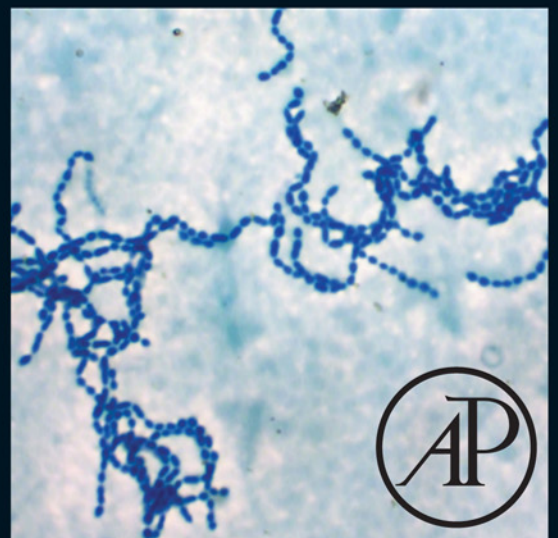


# NANOTECHNOLOGY IN DIAGNOSIS, TREATMENT AND PROPHYLAXIS OF INFECTIOUS DISEASES

Edited by Mahendra Rai and Kateryna Kon



NANOTECHNOLOGY IN DIAGNOSIS,  
TREATMENT AND PROPHYLAXIS OF  
INFECTIOUS DISEASES

---

This page intentionally left blank

# NANOTECHNOLOGY IN DIAGNOSIS, TREATMENT AND PROPHYLAXIS OF INFECTIOUS DISEASES

---

*Edited by*

**MAHENDRA RAI**

*Biotechnology Department, SGB Amravati University, Amravati,  
Maharashtra, India*

**KATERYNA KON**

*Department of Microbiology, Virology and Immunology, Kharkiv National Medical University,  
Kharkiv, Ukraine*



AMSTERDAM • BOSTON • HEIDELBERG • LONDON  
NEWYORK • OXFORD • PARIS • SAN DIEGO  
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Academic Press is an imprint of Elsevier



Academic Press is an imprint of Elsevier  
32 Jamestown Road, London NW1 7BY, UK  
525 B Street, Suite 1800, San Diego, CA 92101-4495, USA  
225 Wyman Street, Waltham, MA 02451, USA  
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK

Copyright © 2015 Elsevier Inc. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: [www.elsevier.com/permissions](http://www.elsevier.com/permissions).

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

### Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

ISBN: 978-0-12-801317-5

### British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

### Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress.

For Information on all Academic Press publications  
visit our website at <http://store.elsevier.com/>

Typeset by MPS Limited, Chennai, India  
[www.adi-mps.com](http://www.adi-mps.com)

Printed and bound in the United States



Working together  
to grow libraries in  
developing countries

[www.elsevier.com](http://www.elsevier.com) • [www.bookaid.org](http://www.bookaid.org)

# Contents

---

List of Contributors ix

Preface xiii

## 1. Gold and Silver Nanoparticles for Diagnostics of Infection

PEDRO PEDROSA AND PEDRO V. BAPTISTA

- 1.1 Nanotechnology and Infection 1
- 1.2 Gold and Silver NPs for Molecular Diagnostics 2
- 1.3 Nanodiagnostics for Nucleic Acids 4
- 1.4 Aptamers and Antibodies 10
- 1.5 iPCR and Other Methods 12
- 1.6 Conclusion 13
- Acknowledgments 13
- References 13

## 2. Antimicrobial Models in Nanotechnology: From the Selection to Application in the Control and Treatment of Infectious Diseases

JUAN BUENO

- 2.1 Introduction 19
- 2.2 Antimicrobial Susceptibility Testing Methods of NMs 22
- 2.3 Nanotoxicology 28
- 2.4 *In Vitro* Pharmacokinetics/Pharmacodynamic Models 30
- 2.5 Conclusions 32
- Acknowledgment 33
- References 33

