ANTISEPSIS,
DISINFECTION,
AND
STERILIZATION
ANTISEPSIS, DISINFECTION, AND STERILIZATION
TYPES, ACTION, AND RESISTANCE

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CONTENTS

Preface xix
About the Author xxii

Chapter 1 Introduction

1.1 General introduction 1
1.2 Definitions 2
1.3 General microbiology 6
    1.3.1 Introduction 6
    1.3.2 Eukaryotes & prokaryotes 6
    1.3.3 Eukaryotes 6
        1.3.3.1 Multicellular eukaryotes 6
        1.3.3.2 Fungi 8
        1.3.3.3 Algae 13
        1.3.3.4 Protozoa 13
    1.3.4 Prokaryotes 14
        1.3.4.1 Eubacteria 14
        1.3.4.2 Archaea 26
    1.3.5 Viruses 28
    1.3.6 Prions 33
    1.3.7 Toxins 34
1.4 General considerations 36
    1.4.1 Microbial resistance 36
    1.4.2 Evaluation of efficacy 38
        1.4.2.1 Suspension testing 38
        1.4.2.2 Surface testing 43
        1.4.2.3 In-use testing 45
1.4.2.4 Biological, chemical, and other indicators  46
1.4.2.5 Parametric control  49
1.4.2.6 Microscopy and other techniques  49
1.4.3 Disinfection versus sterilization  50
1.4.4 Choosing a process or product  52
1.4.5 Guidelines and standards  53
1.4.6 Formulation effects  53
1.4.7 Process effects  55
1.4.8 The importance of surface cleaning  57
1.4.9 Water quality  59

Chapter 2  Physical Disinfection
2.1 Introduction  61
2.2 Heat  61
  2.2.1 Types  61
  2.2.2 Applications  63
  2.2.3 Spectrum of activity  66
  2.2.4 Advantages  67
  2.2.5 Disadvantages  67
  2.2.6 Mode of action  68
2.3 Cold temperatures  68
2.4 Radiation  68
  2.4.1 Isotopes  68
  2.4.2 Electromagnetic radiation  69
  2.4.3 Types  71
    2.4.3.1 Ultraviolet  71
    2.4.3.2 Infrared  72
    2.4.3.3 Microwaves  72
  2.4.4 Applications  73
    2.4.4.1 UV  73
    2.4.4.2 Infrared  74
    2.4.4.3 Microwaves  74
  2.4.5 Spectrum of activity  74
    2.4.5.1 UV  74
    2.4.5.2 Infrared  75
2.4.5.3 Microwaves 75
2.4.6 Advantages 75
  2.4.6.1 UV 75
  2.4.6.2 Infrared 75
  2.4.6.3 Microwaves 75
2.4.7 Disadvantages 76
  2.4.7.1 UV 76
  2.4.7.2 Infrared 76
  2.4.7.3 Microwaves 76
2.4.8 Mode of action 76
  2.4.8.1 UV 76
  2.4.8.2 Infrared 77
  2.4.8.3 Microwaves 77
2.5 Filtration 77
  2.5.1 Types and applications 77
  2.5.2 Spectrum of activity 82
  2.5.3 Advantages 84
  2.5.4 Disadvantages 84
  2.5.5 Mode of action 84

Chapter 3 Chemical Disinfection

3.1 Introduction 85
3.2 Acids and acid derivatives 85
  3.2.1 Types 85
  3.2.2 Applications 87
  3.2.3 Spectrum of activity 88
  3.2.4 Advantages 88
  3.2.5 Disadvantages 88
  3.2.6 Mode of action 89
3.3 Alkalis or bases 89
  3.3.1 Types 89
  3.3.2 Applications 90
  3.3.3 Spectrum of activity 90
  3.3.4 Advantages 90
  3.3.5 Disadvantages 91
  3.3.6 Mode of action 91
3.4 Aldehydes 91
  3.4.1 Types 91
  3.4.2 Applications 91
    3.4.2.1 Glutaraldehyde and OPA 91
    3.4.2.2 Formaldehyde 92
  3.4.3 Spectrum of activity 93
    3.4.3.1 Glutaraldehyde and OPA 93
    3.4.3.2 Formaldehyde 94
  3.4.4 Advantages 94
    3.4.4.1 Glutaraldehyde and OPA 94
    3.4.4.2 Formaldehyde 94
  3.4.5 Disadvantages 95
    3.4.5.1 Glutaraldehyde and OPA 95
    3.4.5.2 Formaldehyde 95
  3.4.6 Mode of action 95
    3.4.6.1 Glutaraldehyde and OPA 95
    3.4.6.2 Formaldehyde 97

3.5 Alcohols 97
  3.5.1 Types 97
  3.5.2 Applications 97
  3.5.3 Spectrum of activity 98
  3.5.4 Advantages 98
  3.5.5 Disadvantages 99
  3.5.6 Mode of action 99

3.6 Anilides 99
  3.6.1 Types 99
  3.6.2 Applications 100
  3.6.3 Spectrum of activity 100
  3.6.4 Advantages 100
  3.6.5 Disadvantages 100
  3.6.6 Mode of action 100
3.7 Antimicrobial dyes 101
  3.7.1 Types 101
  3.7.2 Applications 101
  3.7.3 Spectrum of activity 102
  3.7.4 Advantages 103
  3.7.5 Disadvantages 103
  3.7.6 Mode of action 103

