Contents

Preface XIII

	List of Contributors XV
1	Molecular Mechanisms of Antibiotic Resistance: The Need for Novel Antimicrobial Therapies 1
1.1	John W. Dale-Skinner and Boyan B. Bonev
1.1	Introduction 2
	Molecular Mechanisms of Resistance 4
1.3	β-Lactams 6
1.4	Glycopeptides 15
1.5	Lantibiotics 19
1.6	Aminoglycosides 20
1.7	Macrolides 27
1.8	Tetracyclines 32
1.9	Fluoroquinolones 37
1.10	Conclusions 40
	References 41
2	Novel Approaches to Combat Drug-Resistant Bacteria 47
	Iqbal Ahmad, Maryam Zahin, Farrukh Aqil, Mohd Sajjad Ahmad Khan
	and Shamim Ahmad
2.1	Introduction 47
2.2	Approaches to Antibacterial Drug Discovery and Combating
	the Problem of Drug Resistance 49
2.2.1	Search for New Antibiotics from Microbial Sources 50
2.2.1.1	Conventional Culturing Methods 51
2.2.1.2	Novel Culturing Environments 51
2.2.1.3	Heterologous DNA-Based Approaches 52
2.2.1.4	Metagenomics and Molecular Engineering 52
2.2.2	Role of Genomics in New Antibacterial Drug Discovery 53
2.2.3	Antimicrobial Peptides as New Anti-Infective Drugs 54
2.3	Combination Drug Therapy 55

New Strategies Combating Bacterial Infection. Edited by Iqbal Ahmad and Farrukh Aqil Copyright © 2009 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim ISBN: 978-3-527-32206-0