## 3. Silver Nanoparticles for the Control of Vector-Borne Infections

KATERYNA KON AND MAHENDRA RAI

- 3.1 Introduction 39
- 3.2 Louse-Borne Infections and Activity of AgNPs Against Lice 40

- 3.3 Mosquito-Borne Infections and Activity of AgNPs Against Mosquitoes 44
- 3.4 Tick-Borne Infections and Activity of AgNPs Against Ticks 45
- 3.5 Flies, Their Role in Transmission and Spread of Infections, and Activity of AgNPs Against Flies 45
- 3.6 Conclusions and Future Prospects 46
- References 46

## 4. Magnetite Nanostructures: Trends in Anti-Infectious Therapy

ALINA MARIA HOLBAN, ALEXANDRU MIHAI GRUMEZESCU AND FLORIN IORDACHE

- 4.1 Introduction 51
- 4.2 Nanoparticles with Biomedical Applications 52
- 4.3 Conclusions 63
- Acknowledgments 64
- References 64

## 5. Photodynamic Therapy of Infectious Disease Mediated by Functionalized Fullerenes

ZEYD ISSA AND MICHAEL R HAMBLIN

- 5.1 Introduction 69
- 5.2 Antibiotic Resistance and the Need for PDT 70
- 5.3 PDT Mechanism of Action 71
- 5.4 Applications 72
- 5.5 The Ideal PS 75
- 5.6 PDT Using Fullerenes 79
- 5.7 *In Vitro* Studies 80
- 5.8 *In Vivo* Studies 83
- 5.9 Conclusions 83
- Acknowledgments 84
- References 84

## 6. Nonconventional Routes to Silver Nanoantimicrobials: Technological Issues, Bioactivity, and Applications

MAURO POLLINI, FEDERICA PALADINI, ALESSANDRO SANNINO, ROSARIA ANNA PICCA, MARIA CHIARA SPORTELLI, NICOLA CIOFFI, MARIA ANGELA NITTI, MARCO VALENTINI AND ANTONIO VALENTINI

- 6.1 Introduction 87
- 6.2 Ion Beam Sputtering Deposition of AgNP-Based Coatings 88
- 6.3 Photo-Assisted Deposition of AgNP-Based Coatings 90
- 6.4 Electrochemical Methods for Nanomaterial Synthesis 91
- 6.5 Overview of the Most Widely Accepted Bioactivity Mechanisms 94
- 6.6 Overview of the Most Promising Applications 96
- 6.7 Conclusions and Future Perspectives 98
- References 98

## 7. Application of Nanomaterials in Prevention of Bone and Joint Infections

NUSRET KOSE AND AYDAN AYSE KOSE

- 7.1 Introduction 107
- 7.2 Orthopedic Implants and Infections 107
- 7.3 Local Delivery of Antimicrobials 109
- 7.4 Antimicrobial Implant Coatings 110
- 7.5 Implant Coating with Nano-Silver 110
- 7.6 Conclusion and Future Perspectives 114
- Acknowledgments 115
- References 115

## 8. The Potential of Metal Nanoparticles for Inhibition of Bacterial Biofilms

KRYSZYNA I. WOLSKA, ANNA M. GRUDNIAK, KONRAD KAMIŃSKI AND KATARZYNA MARKOWSKA

- 8.1 Introduction 119
- 8.2 Diseases Caused by Bacterial Biofilms 120
- 8.3 Biofilm Resistance to Conventional Antibiotics and New Alternative Strategies to Combat Bacterial Biofilms 123
- 8.4 Antibiofilm Activity of Metal NPs 125
- 8.5 Conclusions 128
- References 128