3.8 Biguanides 104
  3.8.1 Types 104
  3.8.2 Applications 104
  3.8.3 Spectrum of activity 105
  3.8.4 Advantages 106
  3.8.5 Disadvantages 106
  3.8.6 Mode of action 106

3.9 Diamidines 107
  3.9.1 Types 107
  3.9.2 Applications 107
  3.9.3 Spectrum of activity 107
  3.9.4 Advantages 108
  3.9.5 Disadvantages 108
  3.9.6 Mode of action 108

3.10 Essential oils and plant extracts 108
  3.10.1 Types 108
  3.10.2 Applications 109
  3.10.3 Spectrum of activity 109
  3.10.4 Advantages 110
  3.10.5 Disadvantages 110
  3.10.6 Mode of action 110

3.11 Halogens and halogen-releasing agents 111
  3.11.1 Types 111
  3.11.2 Applications 115
    3.11.2.1 Iodine 115
    3.11.2.2 Chlorine 116
    3.11.2.3 Bromine 117
  3.11.3 Spectrum of activity 117
    3.11.3.1 Iodine 117
    3.11.3.2 Chlorine 117
3.13.2.2 Hydrogen peroxide 130
3.13.2.3 PAA 134
3.13.2.4 Chlorine dioxide 135

3.13.3 Spectrum of activity 136
3.13.3.1 Ozone 136
3.13.3.2 Hydrogen peroxide 137
3.13.3.3 PAA 138
3.13.3.4 Chlorine dioxide 139

3.13.4 Advantages 139
3.13.4.1 Ozone 139
3.13.4.2 Hydrogen peroxide 139
3.13.4.3 PAA 140
3.13.4.4 Chlorine dioxide 140

3.13.5 Disadvantages 140
3.13.5.1 Ozone 140
3.13.5.2 Hydrogen peroxide 140
3.13.5.3 PAA 141
3.13.5.4 Chlorine dioxide 141

3.13.6 Mode of action 142
3.13.6.1 Ozone 142
3.13.6.2 Hydrogen peroxide 142
3.13.6.3 PAA 143
3.13.6.4 Chlorine dioxide 143

3.14 Phenolics 143
3.14.1 Types 144
3.14.2 Applications 144
3.14.3 Spectrum of activity 145
3.14.4 Advantages 145
3.14.5 Disadvantages 146
### Chapter 3 Antibiotics

#### 3.14.6 Mode of action 146

#### 3.15 Antiseptic phenolics 147

- **3.15.1 Types** 147
- **3.15.2 Applications** 148
- **3.15.3 Antimicrobial activity** 149
- **3.15.4 Advantages** 150
- **3.15.5 Disadvantages** 151
- **3.15.6 Mode of action** 152
  - **3.15.6.1 Triclosan** 152
  - **3.15.6.2 Chloroxylenol** 154
  - **3.15.6.3 Salicylic acid** 154

#### 3.16 Quaternary ammonium compounds and surfactants 155

- **3.16.1 Types** 155
- **3.16.2 Applications** 156
- **3.16.3 Antimicrobial efficacy** 157
- **3.16.4 Advantages** 158
- **3.16.5 Disadvantages** 158
- **3.16.6 Mode of action** 158

#### 3.17 Other miscellaneous biocides or applications 159

- **3.17.1 Pyrithiones** 159
- **3.17.2 Isothiazolones derivatives** 159
- **3.17.3 Biocides integrated into surfaces** 160
- **3.17.4 Micro- or nano-particles** 162
- **3.17.6 Antimicrobial enzymes, proteins, or peptides** 163
- **3.17.7 Bacteriophages** 165

### Chapter 4 Antiseptics and Antisepsis

#### 4.1 Introduction 167

#### 4.2 Some definitions specific to antisepsis 167

#### 4.3 Structure of skin 168

#### 4.4 Skin microbiology 169

#### 4.5 Antiseptic applications 169

- **4.5.1 Routine skin washing/antisepsis** 170
- **4.5.2 Pretreatment of skin prior to surgical intervention** 173
- **4.5.3 Treatment of skin or wound infections** 174
4.5.4 Treatment of oral and other mucous membranes 177
4.5.5 Material-integrated applications 177

4.6 Biocides used as antiseptics 177
4.6.1 General considerations 177
4.6.2 Major types of biocides in antiseptics 180
4.6.3 Other antiseptic biocides 183

Chapter 5 Physical Sterilization
5.1 Introduction 185
5.2 Moist heat sterilization 185
  5.2.1 Types 187
  5.2.2 Applications 192
  5.2.3 Spectrum of activity 193
  5.2.4 Advantages 196
  5.2.5 Disadvantages 196
  5.2.6 Mode of action 197
5.3 Dry heat sterilization 197
  5.3.1 Types 197
  5.3.2 Applications 198
  5.3.3 Spectrum of activity 199
  5.3.4 Advantages 199
  5.3.5 Disadvantages 199
  5.3.6 Mode of action 200
5.4 Radiation sterilization 200
  5.4.1 Types 200
  5.4.2 Applications 203
  5.4.3 Spectrum of activity 206
  5.4.4 Advantages 208
  5.4.5 Disadvantages 208
  5.4.6 Mode of action 209
5.5 Filtration 209
5.6 Other physical sterilization methods 209
  5.6.1 Plasma 209
  5.6.2 Pulsed light 211
  5.6.3 Supercritical fluids 213
  5.6.4 Pulsed electric fields 214
# Chapter 6 Chemical Sterilization

