receptor antagonist)</td>
</tr>
<tr>
<td>Hydrochlorothiazide</td>
<td></td>
</tr>
<tr>
<td>Oxybutynin</td>
<td></td>
</tr>
<tr>
<td>Spironolactone</td>
<td></td>
</tr>
<tr>
<td>Tolterodine</td>
<td></td>
</tr>
</tbody>
</table>

5 Match the neurotransmitter in column 1 with the receptor it acts on in column 2 and the physiological response elicited in column 3.

<table>
<thead>
<tr>
<th>Neurotransmitter</th>
<th>Receptor</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noradrenaline</td>
<td>$M_3$</td>
<td>Detrusor muscle relaxation</td>
</tr>
<tr>
<td>Acetylcholine</td>
<td>$\alpha_1$</td>
<td>Bladder neck smooth muscle contraction</td>
</tr>
<tr>
<td>Noradrenaline</td>
<td>$\beta_3$</td>
<td>Detrusor muscle contraction</td>
</tr>
</tbody>
</table>
**MULTIPLE CHOICE QUESTIONS**

Answer the following multiple choice questions by circling the letter or letters that correspond to the correct answer(s).

1. A healthy glomerular membrane allows the passage of: *(Select all that apply)*
   - a Creatinine
   - b Haemoglobin
   - c Glucose
   - d Urea
   - e Albumin
   - f Myoglobin

2. The kidneys synthesise: *(Select all that apply)*
   - a Renin
   - b Vitamin D
   - c Erythropoietin
   - d Haemoglobin
   - e Prostaglandins
   - f Creatinine

3. Creatinine clearance is a measure of: *(Select all that apply)*
   - a Renal blood flow
   - b Glomerular hydrostatic pressure
   - c Tubular transport
   - d Glomerular filtration
   - e Tubular secretion of creatinine
   - f Renal function

4. Diuretics are commonly used in the treatment of: *(Select all that apply)*
   - a Hypotension
   - b Oedema
   - c Gout
   - d Hepatic cirrhosis
   - e Prostatic obstruction
   - f Heart failure

5. Frusemide acts in the: *(Select all that apply)*
   - a Proximal tubule
   - b Thin descending limb of the loop of Henle
   - c Thick ascending limb of the loop of Henle
   - d Distal convoluted tubule
   - e Cortical collecting duct
   - f Medullary collecting duct

6. Frusemide inhibits the: *(Select all that apply)*
   - a Organic anion transporter OAT3
   - b Na⁺–Cl⁻ symporter
   - c Epithelial sodium channel ENaC
   - d Cation transporter OCT2
   - e Na⁺–K⁺–2Cl⁻ co-transporter
   - f Sodium bicarbonate co-transporter

7. Which of the following electrolyte disturbances are caused by loop diuretics? *(Select all that apply)*
   - a Hyponatraemia
   - b Hypouricaemia
   - c Hypokalaemia
   - d Hypomagnesaemia
   - e Hypercalcaemia

8. With chronic administration thiazide diuretics promote excretion of: *(Select all that apply)*
   - a Chloride
   - b Calcium
   - c Magnesium
   - d Potassium
   - e Sodium
   - f Uric acid
CRITICAL THINKING SCENARIO

SCENARIO 1

Brian, a 67-year-old male, has a history of hypertension that has been treated for a number of years with the angiotensin converting enzyme (ACE) inhibitor enalapril. He has made several visits to the health centre over the past 6 months and on each occasion his blood pressure has been higher than expected. The prescriber decides to change his medication to a combination tablet of enalapril (20 mg) and hydrochlorothiazide (6 mg) once daily, and advises Brian that the combination drug contains a diuretic.

1. As an observing health professional you are asked to explain to the prescriber how hydrochlorothiazide promotes diuresis.

Brian asks you to explain to him any adverse effects he should be aware of.

2. Which of the common adverse effects of hydrochlorothiazide are most likely to be problematic for Brian?

Brian remains well for several months but on his latest visit he complains of pain and inflammation of his right big toe joint. He indicates that he is unable to sleep because of the pain.

3. What is the most likely explanation for his painful big toe?

4. Explain how hydrochlorothiazide may have contributed to Brian’s problem.

Brian tells the prescriber that because his toe was so painful he has taken for the last 5 days some of his wife’s prescribed non-steroidal anti-inflammatory drugs (NSAIDs). The prescriber takes Brian’s blood pressure, which is elevated, advises Brian that he should not have taken the NSAIDs and immediately orders some renal function tests.

5. Explain why the prescriber has ordered the renal function tests.

6. With regard to the NSAID Brian has taken, what is the explanation for his elevated blood pressure?