## 9. Tackling the Problem of Tuberculosis by Nanotechnology: Disease Diagnosis and Drug Delivery

MAHENDRA RAI, AVINASH P. INGLE, SUNITA BANSOD AND KATERYNA KON

- 9.1 Introduction 133
- 9.2 The Present Scenario of Antibiotics Used Against TB 135
- 9.3 Nanotechnology as a Novel Approach in Drug Discovery 137
- 9.4 Nano-Based DNA Vaccines for TB 141
- 9.5 Role of Nanobiosensors in Diagnostics of TB 143
- 9.6 Conclusion and Future Perspectives 145
- References 145

## 10. Influence of Physicochemical Properties of Nanomaterials on Their Antibacterial Applications

HEMANT KUMAR DAIMA AND VIPUL BANSAL

- 10.1 Introduction 151
- 10.2 Physicochemical Properties of Nanomaterials and Their Influence on Antibacterial Performance 153
- 10.3 Conclusions 163
- References 164

## 11. Nanocarriers Against Bacterial Biofilms: Current Status and Future Perspectives

NOHA NAFEE

- 11.1 Introduction 167
- 11.2 Biofilms—Health and Economic Burdens 168
- 11.3 Biofilms—Definition, Composition, and Development 169
- 11.4 Challenges in Antimicrobial Treatment of Biofilms 171
- 11.5 Current Approaches for Efficient Anti-Infective Therapy 173
- 11.6 Biofilm Targeting 181
- 11.7 Experimental Evaluation of Nanocarrier–Biofilm Interaction 181
- 11.8 Pharmaceutical Application of Nanoantimicrobials 182



- 11.9 Clinical Studies and Marketed Products 184  
 11.10 Conclusion and Future Perspectives 184  
 References 185

## 12. Nanomaterials for Antibacterial Textiles

NABIL A. IBRAHIM

- 12.1 Introduction 191  
 12.2 Textile Fibers 192  
 12.3 Preparatory Processes 194  
 12.4 Coloration Processes 194  
 12.5 Environmental Concerns 195  
 12.6 Antibacterial Function Finish 195  
 12.7 Antibacterial Textiles Using Nanomaterials 197  
 12.8 Potential Implications 209  
 12.9 Evaluation of Antibacterial Efficacy 210  
 12.10 Future Scope 210  
 Acknowledgment 210  
 References 210

## 13. Complexes of Metal-Based Nanoparticles with Chitosan Suppressing the Risk of *Staphylococcus aureus* and *Escherichia coli* Infections

DAGMAR CHUDOBOVA, KRISTYNA CIHALOVA, PAVEL KOPEL, LUKAS MELICHAR, BRANISLAV RUTTKAY-NEDECKY, MARKETA VACULOVICOVA, VOJTECH ADAM AND RENE KIZEK

- 13.1 Introduction 217  
 13.2 Synthesis of Metal Nanoparticles, Characterization, and Modification 218  
 13.3 Interaction of Metal Nanoparticles with Cell Components Affecting Cellular Processes 220  
 13.4 Biochemical Mechanism of Toxicity to Prokaryotic Cells 221  
 13.5 Oxidative Stress and Formation of ROS by Metal Nanoparticles 222  
 13.6 Antibacterial Effect of Metal Nanoparticles in Complex with Chitosan 224  
 13.7 Effect of Metal Nanoparticles in Specific Examples 225  
 13.8 Conclusion 228  
 Acknowledgment 228  
 References 228

## 14. Nanotechnology—Is There Any Hope for Treatment of HIV Infections or Is It Simply Impossible?

RANJITA SHEGOKAR

- 14.1 Introduction 233  
 14.2 Current Antiretroviral Chemotherapy 235  
 14.3 Nanotechnology in HIV Chemotherapy—Why? 238  
 14.4 Nanoparticle Research 239  
 14.5 Industry Approach and Commercialization Success 245  
 14.6 Conclusion and Perspectives 246  
 References 247

## 15. Nanotherapeutic Approach to Targeting HIV-1 in the CNS: Role of Tight Junction Permeability and Blood–Brain Barrier Integrity