## 6.1 Introduction 215

## 6.2 Epoxides 215

### 6.2.1 Types 216

### 6.2.2 Applications 216

### 6.2.3 Spectrum of activity 219

### 6.2.4 Advantages 221

### 6.2.5 Disadvantages 221

### 6.2.6 Mode of action 222

## 6.3 Low temperature steam-formaldehyde 222

### 6.3.1 Types and applications 222

### 6.3.2 Spectrum of activity 225

### 6.3.3 Advantages 225

### 6.3.4 Disadvantages 225

### 6.3.5 Mode of action 225

## 6.4 High temperature formaldehyde-alcohol

### 6.4.1 Types and applications 225

### 6.4.2 Spectrum of activity 226

### 6.4.3 Advantages 226

### 6.4.4 Disadvantages 226

### 6.4.5 Mode of action 226

## 6.5 Hydrogen peroxide 226

### 6.5.1 Types 226

### 6.5.2 Applications 228

### 6.5.3 Spectrum of activity 232

### 6.5.4 Advantages 233

### 6.5.5 Disadvantages 233

### 6.5.6 Mode of action 233

## 6.6 Other oxidizing agent-based processes 233

### 6.6.1 Liquid peracetic acid 234

### 6.6.2 Electrolyzed water 234

#### 6.6.2.1 Types 234

#### 6.6.2.2 Applications 236

#### 6.6.2.3 Spectrum of activity 237

#### 6.6.2.4 Advantages 237

#### 6.6.2.5 Disadvantages 238

#### 6.6.2.6 Mode of action 238
6.6.3 Gaseous peracetic acid 239
6.6.4 Ozone 240
6.6.5 Chlorine dioxide 242
6.6.6 Nitrogen dioxide 242

Chapter 7 Mechanisms of Action

7.1 Introduction 247
7.2 Anti-infectives 248
  7.2.1 Antibacterials (antibiotics) 248
  7.2.2 Antifungals 251
  7.2.3 Antivirals 251
  7.2.4 Antiparasitic drugs 251
7.3 Macromolecular structure 251
7.4 General mechanisms of action 255
  7.4.1 Introduction 255
  7.4.2 Oxidizing agents 257
  7.4.3 Cross-linking or coagulating agents 263
  7.4.4 Transfer of energy 270
  7.4.5 Other structure-disrupting agents 276

Chapter 8 Mechanisms of Microbial Resistance

8.1 Introduction 285
8.2 Biocide/microorganism interaction 285
8.3 Intrinsic bacterial resistance mechanisms 287
  8.3.1 General stationary phase phenomenon 288
  8.3.2 Motility and chemotaxis 289
  8.3.3 Stress responses 289
  8.3.4 Efflux mechanisms 295
  8.3.5 Enzymatic and chemical protection 299
  8.3.6 Intrinsic mechanisms to heavy metals 300
  8.3.7 Capsules, slime formation, and S-layers 302
  8.3.8 Biofilm development 304
  8.3.9 Bacteria with extreme intrinsic resistance 310
  8.3.10 Extremophiles 312
  8.3.11 Dormancy 316
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.3.12 Revival mechanisms</td>
<td>327</td>
</tr>
<tr>
<td>8.4 Intrinsic resistance of mycobacteria</td>
<td>329</td>
</tr>
<tr>
<td>8.5 Intrinsic resistance of other Gram-positive bacteria</td>
<td>333</td>
</tr>
<tr>
<td>8.6 Intrinsic resistance of Gram-negative bacteria</td>
<td>337</td>
</tr>
<tr>
<td>8.7 Acquired bacterial resistance mechanisms</td>
<td>341</td>
</tr>
<tr>
<td>8.7.1 Introduction</td>
<td>341</td>
</tr>
<tr>
<td>8.7.2 Mutational resistance</td>
<td>344</td>
</tr>
<tr>
<td>8.7.3 Plasmids and transmissible elements</td>
<td>355</td>
</tr>
<tr>
<td>8.8 Mechanisms of viral resistance</td>
<td>366</td>
</tr>
<tr>
<td>8.9 Mechanisms of prion resistance</td>
<td>372</td>
</tr>
<tr>
<td>8.10 Mechanisms of fungal resistance</td>
<td>376</td>
</tr>
<tr>
<td>8.11 Mechanisms of resistance in other eukaryotic microorganisms</td>
<td>386</td>
</tr>
<tr>
<td>Index</td>
<td>393</td>
</tr>
</tbody>
</table>
The control of microorganisms and microbial growth is an important consideration in medical, veterinary, dental, industrial, pharmaceutical, environmental, and food processing settings. This book has been developed to provide a basic understanding of the various chemical and physical antisepsis, disinfection, and sterilization methods used for infection prevention and contamination control. Disinfection and sterilization technologies are used for the control of microorganisms on surfaces, in products, or in air, while antisepsis is particularly associated with microbial reduction on the skin or mucous membranes. Many of these applications have been used over many years and continue to play important roles in our daily lives, including the provision of safe drinking water, production and preservation of products, laboratory safety, food safety, sterilization of medical devices, and disinfection of critical surfaces. The benefits of microbial control have been appreciated since ancient times—for example, in the use of heating, salts, and metals for preservation and wound treatment—despite the absence in those times of any pure understanding of microbiology. Over the last 160 years, we have gained a greater appreciation of microorganisms and their roles in contamination and infection. In parallel, various chemical and physical antisepsis, disinfection, and sterilization methods have been developed and are widely used to render surfaces and products safe for use. Despite these advancements, microbial control issues continue to challenge us. Notable examples include controlling the risk of virus transmission in outbreaks of Zika virus, Ebola virus, and noroviruses; medical device contamination associated with health care outbreaks of infection (such as with flexible endoscopes); the emerging concerns with unique infectious agents (such as prions or other transmissible proteinaceous agents); and the continuing concern of anti-infective (including antibiotic)-resistant microorganisms in hospitals and the general community. As our knowledge increases in microbiology, so does our understanding of the novel ways that microorganisms can present with mechanisms of surviving the many broad-spectrum contamination control technology that we use, including chemical and physical disinfection and sterilization methods.

