Companion website

Purchasing this book entitles you to access the companion website:
www.wiley.com/go/denyer/microbiology

The website includes:
• Figures from the book as Powerpoints for downloading
• Additional teaching and learning resources
Hugo and Russell's
Pharmaceutical Microbiology

EDITED BY

Stephen P. Denyer B Pharm PhD FRPharmS
Professor of Pharmacy and Deputy Pro Vice-Chancellor
Welsh School of Pharmacy
Cardiff University
Cardiff

Norman Hodges B Pharm PhD
Principal Lecturer
School of Pharmacy and Biomolecular Sciences
Brighton University
Lewes Road
Brighton

Sean P. Gorman CBE BSc PhD FPS
Dean, Faculty of Medicine, Health and Life Sciences
Professor of Pharmaceutical Microbiology
Queen’s University Belfast
Belfast

Brendan F. Gilmore BSc, PhD, MRSC, MPS
Senior Lecturer in Pharmaceutics
School of Pharmacy
Queen’s University Belfast
Medical Biology Centre
Belfast

EIGHTH EDITION

A John Wiley & Sons, Ltd., Publication
Contents

List of contributors vii
Preface to the eighth edition ix
Preface to the first edition x

Part 1 Biology of microorganisms 1
1 Introduction to pharmaceutical microbiology 3
   Norman Hodges
2 Fundamental features of microbiology 9
   Norman Hodges
3 Bacteria 24
   David Allison
4 Fungi 44
   Kevin Kavanagh and Judy Kelly
5 Viruses 59
   Jean-Yves Maillard
6 Protozoa 84
   Tim Paget

Part 2 Pathogens and host responses 107
7 Principles of microbial pathogenicity and epidemiology 109
   David Allison and Andrew McBain
8 Microbial biofilms: consequences for health 121
   Howard Ceri, Sean P. Gorman and Brendan F. Gilmore
9 Immunology 131
   Mark Gumbleton and Mathew W. Smith
10 Vaccination and immunization 151
    Andrew McBain and David Allison

Part 3 Prescribing therapeutics 167
11 Antibiotics and synthetic antimicrobial agents: their properties and uses 169
   Norman Hodges
12 Mechanisms of action of antibiotics and synthetic anti-infective agents
   Peter Lambert
   200
13 Bacterial resistance to antibiotics
   Anthony W. Smith
   217
14 Clinical uses of antimicrobial drugs
   Hayley Wickens and Roger Finch
   230
15 Antibiotic prescribing and antibiotic stewardship
   Norman Hodges
   248
16 Public health microbiology: infection prevention and control
   Brian I. Duerden
   257

Part 4  Contamination and infection control
17 Microbial spoilage, infection risk and contamination control
   Rosamund M. Baird
   271
18 Laboratory evaluation of antimicrobial agents
   Brendan F. Gilmore, Howard Ceri and Sean P. Gorman
   273
19 Chemical disinfectants, antiseptics and preservatives
   Sean P. Gorman and Brendan F. Gilmore
   293
20 Non-antibiotic antimicrobial agents: mode of action and resistance
   Stephen P. Denyer and Jean-Yves Maillard
   312
21 Sterilization procedures and sterility assurance
   Stephen P. Denyer, Norman Hodges and Catherine Talbot
   334

Part 5  Pharmaceutical production
22 Sterile pharmaceutical products
   James L. Ford and Robert W. Jones
   352
23 Principles of good manufacturing practice
   Robert W. Jones, Shaqil Chaudary, Touraj Ehtezazi and James L. Ford
   381
24 The manufacture and quality control of immunological products
   Michael Corbel and Dorothy Xing
   402
25 Recombinant DNA technology
   Miguel Cámara and Stephan Heeb
   416

Part 6  Current trends and new directions
26 The wider contribution of microbiology to the pharmaceutical sciences
   Matthew W. Smith, James C. Birchall and Sion A. Coulman
   435
27 Alternative strategies for antimicrobial therapy
   Geoff Hanlon
   461

Index
   483
List of contributors

Dr David Allison
Senior Lecturer
School of Pharmacy and Pharmaceutical Sciences
University of Manchester
Oxford Road
Manchester
UK