SUPRIYA D. MAHAJAN, RAVIKUMAR AALINKEEL, JESSICA L. REYNOLDS, BINDUKUMAR B. NAIR, MANOJ J. MAMMEN, LILI DAI, PARAS N. PRASAD AND STANLEY A. SCHWARTZ

- 15.1 Introduction 251  
 15.2 HIV-1 Reservoir in the Brain 253  
 15.3 Characteristics of Nanoparticles That Enhance Their Applicability to Biomedical Application 253  
 15.4 Nanotechnology-Based HIV Therapeutics 257  
 15.5 The Blood–Brain Barrier 258  
 15.6 *In Vitro* Model of the Human BBB 258  
 15.7 Role of TJ Protein in BBB Preservation 259  
 15.8 Key TJ Proteins—JAM-2, ZO-1, Claudin-5, and Occludin 260  
 15.9 Mechanisms of TJ Modulation 260  
 15.10 Effect of Nanoparticles on TJ Proteins in BMVEC Cultures 261  
 15.11 Conclusion 263  
 References 264

## 16. A Novel Fungicidal Action of Silver Nanoparticles: Apoptosis Induction

WON YOUNG LEE AND DONG GUN LEE

- 16.1 Introduction 269  
 16.2 ROS Accumulation 270  
 16.3 Phosphatidyl Serine Exposure 272



- 16.4 Mitochondrial Dysfunction 272  
16.5 Caspase Activation 274  
16.6 DNA Fragmentation and Chromosome  
Condensation 275  
16.7 Cell-Cycle Arrest 276  
16.8 Synergistic Effect of Silver Nanoparticles 276  
16.9 Conclusion and Future Prospects 279  
References 279
- 17. Silver Nanoparticles to Fight *Candida*  
Coinfection in the Oral Cavity**  
DOUGLAS ROBERTO MONTEIRO, SÓNIA SILVA, MELYS  
SA NEGRI, LUIZ FERNANDO GORUP, EMERSON RODRIGUES DE  
CAMARGO, DEBORA BARROS BARBOSA AND  
MARIANA HENRIQUES
- 17.1 Introduction 283  
17.2 Silver Nanoparticles Against *Candida*  
Biofilms 285
- 17.3 Conclusions and Future Perspectives 293  
References 293
- 18. Nanomedical Therapeutic  
and Prophylaxis Strategies  
Against Intracellular Protozoa in the  
Americas**  
MARIA JOSE MORILLA AND EDER LILIA ROMERO
- 18.1 Introduction 297  
18.2 Leishmaniasis 299  
18.3 Chagas Disease 310  
18.4 Conclusions 313  
References 314
- Index 319**

# List of Contributors

---

- Ravikumar Aalinkeel** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Vojtech Adam** Central European Institute of Technology, Brno University of Technology, Technicka, Brno, Czech Republic, European Union; Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Vipul Bansal** Ian Potter NanoBioSensing Facility and NanoBiotechnology Research Laboratory (NBRL), School of Applied Sciences, RMIT University, Melbourne, Australia
- Sunita Bansod** Nanobiotechnology Laboratory, Department of Biotechnology, Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
- Pedro V. Baptista** CIGMH, Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, Faculdade de Ciências e Tecnologia Caparica, Portugal
- Debora Barros Barbosa** Department of Dental Materials and Prosthodontics, Araçatuba Dental School, Univ Estadual Paulista (UNESP), São Paulo, Brazil
- Juan Bueno** Bioprospecting Development and Consulting, Bogotá, Colombia
- Dagmar Chudobova** Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Kristyna Cihalova** Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Nicola Cioffi** Department of Chemistry, University of Bari “Aldo Moro,” Bari, Italy
- Lili Dai** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Hemant Kumar Daima** Department of Biotechnology, Siddaganga Institute of Technology, Tumkur, Karnataka, India
- Emerson Rodrigues de Camargo** Department of Chemistry, Federal University of São Carlos (UFSCar), São Paulo, Brazil
- Luiz Fernando Gorup** Department of Chemistry, Federal University of São Carlos (UFSCar), São Paulo, Brazil
- Anna M. Grudniak** Department of Bacterial Genetics, Institute of Microbiology, Faculty of Biology, University of Warsaw, Warsaw, Poland
- Alexandru Mihai Grumezescu** AMG Transcend, Bucharest, Romania; Department of Science and Engineering of Oxide Materials and Nanomaterials, Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, Bucharest, Romania
- Michael R Hamblin** Department of Dermatology, Harvard Medical School, Boston, MA, USA; Wellman Center for Photomedicine, Massachusetts General Hospital, Boston, MA, USA; Harvard-MIT Division of Health Sciences and Technology, Cambridge, MA, USA
- Mariana Henriques** CEB—Center of Biological Engineering, LIBRO—Laboratório de Investigação em Biofilmes, Rosário Oliveira, University of Minho, Braga, Portugal