As a background to this subject, a brief introduction to microbiology is provided, to include the various types of microorganisms in their major classes. This section also provides the definitions of some key terms widely used in the area, the overall resistance profiles of microorganisms to inactivation, and the variety of methods that are used to test the effectiveness and optimize the use of antimicrobial products and processes.

Disinfection and sterilization can be generally considered as either based on chemical or physical antimicrobial technologies. Chemicals include various types of aldehydes, halogens, and oxidizing agents, while physical processes include the use of heat, filtration, and radiation. For each general group, the various types of technologies are discussed, along with their applications, spectra of
activity, advantages, and disadvantages, and a brief description of their modes of action. A wider range of methods is used for disinfection and antisepsis applications. Many of these are required to reduce the number of microorganisms, or even the number of certain types of microorganisms, to an acceptable level. In contrast, only a limited number of technologies are utilized for sterilization, which has the ultimate goal of rendering a surface, area, or substance free of all viable microbial contamination. For this reason, disinfection and sterilization methods are considered separately, with a specific chapter dedicated to the various antimicrobials used as antiseptics and in antisepsis applications.

The current understanding of the mechanisms of action on microorganisms is considered in chapter 7. It is important to note that the modes of action of these technologies are generally nonspecific and distinct from the more specific mechanisms of action described for anti-infective agents, such as antibiotics and antiviral agents. Most biocides demonstrate a wider range of antimicrobial activity, generally corresponding to nonspecific and varied modes of action. The mechanisms of action of biocides are considered in four general categories: oxidizing agents, cross-linking agents, agents that act by transfer of energy, and other structure-disrupting agents. Despite these general mechanisms, some biocides have been shown to have primary targets similar to those of certain antibiotics, and a better understanding of their mechanisms of action is of interest in the development of the next generation of anti-infectives and/or optimized antimicrobial processes.

Microorganisms demonstrate various natural (intrinsic) and acquired mechanisms to resist the antimicrobial effects of chemical and physical processes. These mechanisms are discussed in further detail in chapter 8 and are important to consider in order to ensure the safe and effective use of these technologies. This topic, and the impact of microbial resistance, has been particularly well published in the use of widely used anti-infectives (notably antibiotic-resistant bacteria like methicillin-resistant *Staphylococcus* and carbapenem-resistant *Enterobacteriaceae*), but similar and distinct mechanisms in microbial resistance to more broad-spectrum antimicrobial products and processes have been described. Biocide resistance in bacteria has been studied in greater detail since the publication of the first edition of this book, with many examples of intrinsic and acquired mechanisms of resistance. Intrinsic mechanisms include biofilm formation, development of dormant endospores, and the accumulation of resistance mechanisms in extremophiles. Acquired resistance mechanisms due to mutations and the acquisition of transposons and/or plasmids, not unlike those described for antibiotics, have also been described in more detail. Although many of these mechanisms allow for the tolerance in the presence of antimicrobial chemicals at normally inhibitory levels, other mechanisms have been shown to dramatically change the response of some microorganisms to biocides and to enable them to survive highly toxic conditions. Further advances have also been made in our understanding of specific mechanisms of resistance in other microorganisms such as viruses, prions, fungi, and protozoa.

Overall, it is intended that this book will give a basic understanding of and reference for the various types, modes of action, and mechanisms of resistance of antiseptics, disinfectants, and sterilization processes for students of microbiology, chemistry, infection prevention, contamination control, public health, and industrial applications. A greater understanding and appreciation of these technologies will continue to ensure their long-term safe and effective use in contamination and infection prevention.
ABOUT THE AUTHOR