Dr Rosamund M. Baird
Visiting Senior Lecturer
School of Pharmacy and Pharmacology
University of Bath
Claverton Down
Bath
UK

Dr James C. Birchall
Reader in Pharmaceutics
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Professor Miguel Cámara
Professor of Molecular Microbiology
School of Molecular Medical Sciences
University of Nottingham
Nottingham
UK

Professor Howard Ceri
Chairman Biofilm Research Group and Professor of Biological Sciences
University of Calgary
Calgary
Alberta
Canada

Dr Shaqil Chaudary
Principal Lecturer
School of Pharmacy & Biomolecular Sciences
Liverpool John Moores University
Liverpool
UK

Dr Michael Corbel
Head of Division
Bacteriology Division
National Institute for Biological Standards and Control
South Mimms
Potters Bar
Hertfordshire
UK

Dr Sion A. Coulman
Lecturer in Pharmacy
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Professor Stephen P. Denyer
Professor of Pharmacy and Deputy Pro Vice-Chancellor
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Professor Brian I. Duerden
Inspector of Microbiology and Infection Control
Department of Health
England; Emeritus Professor of Medical Microbiology
Cardiff University
Cardiff
UK

Professor Roger Finch
Professor of Infectious Diseases
The Nottingham University Hospitals NHS Trust
City Hospital Campus
Nottingham
UK

Professor James L. Ford
Director
School of Pharmacy & Biomolecular Sciences
Liverpool John Moores University
Liverpool
UK

Dr Brendan F. Gilmore
Senior Lecturer in Pharmaceutics
School of Pharmacy
Queen's University Belfast
Belfast
UK

Professor Sean P. Gorman
Dean, Faculty of Medicine
Health & Life Sciences
Professor of Pharmaceutical Microbiology
Queen's University Belfast
Belfast
UK

Dr Mark Gumbleton
Reader
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Professor Geoff Hanlon
Professor of Pharmaceutical Microbiology
School of Pharmacy and Biomolecular Sciences
University of Brighton
Brighton
UK
Dr Stephan Heeb
Senior Research Fellow
School of Molecular Medical Sciences
University of Nottingham
Nottingham
UK

Dr Norman Hodges
Principal Lecturer in Pharmaceutical Microbiology
School of Pharmacy and Biomolecular Sciences
Brighton University
Brighton
UK

Dr Robert W. Jones
Senior Lecturer
School of Pharmacy & Biomolecular Sciences
Liverpool John Moores University
Liverpool
UK

Dr Kevin Kavanagh
Head of Laboratory
Medical Mycology Unit
Department of Biology
National University of Ireland Maynooth
Co. Kildare
Ireland

Dr Judy Kelly
Research Fellow
Department of Biology
National University of Ireland Maynooth
Co. Kildare
Ireland

Professor Peter Lambert
Professor of Microbiology
School of Life and Health Sciences
Aston University
Birmingham
UK

Dr Jean-Yves Maillard
Reader in Pharmaceutical Microbiology
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Dr Andrew McBain
Senior Lecturer in Microbiology
School of Pharmacy and Pharmaceutical Sciences
University of Manchester
Manchester
UK

Professor Tim Paget
Professor of Chemistry and Chair
Lehman College-CUNY
Bronx, NY, USA

Dr Anthony W. Smith
Dean
The School of Pharmacy
University of London
London
UK

Dr Mathew W. Smith
Lecturer
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Mrs Catherine Talbot
Education Development Officer, Education and Students
Welsh School of Pharmacy
Cardiff University
Cardiff
UK

Dr Hayley Wickens
Senior Lead Pharmacist, Antibiotic Audit and Research
Imperial College Healthcare NHS Trust
Pharmacy Department
St Mary’s Hospital
London
UK

Dr Dorothy Xing
Principal Scientist
Bacteriology Division
National Institute for Biological Standards and Control
South Mimms
Potters Bar
Hertfordshire
UK
Preface to the eighth edition

We have been enthusiastic participants in the preparation of this 8th edition of Pharmaceutical Microbiology, a textbook which has again grown in size, reflecting advances in knowledge and the sustained relevance of microbiology in pharmacy. We have continued to develop the theme of recent editions, strengthening the connection between the basic sciences and clinical practice with an increased emphasis on pathogens and the host response, prescribing therapeutics and public health microbiology.