- Alina Maria Holban** AMG Transcend, Bucharest, Romania; Microbiology Immunology Department, Faculty of Biology, University of Bucharest, Bucharest, Romania; Department of Science and Engineering of Oxide Materials and Nanomaterials, Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, Bucharest, Romania
- Nabil A. Ibrahim** Textile Research Division, National Research Centre, Giza, Egypt
- Avinash P. Ingle** Nanobiotechnology Laboratory, Department of Biotechnology, Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
- Florin Iordache** Institute of Cellular Biology and Pathology of Romanian Academy, "Nicolae Simionescu," Department of Fetal and Adult Stem Cell Therapy, Bucharest, Romania
- Zeyd Issa** University of Exeter Medical School, Exeter, Devon, UK; Wellman Center for Photomedicine, Massachusetts General Hospital, Boston, MA, USA
- Konrad Kamiński** Department of Bacterial Genetics, Institute of Microbiology, Faculty of Biology, University of Warsaw, Warsaw, Poland
- Rene Kizek** Central European Institute of Technology, Brno University of Technology, Technicka, Brno, Czech Republic, European Union; Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Kateryna Kon** Department of Microbiology, Virology and Immunology, Kharkiv National Medical University, Kharkiv, Ukraine
- Pavel Kopel** Central European Institute of Technology, Brno University of Technology, Technicka, Brno, Czech Republic, European Union; Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Aydan Ayse Kose** Department of Plastic and Reconstructive Surgery, Eskisehir Osmangazi University, Eskisehir, Turkey
- Nusret Kose** Department of Orthopedics and Traumatology, Eskisehir Osmangazi University, Eskisehir, Turkey
- Dong Gun Lee** School of Life Sciences and Biotechnology, College of Natural Sciences, Kyungpook National University, Daegu, Republic of Korea
- Won Young Lee** School of Life Sciences and Biotechnology, College of Natural Sciences, Kyungpook National University, Daegu, Republic of Korea
- Supriya D. Mahajan** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Manoj J. Mammen** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Katarzyna Markowska** Department of Bacterial Genetics, Institute of Microbiology, Faculty of Biology, University of Warsaw, Warsaw, Poland
- Lukas Melichar** Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Douglas Roberto Monteiro** Department of Pediatric Dentistry and Public Health, Araçatuba Dental School, Univ Estadual Paulista (UNESP), São Paulo, Brazil
- Maria Jose Morilla** Programa de Nanomedicinas, Departamento de Ciencia y Tecnología, Universidad Nacional de Quilmes, Buenos Aires, Argentina
- Bindukumar B. Nair** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Melyssa Negri** Faculdade INGÁ, Maringá, Paraná, Brazil