Gerald E. McDonnell received a B.Sc. degree in medical laboratory sciences from the University of Ulster (1989) and a Ph.D. in microbial genetics at the Department of Genetics, Trinity College, University of Dublin (1992). His graduate work involved studies on the control of gene expression in *Bacillus subtilis*. He spent 3 years at the Mycobacterial Research Laboratories, Colorado State University, investigating the mechanisms of antibiotic resistance and cell wall biosynthesis in mycobacteria. In 1995 he joined the St. Louis, Mo., operations of ConvaTec, a division of Bristol-Myers Squibb, as a group leader in microbiology in the research and development of skin care, hard surface disinfection, and cleaning chemistries. He worked for STERIS Corporation for 19 years in the USA and in Europe on the development, research, and support of infection and contamination prevention products and services in health care and industrial applications, with a particular focus on cleaning, antisepsis, disinfection, and sterilization. Dr. McDonnell is currently the senior director for sterility assurance for DePuySynthes, a Johnson & Johnson company, and a member of the Johnson & Johnson Sterility Assurance leadership team. He serves as the global technical leader in the areas of microbiology and contamination control including sterilization, aseptic technique, reprocessing, microbiology, and cleanliness requirements. His basic research interests include infection prevention, decontamination microbiology, emerging pathogens, and modes of action and resistance to biocides. His work also includes the development and implementation of international and national guidance and standards in cleaning, disinfection, and sterilization. He has over 180 publications, 22 patents and is a frequent presenter on various aspects of his work internationally.
INDEX

Acanthamoeba, 1
diamidines, 107, 108
hydrogen peroxide, 137, 232
resistance mechanisms, 386–387
Acanthamoeba castellanii
fungal resistance, 382
intrinsic resistance, 331
resistance mechanisms, 386, 388–389
Acanthamoeba polyphaga, intrinsic resistance, 331
Acetobacter, 24, 88
Acidiphilium, 302
Acidophiles, 314–316
Acids and acid derivatives
advantages, 88
applications, 87–88
chemical disinfection, 85–89
disadvantages, 88–89
dissociation of benzoic acid, 87f
modes of action, 89
spectrum of activity, 88
types, 85–87
Acinetobacter
Gram-negative bacteria, 24
intrinsic resistance to heavy metals, 302
plasmid-mediated resistance, 361–362
radiation, 207
radiation resistance, 311
silver resistance, 358
wound infection, 174
Acinetobacter baumannii
chlorhexidine, 350
copper disinfection, 123
intrinsic resistance, 341
skin infection, 170
Acquired bacterial resistance mechanisms,
341–344
antimicrobial drugs, 343
mutational resistance, 344–355
penicillin, 341, 342f
plasmids and transmissible elements, 342, 355–366
Acridines, mode of action, 276–277
Actinomyces, dormancy, 326
Actinomycetes, cell wall structures, 27
Active transport, 295–296
Adenoviridae, classification, 29
Aerobe, definition, 2–3
Aflatoxin, 36, 36f
Alcaligenes xylosoxidans
enzymatic and chemical protection, 299
intrinsic resistance, 340
Alcohols
advantages, 98–99
antisepsics in washes, 180–181
applications, 97–98
disadvantages, 99
modes of action, 99, 263, 270
spectrum of activity, 98
types, 97
Aldehydes
advantages, 94–95
amino acids cross–linking by, 265f
applications, 91–93
cross-linking agents, 263
disadvantages, 95
formaldehyde, 91, 92–93, 94–95, 97
glutaraldehyde, 91–92, 93–94, 95–97
mode of action, 95–97, 263
ortho-phthaldehyde (OPA), 91–92, 93–94, 95–97
spectrum of activity, 93–94
types, 91
Alexidine, 281
Algae, 13
microorganisms, 7
types of algal toxins, 34
Alkalis (bases)
advantages, 90–91
applications, 90
chemical disinfection, 89–91
disadvantages, 91
modes of action, 91
spectrum of activity, 90
types, 89
Aminacrine, 101, 102f, 103
Amino acids
macromolecules, 252, 253f
oxidizing agents on, 260
reaction of ethylene oxide with, 264, 265f
Babesia, resistance mechanisms, 387
Bacilli, differentiation of, 17

Bacillus
biguanides, 107
dormancy, 317–318, 321
flagella, 289
Gram-positive bacteria, 20, 22, 333
heat activity, 67
intrinsic resistance, 334, 336
plasma, 211
plasmids, 342
stress response, 291

Bacillus anthracis
acid disinfection, 85, 88
capsules and slime layers, 303
glycocalyx, 21
hydrogen peroxide, 131

Bacillus atrophaeus
dormancy, 317, 320–321, 324, 325f
dry heat sterilization, 199
epoxide for sterilization, 219, 220f
 glutaraldehyde treatment, 267
hydrogen peroxide, 232, 293
microwave radiation, 75
stress response, 290

Bacillus cepacia
biofilm formation, 307
intrinsic resistance, 339, 340

Bacillus cereus, dormancy, 321

Bacillus megaterium, 223
hexachlorophene, 154
intrinsic resistance, 334

Bacillus pumilus
radiation, 207
 ultraviolet radiation, 75

Bacillus subtilis
dormancy, 317
dry heat sterilization, 199
 glutaraldehyde treatment, 268
Gram-positive bacteria, 334
intrinsic resistance, 334–336
microwave radiation, 75
triclosan, 152

Bacillus subtilis subsp. niger, epoxide for sterilization, 219

Bacteria
basic structure of cell, 18f
cell wall structures, 19f
differentiation of, 17
efflux systems, 298
endospore structure, 320f
extreme intrinsic resistance, 310–312
growth curve, 288f
intrinsic resistance to heavy metals, 300
microorganisms, 7
protective cell surface structures, 302

Bacterial endotoxins, examples, 34
Bacterial exotoxins, examples, 34
Bacterial toxins, 35
Bacteriophages, 32, 165
Bacteroides, Gram-negative bacteria, 25
Balantidium coli, classification of, 15
Barophiles, 27
Bases. See Alkalis (bases)
Benzoyl peroxide, 126f
biocide as antiseptic, 176
mode of action, 143