2.4 Strategies to Target Mechanisms of Drug Resistance 56 2.4.1 Bacterial Efflux Systems and Efflux Pump Inhibition 56 2.5 Quorum Sensing Inhibition: A Novel Anti-Infective Drug Target 58 2.5.1 Anti-QS Compound Effects In Vitro 60 2.5.2 Efficacy of QS-Inhibitory Compounds in Animal Infection Models 63 2.6 Phage Therapy: An Alternative Therapy 63 2.7 Antibiotic Use Policy: Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinicius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.6 Pyrrole IL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Marine Natural Products 85 3.4.3.1 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujir Kumar Bhattacharya 4.1 Introduction 89	VI	Contents	
 2.4.1 Bacterial Efflux Systems and Efflux Pump Inhibition 56 2.5 Quorum Sensing Inhibition: A Novel Anti-Infective Drug Target 58 2.5.1 Anti-QS Compound Effects In Vitro 60 2.5.2 Efficacy of QS-Inhibitory Compounds in Animal Infection Models 63 2.6 Phage Therapy: An Alternative Therapy 63 2.7 Antibiotic Use Policy: Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinicius and Nora de Souza 3.1 Introduction 71 3.2 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Caprazamycin 83 3.4.2.1 Calanolide 83 3.4.2.1 Calanolide 83 3.4.2.1 Calanolide 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.6 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 	•	2.4	Strategies to Target Mechanisms of Drug Resistance 56
 Quorum Sensing Inhibition: A Novel Anti-Infective Drug Target 58 2.5.1 Anti-QS Compound Effects In Vitro 60 2.5.2 Efficacy of QS-Inhibitory Compounds in Animal Infection Models 63 Phage Therapy: An Alternative Therapy 63 2.7 Antibiotic Use Policy: Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinicius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89			
 2.5.1 Anti-QS Compound Effects In Vitro 60 2.5.2 Efficacy of QS-Inhibitory Compounds in Animal Infection Models 63 2.6 Phage Therapy. An Alternative Therapy 63 2.7 Antibiotic Use Policy. Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinicius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin 81 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 		2.5	
 2.5.2 Efficacy of QS-Inhibitory Compounds in Animal Infection Models 63 2.6 Phage Therapy: An Alternative Therapy 63 2.7 Antibiotic Use Policy: Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinicius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.4 Natural Products Against MDR-TB 81 3.4.1.1 Flungi 81 3.4.1.2 Pacidamycin 81 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.1.5 Calanolide 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			
 2.6 Phage Therapy. An Alternative Therapy 63 2.7 Antibiotic Use Policy. Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinícius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			, -
2.7 Antibiotic Use Policy. Practical Management of the Problem of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinícius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin 83 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
of Antibiotic Resistance 64 2.8 Conclusions 65 References 66 3 Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinícius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinícius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caparazmycin 83 3.4.1.5 Calanolide 83 3.4.2 Plants 83 3.4.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 Seferences 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya		,	·
Promising Current Drug Candidates in Clinical Trials and Natural Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinícius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya		2.8	Conclusions 65
Products Against Multidrug-Resistant Tuberculosis 71 Marcus Vinícius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			References 66
Marcus Vinicius and Nora de Souza 3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.1.4 Caprazamycin 83 3.4.2.1 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya		3	
3.1 Introduction 71 3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.1.4 Calanolide 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics - An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
3.2 Current MDR-TB Treatment 72 3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya		2 1	
3.3 Current Drugs in Development Against MDR-TB 73 3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.1 Calanolide 83 3.4.2.1 Calanolide 83 3.4.2.1 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
3.3.1 Fluoroquinolones (Gatifloxacin and Moxifloxacin) 75 3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
3.3.1.1 Fluoroquinolones against MDR-TB 75 3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
3.3.1.2 Gatifloxacin 76 3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			<u> </u>
3.3.1.3 Moxifloxacin 77 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
 3.3.2 PA-824 78 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			
 3.3.3 Diarylquinoline TMC207 79 3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			
3.3.4 Nitroimidazo-Oxazole OPC-67683 79 3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
3.3.5 SQ-109 80 3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			· -
3.3.6 Pyrrole LL-3858 80 3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
3.4 Natural Products Against MDR-TB 81 3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			·
3.4.1 Fungi 81 3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			·
3.4.1.1 Thiolactomycin 81 3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			· ·
3.4.1.2 Pacidamycin Family 82 3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			· ·
3.4.1.3 Capuramycin 83 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
 3.4.1.4 Caprazamycin 83 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			·
 3.4.2 Plants 83 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			• '
 3.4.2.1 Calanolide 83 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			- · · ·
 3.4.2.2 Diospyrin 84 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			
 3.4.3 Marine Natural Products 85 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			
 3.4.3.1 Aerothionin 85 3.5 Future Perspectives Against MDR-TB 85 References 86 4 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			1.
 Future Perspectives Against MDR-TB 85 References 86 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya 			
References 86 Non-antibiotics – An Alternative for Microbial Resistance: Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya			
Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra, and Sujit Kumar Bhattacharya		3.5	
· · · · · · · · · · · · · · · · · · ·		4	Scope and Hope 89 Debprasad Chattopadhyay, Soumen Kumar Das, Arup Ranjan Patra,
		4.1	•

4.2	Historical Development: Non-antibiotics with Antimicrobial Potential 90
4.3	Psychotherapeutics as Non-antibiotics 92
4.4	Sedatives and Tranquilizers as Non-antibiotics 100
4.5	Antihistaminics as Non-antibiotics 101
4.6	In vitro and In vivo Antimicrobial Potential of Non-antibiotics 101
4.6.1	Antiviral Activity of Non-antibiotics 103
4.6.2	Antibacterial Activity of Non-antibiotics 104
4.6.3	Activity Against Diarrheagenic Bacteria 106
4.6.4	Activity Against Mycobacteria 107
4.6.5	Activity Against Protozoa 109
4.7	Single and Combined Activity Against Bacteria 109
4.8	Synergism and 'Reversal of Resistance': A Special Synergy 111
4.8.1	Clinical Synergism 113
4.8.2	Reversal of Resistance 113
4.9	Mechanism of Action of Non-antibiotics 115
4.10	Conclusions 117
	References 118
5	Use of Natural Products to Combat Multidrug-Resistant Bacteria 127
	Christine M. Slover, Larry H. Danziger, Bolanle A. Adeniyi,
	and Gail B. Mahady
5.1	Introduction 127
5.1.1	Penicillin-Resistant Microorganisms 128
5.1.2	Multidrug-Resistant Microorganisms 128
5.2	Natural Product Development 129
5.2.1	Natural Products as Medicines 129
5.2.2	Use of Natural Medicines Worldwide 130
5.2.3	Natural Products as Antimicrobial Agents 130
5.3	MRSA 131
5.3.1	Natural Products for MRSA: In Vitro Data 131
5.3.2	Natural Products for MRSA: Clinical Data 132
5.4	Natural Products for MDR Microorganisms 133
	References 134
6	West African Plants and Related Phytocompounds
	with Anti-Multidrug-Resistance Activity 137
	Koné Mamidou Witabouna and Kamanzi Atindehou Kagoyire
6.1	Introduction 138
6.2	MDR Bacteria in West Africa 139
6.2.1	Staphylococci 139
6.2.2	Enterobacteria 139
6.2.3	Pneumococci (S. pneumoniae) 140
6.2.4	Pseudomonas 140
6.2.5	Mycobacteria 140