Once again, the editors must pay tribute to the willing efforts of our contributors, some of whom join us for the first time. So too must we thank our publishers for their support and expertise.

A book that outlasts its original editors is a tribute to their far-sightedness. It is with great sadness but much respect that the editors record the passing of Denver Russell in 2004. This edition is dedicated to him.

S.P. Denyer
B. Gilmore
S.P. Gorman
N.A. Hodges
When we were first approached by the publishers to write a textbook on pharmaceutical microbiology to appear in the spring of 1977, it was felt that such a task could not be accomplished satisfactorily in the time available.

However, by a process of combined editorship and by invitation to experts to contribute to the various chapters this task has been accomplished thanks to the cooperation of our collaborators.

Pharmaceutical microbiology may be defined as that part of microbiology which has a special bearing on pharmacy in all its aspects. This will range from the manufacture and quality control of pharmaceutical products to an understanding of the mode of action of antibiotics. The full extent of microbiology on the pharmaceutical area may be judged from the chapter contents.

As this book is aimed at undergraduate pharmacy students (as well as microbiologists entering the pharmaceutical industry) we were under constraint to limit the length of the book to retain it in a defined price range. The result is to be found in the following pages. The editors must bear responsibility for any omissions, a point which has most concerned us. Length and depth of treatment were determined by the dictate of our publishers. It is hoped that the book will provide a concise reading for pharmacy students (who, at the moment, lack a textbook in this subject) and help to highlight those parts of a general microbiological training which impinge on the pharmaceutical industry.

In conclusion, the editors thank most sincerely the contributors to this book, both for complying with our strictures as to the length of their contribution and for providing their material on time, and our publishers for their friendly courtesy and efficiency during the production of this book. We also wish to thank Dr H.J. Smith for his advice on various chemical aspects, Dr M.I. Barnett for useful comments on reverse osmosis, and Mr A. Keall who helped with the table on sterilization methods.

W.B. Hugo
A.D. Russell
Part 1  Biology of microorganisms
Introduction to pharmaceutical microbiology

Norman Hodges
Brighton University, Brighton, UK

1 Microorganisms and medicines

The opening paragraph of the previous edition of this book published in 2004 stated that ‘despite continuing poverty in many parts of the world and the devastating effects of HIV and AIDS, the health of the world’s population is progressively improving’. That trend has been sustained in recent years with the number of AIDS deaths reaching a peak in 2006 and the number of new HIV infections falling 16% between 2000 and 2008. During that same period life expectancy rose in 157 out of the 193 countries reporting data to the World Health Organization and declined in only 9. Much of this improvement is due to better nutrition and sanitation, but improved health care and the greater availability of effective medicines with which to treat common human and animal diseases are also major contributing factors. Substantial inroads have been made in both the prevention and treatment of cancer, cardiovascular disease and other major causes of death in Western society, and of infections and diarrhoeal disease that remain the big killers in developing countries. Several infectious diseases have been eradicated completely, and others from substantial parts of the world. The global eradication of smallpox in 1977 is well documented, and in 2011 rinderpest, the high-mortality cattle disease which, for centuries, has contributed to poverty and famine in Africa and Asia, will also formally be declared extinct; polio and Guinea-worm infection are expected to follow in the next few years.

The development of the many vaccines and other medicines that have been so crucial to the improvement in world health has been the result of the large investment in research by the major international pharmaceutical companies. This has led to the manufacture of pharmaceuticals becoming one of the most consistently successful and important industries in many countries, not only in the traditional strongholds of North America, Western Europe and Japan but, increasingly, in Eastern Europe, the Indian subcontinent and the Far East. Worldwide sales of medicines and medical devices are estimated to have exceeded $711 billion in 2007 (the latest year for which statistics are available), and in the UK pharmaceuticals was the industry sector with the largest trade surplus in 2007 having exports of £14.6 billion—a figure that translates into more than £235,000 for each employee in the industry. The growth of the pharmaceutical industry in recent decades has been paralleled by rising standards for product quality and more rigorous regulation of manufacturing procedures. In order to receive a manufacturing licence, a modern medicine must be shown to be effective, safe and of good quality. Most medicines