Biguanides
advantages, 106
applications, 104–105
chlorhexidine, 104
chlorhexidine-based antiseptics/disinfectants, 105f
disadvantages, 106
modes of action, 106–107, 280
polyhexamethylbiguanides (PHMBs), 104–106
spectrum of action, 105
types, 104

Bioburden, definition, 3
Biocide-microorganism interaction, 285–287

Biocides
acquired resistance mechanisms, 288
anti-infectives vs., 247–248
antimicrobial activity of, 38
antimicrobial efficacy, 178
antimicrobial surfaces, 161
as antiseptics, 177–183
biocidal processes, 1–2
choosing process or product, 52–53
definition, 3, 247
determination of D value, 40f
effects on cytoplasmic membranes, 279f
formulation of, 53–55
fungal resistance mechanisms, 376–386
guidelines, 53
integration into surfaces, 160–162
intrinsic resistance mechanisms, 288
known extreme resistance to, 310
loss of resistance to, 323f
material-integrated applications, 177
mechanisms of resistance against prions, 374f
microbial resistance, 36, 37, 286f
multidrug resistance determinant, 364
mutations causing sensitivity to, 352
oxidizing agent-based mode of action, 258
plasmid-encoded resistance to, 356
plasmids and transmissible elements, 355–366
process effects, 55–57
qualitative and semi-quantitative population determination, 41f
standards, 53, 54
treatment of oral and mucous membranes, 177
Biocides (continued)

- types in antiseptic skin washes/rinses, 180–183
- typical survivor curves, 41f
- viral resistance, 366–372

Biocompatibility, definition, 3

Biofilm

- bacteria and fungi associated with, 304
- conditioning, 305
- definition, 3
- development, 304–309
- schematic of development, 305f
- viruses in, 367

Biological indicators

- definition, 3
- efficacy testing, 45–47

Bland soap, definition, 168

Bordetella, Gram-negative bacteria, 24

Borrelia, Gram-negative bacteria, 24

Borrelia mylophora, bacteria, 16

Bowie-Dick test, 190, 191f

Boyle’s law, 185

Bromine, 111

- advantages, 118–119
- agents releasing, 115f
- applications, 117
- characteristics, 114
- disadvantages, 119–120
- mode of action, 121
- spectrum of activity, 118

See also Halogens and halogen-releasing agents

Brucella, bacteria, 16

Burkholderia

- enzymatic and chemical protection, 299
- Gram-negative bacteria, 24
- intrinsic resistance, 337
- plasmid-mediated resistance, 362

Byssoclamys, 384

Caenorhabditis, hydrogen peroxide, 138, 232

Campylobacter, Gram-negative bacteria, 24

Candida

- acid disinfection, 88
- antifungals, 251
- biofilm formation, 308
- capsules and slime layers, 302
- chlorhexidine, 181
- chloroxylenol, 150
- copper disinfection, 124
- essential oils, 110
- fungal resistance, 379–380
- skin floras, 169

Candida albicans, 12

- antiseptic effect, 178
- biofilm formation, 304
- copper disinfection, 123

- fungal resistance, 379
- heavy metal resistance, 385
- skin floras, 169
- skin infection, 170
- wound infection, 174

Carrier tests

- standardized, 44
- surface testing, 43–44

Cell culture, efficacy, 50

Cestodes, disease associated with, 10

Chaetomium

- fungal resistance, 382
- mycotoxins, 36

Charles’ law, 185–186

Chemical disinfection

- acids and acid derivatives, 85–89
- alcohols, 97–99
- aldehydes, 91–97
- alkanes (bases), 89–91
- anilides, 99–101
- antimicrobial dyes, 101–104
- antimicrobial enzymes, proteins, and peptides, 163–165
- antiseptic phenolics, 147–155
- bacteriophages, 165
- biguanides, 104–107
- biocides integrated into surfaces, 160–162
- diamidines, 107–108
- essential oils and plant extracts, 108–111
- guidelines and standards on use and application of, 86
- halogens and halogen-releasing agents, 111–121
- isothiazolinone derivatives, 159–160
- metals, 121–126
- micro- and nanoparticles, 162–163
- peroxygens and other oxygen forms, 126–143
- phenolics, 143–147
- pyrithiones, 159
- QACs and other surfactants, 155–159