١	Contents	
	6.3	Plants Used in Bacterial Disease Treatment in West Africa 140
	6.4	West African Medicinal Plants with Activity against MDR Bacteria 146
	6.5	Metabolites Isolated from West African Medicinal Plants Effective on
		MDR Bacteria 149
	6.5.1	B. madagascariensis (Caesalpiniaceae) syn: Swartzia
		madagascariensis 150
	6.5.2	E. senegalensis and E. vogelii (Fabaceae) 151
	6.5.3	Erythrophleum ivorense (Caesalpiniaceae) 151
	6.5.4	Garcinia kola (Clusiaceae) 151
	6.5.5	Harungana madagascariensis (Hypericaceae) 153
	6.5.6	O. gratissimum and Ocimun canum (Lamiaceae) 154
	6.5.7	M. balsamina (Cucurbitaceae) 157
	6.5.8	M. lucida (Rubiaceae) 158
	6.5.9	P. umbellata (Piperaceae) 158
	6.5.10	S. mombin (Anacardiaceae) 158
	6.5.11	Other Plant Species 158
	6.6	Conclusions 160
	0.0	References 161
		NOTE OF THE PARTY
	7	Essential Oils and New Antimicrobial Strategies 165
		Sabulal Baby and Varughese George
	7.1	Introduction: Essential Oils 165
	7.2	Biosynthetic Origin 167
	7.3	Extraction of Essential Oils 168
	7.3.1	Steam Distillation 168
	7.3.2	Hydrodistillation 169
	7.3.3	Enfleurage Technique 169
	7.3.4	Supercritical Fluid Extraction 169
	7.3.5	Microwave Extraction 169
	7.3.6	Headspace Sampling Techniques 170
	7.4	Storage of Essential Oils 171
	7.5	Chemical Analysis of Essential Oils 171
	7.5.1	Chromatographic Techniques in Essential Oil Analysis 171
	7.5.1.1	TLC/HPTLC 172
	7.5.1.2	GLC 172
	7.5.1.3	GC-MS 173
	7.5.2	Spectroscopic Techniques 174
	7.6	Physical Parameters 175
	7.6.1	Specific Gravity 175
	7.6.2	Refractive Index 175
	7.6.3	Specific Rotation 176
	7.0.3	Olfactory Evaluation 177
	7.7	E 11.00
	7.8 7.9	
		Antimicrobial Activity: Mode of Action 178
	7.10	Antimicrobial Assays 190