- Maria Angela Nitti** Department of Physics “M. Merlin”, University of Bari “Aldo Moro,” Bari, Italy
- Noha Nafee** Department of Pharmaceutics and Biopharmacy, Philipps University, Marburg, Germany; Department of Pharmaceutics, Faculty of Pharmacy, Alexandria University, Alexandria, Egypt
- Federica Paladini** Department of Engineering for Innovation, University of Salento, Lecce, Italy
- Pedro Pedrosa** CIGMH, Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, Faculdade de Ciências e Tecnologia Caparica, Portugal
- Rosaria Anna Picca** Department of Chemistry, University of Bari “Aldo Moro,” Bari, Italy
- Mauro Pollini** Department of Engineering for Innovation, University of Salento, Lecce, Italy
- Paras N. Prasad** Institute for Laser, Photonics and Biophotonics, State University of New York at Buffalo, Buffalo, NY, USA
- Mahendra Rai** Nanobiotechnology Laboratory, Department of Biotechnology, Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
- Jessica L. Reynolds** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Eder Lilia Romero** Programa de Nanomedicinas, Departamento de Ciencia y Tecnología, Universidad Nacional de Quilmes, Buenos Aires, Argentina
- Branislav Ruttkay-Nedecky** Central European Institute of Technology, Brno University of Technology, Technicka, Brno, Czech Republic, European Union; Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Alessandro Sannino** Department of Engineering for Innovation, University of Salento, Lecce, Italy
- Stanley A. Schwartz** Department of Medicine, Division of Allergy, Immunology, and Rheumatology, State University of New York at Buffalo, Clinical Translational Research Center, Buffalo, NY, USA
- Ranjita Shegokar** Freie Universität Berlin, Institute of Pharmacy Department of Pharmaceutics, Biopharmaceutics & NutriCosmetics, Kelchstraße, Berlin, Germany
- Sónia Silva** CEB—Center of Biological Engineering, LIBRO—Laboratório de Investigação em Biofilmes, Rosário Oliveira, University of Minho, Braga, Portugal
- Maria Chiara Sportelli** Department of Chemistry, University of Bari “Aldo Moro,” Bari, Italy
- Marketa Vaculovicova** Central European Institute of Technology, Brno University of Technology, Technicka, Brno, Czech Republic, European Union; Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Zemedelska, Brno, Czech Republic, European Union
- Antonio Valentini** Department of Physics “M. Merlin”, University of Bari “Aldo Moro,” Bari, Italy
- Marco Valentini** Department of Physics “M. Merlin”, University of Bari “Aldo Moro,” Bari, Italy
- Krystyna I. Wolska** Department of Bacterial Genetics, Institute of Microbiology, Faculty of Biology, University of Warsaw, Warsaw, Poland

This page intentionally left blank

# Preface

---

Resistance to antimicrobial agents has been reaching high levels among all types of microorganisms. Bacteria constantly demonstrate growing rates of resistance to classical and newly introduced antibiotics, fungi increase rates of resistance to antimycotics, viruses increase rates of resistance to antiviral agents, and even insect vectors carrying microorganisms have been acquiring the ability to develop resistance to the most common insecticidal agents. Because of this, the efforts of scientists all over the world are being directed to the search for new and effective methods to cope with drug resistance. One promising approach is the application of nanotechnology in the battle against microorganisms.

Nanotechnology is being applied not only to the treatment of infectious diseases but also to diagnostics of infections and to prophylaxis by

reducing the number of insecticidal vectors spreading microorganisms. This book discusses the potential of nanotechnology for fighting all common types of infective agents (bacteria, viruses, fungi, protozoa) and their vectors (ticks, mosquitoes, flies, etc.), as well as recent advances in diagnostics of infectious diseases and nanotechnology techniques.

Potential readers include researchers in applied microbiology, biotechnology, pharmacology, nanotechnology, and infection control, students of medical and biological faculties, and clinicians dealing with infectious diseases.

The editors thank Elizabeth Gibson, Editorial Project Manager, Academic Press/Elsevier S&T Books, Waltham, MA, USA, for her constant help and valuable suggestions, and the contributors for devoting their time to this book.

This page intentionally left blank