See also Peroxygens and other forms of oxygen

Chemical indicators

- definition, 4
- efficacy testing, 47–48
- examples of standards, 49

Chemical sterilization

- Chlorine dioxide, 242
- electrolyzed water, 234–239
- epoxides, 215–222
- gaseous peracetic acid (PAA) sterilization, 239–240
- high-temperature formaldehyde-alcohol, 225–226
- liquid PAA, 234
- low-temperature steam-formaldehyde (LTSF), 222–225
nitrogen dioxide, 242–245
ozone, 240–242
Chitin, 12, 13, 165
*Chlamydia*
  Gram-negative bacteria, 25
  intrinsic resistance, 340
  microorganisms, 7
*Chlamydia trachomatis*, 21
*Chlamydomonas*, 13, 390
*Chlamydomonas reinhardtii*, 390
*Chlamydophila*, 25
*Chlamydophila pneumoniae*, 21
*Chlamydophila psittaci*, 21
Chloramphenicol, spectrum of activity and mode of action, 250
Chlorhexidine
  Gram-positive bacteria, 366
  penetration into skin epidermis, 180f
  resistance to, 350–352
  *Saccharomyces cerevisiae* response, 378
  therapeutic antiseptic, 181
Chlorine, 111
  advantages, 118
  applications, 116–117
  characteristics, 111–114
  chemistry in water, 113f
  disadvantages, 119
  mode of action, 120–121
  organic chloramines, 113f
  peptide bond breakage, 261
  sodium hypochlorite-based disinfectants, 116f
  spectrum of activity, 117–118
See also Halogens and halogen-releasing agents
Chlorine dioxide, 126, 372
  advantages, 140
  applications, 135–136
  biocide as antiseptic, 176
  characteristics, 127–129
  chemical sterilization, 242
  disadvantages, 141–142
  fumigation cycle, 137f
  generator systems, 135f
  liquid formulations for medical device disinfection, 136f
  mode of action, 143
  production of, 128f
  spectrum of activity, 139
See also Peroxygens and other forms of oxygen
Chloroxylenol
  advantages, 151
  antimicrobial activity, 150
  antiseptic in wash, 182
  disadvantages, 152
  mode of action, 154
structure, 147
–Cidal, definition, 3–4
Ciprofloxacin, spectrum of activity and mode of action, 250
*Citrobacter*, 358
*Cladosporium*, 382
*Cladosporium herbarum*, 111
Cleaning
  chemical methods, 57–59
  components of formulations, 58
  definition, 4
  importance of, 57–59
  physical methods, 57, 59
*Clostridium*
  dormancy, 317–318, 321
  extreme resistance, 310
  Gram-positive bacteria, 23
  heat activity, 67
  intrinsic resistance, 335
  oxygen requirements, 316
  skin infection, 170
*Clostridium botulinum*
  antimicrobial peptides, 165
  recovery, 329
*Clostridium difficile*, 1, 131
Coagulating agents, mode of action, 263–270
Cocci, differentiation of, 17
Cold temperatures, biocidal effects, 68
*Comoviridae*, 32
Contamination, importance of cleaning, 57–59
Copper, 121
  advantages, 124
  antimicrobial surfaces, 161
  applications, 122–123
  characteristics, 121
  disadvantages, 124
  mode of action, 125, 276, 278
  spectrum of activity, 123–124
*Coronaviridae*, viral diseases, 31
*Corynebacteria*, 150
*Corynebacterium*, 8, 27
  cell wall, 26
  dormancy, 326
  Gram-positive bacteria, 23
  skin floras, 169
*Cryptococcus*, 13
  antifungals, 251
  capsules and slime layers, 302
  fungal resistance, 380
  structure, 147
See also Peroxygens and other forms of oxygen

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IP:  54.70.40.11
Cryptococcus neoformans, 12  
fungal resistance, 379–380  
silver disinfection, 125

Cryptosporidium  
chlorine dioxide, 139  
chlorine disinfection, 118  
hydrogen peroxide, 137  
hydrogen peroxide sterilization, 232  
iodine disinfection, 117  
liquid peracetic acid (PAA) sterilization, 234  
ozone, 137  
PAA, 139  
resistance mechanisms, 386  
ultraviolet radiation, 75

Cryptosporidium parvum  
classification of, 15  
resistance mechanisms, 387–388

Cyanobacteria, Gram-negative bacteria, 25

D10 value/D value  
definition, 4  
estimation, 42f  
time-kill determinations, 39–42

Decontamination, definition, 4

Definitions, 2–6

Deinfestation, definition, 4

Deinococcus, extreme resistance, 310–312

Deinococcus geothermalis, 304

Deinococcus radiodurans  
extreme resistance, 310, 312  
intrinsic resistance, 340  
radiation, 207  
survival of radiation, 311f  
ultraviolet radiation, 75

Deoxyribonucleic acid (DNA)  
heat denaturation of, 271–272, 272f  
polynucleotides, 255, 257f  
radiation, 274–275  
viruses, 369–372

Depyrogenation, definition, 4

Dermatophytes, skin infection, 170

Dermis, skin structure, 168f

Detergent, definition, 4

Diamidines  
advantages, 108  
applications, 107  
disadvantages, 108  
mode of action, 108, 276  
spectrum of activity, 107–108  
types, 107

Dimorphic fungi, 12

Disinfec tant, definition, 4

Disinfection  
definition, 4  
importance of cleaning, 57–59  
microorganisms, 50–52  
prions, 373

standards and guidelines, 54

water quality, 59–60  
See also Chemical disinfection; Physical disinfection

Dormancy  
endospores, 317–325  
exospor es, 325–327  
microbial resistance, 316–327

Dry heat sterilization  
advantages, 199  
applications, 198–199  
disadvantages, 199–200  
mode of action, 200  
series of industrial sterilizers, 198f  
spectrum of activity, 199  
types, 197–198

Dyes. See Antimicrobial dyes

Efficacy evaluation, 38–50  
biological indicators, 46–47  
chemical indicators, 47–48, 49  
in-use testing, 45–46  
microscopy, 49–50  
miscellaneous indicators, 48–49  
parametric control, 49  
simulated testing, 45  
standardized carrier tests, 44  
standardized suspension tests, 43  
surface testing, 43–44  
suspension testing, 38–43  
time-kill (D-value), 39–42