7.10.1	Disc Diffusion Assay 190
7.10.2	Broth and Agar Dilution Methods: Determination of MIC 191
7.11	Other Applications of Essential Oils 194
7.12	Toxicity of Essential Oils 195
7.13	Scope for Future Research 195
	References 197
8	Application of Plant Extracts and Products in Veterinary Infections 205 Jacobus N. Eloff and Lindy J. McGaw
8.1	Introduction 206
8.2	Veterinary Infectious Diseases and their Significance 207
8.2.1	Protozoal Diseases 208
8.2.2	Viral Diseases 208
8.2.3	Rickettsial and Chlamydial Diseases 209
8.2.4	Bacterial and Fungal Diseases 209
8.2.5	Helminth Parasites 210
8.2.6	Ticks as Vectors of Infectious Diseases 210
8.3	Plants as Sources of Antimicrobial Compounds 211
8.3.1	Traditional Ethnoveterinary Medicine 211
8.3.2	Evaluation of Ethnoveterinary Plants for Efficacy Against
	Infectious Diseases 212
8.4	Antibiotic Resistance and the Impact of Antibiotic Feed Additives 217
8.5	Plants as Replacements for Antibiotic Feed Additives 219
8.6	Conclusions 222
	References 223
9	Honey: Antimicrobial Actions and Role in Disease Management 229
	Peter Molan
9.1	Introduction 230
9.1.1	History 230
9.2	Nature of the Antimicrobial Activity of Honey 231
9.2.1	High Osmolarity 231
9.2.2	Acidity 232
9.2.3	Hydrogen Peroxide 233
9.2.4	Additional Antibacterial Factors 236
9.2.5	Manuka Honey 236
9.3	Spectrum and Potency of the Antimicrobial Activity of Honey 238
9.4	Other Actions 243
9.5	Clinical Uses of Honey as an Antimicrobial Agent 244
9.6	Clinical Evidence for Effectiveness of Honey on Infected Wounds 245
9.7	Resistant Bacteria 247
9.8	Benefits Apart from Control of Infection in Topical Treatment
	with Honey 248
9.9	Future Directions 248
	References 249

10	Honey: Biological Characteristics and Potential Role in
	Disease Management 255
	Mohammed Shahid
10.1	Introduction 255
10.1.1	Nature of Honey 255
10.1.2	Medicinal History of Honey 256
10.2	Biological Characteristics of Honey 257
10.2.1	Ingredients of Honey 257
10.2.1.1	Enzymes in Honey 258
10.2.1.2	Antibiotics in Honey 259
10.3	Antibacterial Potential of Honey 260
10.3.1	Osmotic Effect of Honey 260
10.3.2	Acidity of Honey 260
10.3.3	Hydrogen Peroxide Effect of Honey 262
10.3.4	Activity Due to the Presence of Nonperoxide Compounds 262
10.4	Potential Use of Honey as an Antibacterial Agent 263
10.4.1	Use of Honey in Wound Management 263
10.4.2	Use of Honey in Peptic Ulcers 264
10.4.3	Use of Honey in Gastroenteritis 265
10.4.4	Use of Honey in Dermatophytoses 265
10.4.5	Role of Honey in Diabetes 266
10.4.6	Role of Honey in Diabetic Foot Ulcers 266
10.4.7	Role of Honey in Ophthalmology 267
10.4.8	Honey in the Treatment of Viral Diseases 267
10.4.9	Use of Honey in Mastitis in Dairy Animals 268
10.5	Use of Honey against Multidrug Resistance 268
10.6	Conclusions 269
	References 269
11	Probiotics: Benefits in Human Health and Bacterial
	Disease Management 275
	María Carmen Collado and Yolanda Sanz
11.1	Gut Microbiota 275
11.1.1	Functions of the Intestinal Microbiota 276
11.1.2	Development of the Gut Microbiota 278
11.1.3	Factors Influencing the Composition of the Gut Microbiota 278
11.2	Probiotics, Intestinal Microbiota and Host Health 280
11.2.1	Probiotic Concept and Selection Criteria 280
11.2.1.1	Strain and Specie Identification 281
11.2.1.2	Functional Characterization 281
11.2.1.3	Safety Considerations 283
11.2.1.4	Functional In Vitro and In Vivo Studies Using Animals
4404-	and Humans 283
11.2.1.5	Health Claims 284
11.2.2	Probiotic Benefits on Human Health 284

11.3	Studies on the Management and Prevention of Diseases 285	
11.3.1	Pathogen Infection 285	
11.3.1.1	H. pylori Infection 286	
11.3.1.2	Diarrhea in Children 286	
11.3.1.3	Antibiotic- and C. difficile-Associated Diarrhea 287	
11.3.2	Irritable Bowel Disease (IBD) and Irritable Bowel Syndrome (IBS)	287
11.3.3	Allergic Disease 288	
11.4	Clinical Prospects of Gut Microbiota Research 288	
	References 289	

Index 297