Electric fields, pulsed, 214

Electrolyzed water  
advantages, 237–238  
applications, 236–237  
chemical sterilization, 234–239  
disadvantages, 238  
generators, 237f  
mode of action, 238–239  
spectrum of activity, 237  
types, 235f

Electromagnetic radiation, 69–70  
atomic structure, 69f  
electromagnetic spectrum, 70f  
wavelengths and energies, 70

Endospores, dormancy, 317–325

Endotoxins, 4–5, 34, 35–36

Entamoeba histolytica, classification of, 15

Enterobacteriaceae, resistance mechanisms, 387  
silver resistance, 358  
skin, 169

Enterobacter aerogenes, 364

Enterobacter cloacae, diamides, 108

Enterobacteriaceae, 1  
Gram-negative bacteria, 25
plasmid-mediated resistance, 361

**Enterobius**
- hydrogen peroxide, 138
- hydrogen peroxide sterilization, 232

**Enterobius vermicularis**
- disease associated with, 10
- life cycle, 11f

**Enterococcus**
- biguanides, 106
- heat activity, 66
- heat sensitivity, 62
- intrinsic resistance, 334–336
- multidrug resistance plasmids, 364
- skin floras, 169
- skin infection, 170
- wound infection, 174

**Enterococcus faecalis**
- efflux systems, 298
- Gram-positive bacteria, 22
- potassium uptake, 281
- skin infection, 170
- triclosan, 349

**Enterococcus faecium**
- antibiotic resistance, 366
- Gram-positive bacteria, 22

**Environia**, 25

**Environmental Protection Agency (EPA)**, 50

**Epidermophyton**, anilide disinfection, 100

**Episomes**, 342

**Epoxides**
- advantages, 221
- applications, 216–219
- chemical sterilization, 215–222
- disadvantages, 221–222
- modes of action, 222
- spectrum of activity, 219–221
- structures, 215
- types, 216

**Ergosterol**, 247, 256f

**Erythromycin**, spectrum of activity and mode of action, 250

**Escherichia**
- aldehyde disinfection, 94
- flagella, 289
- Gram-negative bacteria, 25
- mutation resistance, 345
- skin floras, 169

**Escherichia coli**
- alcohol disinfection, 99
- anilide disinfection, 101
- bactericidal activity of glutaraldehyde, 267
- bacteriophages, 32f
- chlorine disinfection, 120
- copper disinfection, 124
- efflux, 296, 298
- endotoxins, 35

**Essential oils and plant extracts**
- advantages, 110
- applications, 109
- biocide as antiseptic, 176
- disadvantages, 110
- modes of action, 110–111
- products containing, 110f
- spectrum of activity, 109–110
types, 108–109
types and sources, 109

**Ethanol**, 97. See also Alcohol

**Ethylene oxide (EO)**, 215, 216
- advantages, 221
- disadvantages, 221–222
- mode of action, 222
- reaction with amino acid side chains, 264, 265f
- reaction with guanine, 263–264, 264f
- spectrum of activity, 219–221
- sporidal Bacillus atrophaeus effect of, 220f
- sterilizers, 216f, 217f
- typical sterilization processes, 218f
See also Epoxides

**Eubacteria**, 14, 16–18, 20–21, 26

**Eufluavine**, 102f

**Euglena**, resistance mechanism, 389, 390

**Eukaryotes**, 6
- general structure, 9
- multicellular, 6, 8
- resistance mechanisms, 386–392

**Eurotrium**, 384

**Exosporium**, dormancy, 325–327

**Exotoxins**, 5, 34, 35

**Extreme intrinsic resistance, bacteria with**, 310–312

**Extremophiles**, 312–316

**Facilitated diffusion**, 295

**Fasciola hepatica**, disease associated with, 10

**Fatty acids**, biosynthesis of, 282–283

**Filamentous fungi**, 12

**Environmental stress**, 294

**enzymatic and chemical protection**, 299–300

**generation time**, 289

**heat shock response**, 294

**intrinsic resistance**, 337–338, 340

**mercury resistance**, 356

**mutation resistance**, 351–353

**oxidizing agents on**, 260, 262

**phenolics**, 146

**plasmid-mediated resistance**, 360

**radiation**, 206, 208

**silver disinfection**, 124

**skin infection**, 170

**stress disinfection**, 290, 292

**triclosan**, 152, 154, 345, 348–350

**ultraviolet radiation**, 75

**Essential oils and plant extracts**
- advantages, 110
- applications, 109
- biocide as antiseptic, 176
- disadvantages, 110
- modes of action, 110–111
- products containing, 110f
- spectrum of activity, 109–110
types, 108–109
types and sources, 109

**Ethanol**, 97. See also Alcohol

**Ethylene oxide (EO)**, 215, 216
- advantages, 221
- disadvantages, 221–222
- mode of action, 222
- reaction with amino acid side chains, 264, 265f
- reaction with guanine, 263–264, 264f
- spectrum of activity, 219–221
- sporidal Bacillus atrophaeus effect of, 220f
- sterilizers, 216f, 217f
- typical sterilization processes, 218f
See also Epoxides

**Eubacteria**, 14, 16–18, 20–21, 26

**Eufluavine**, 102f

**Euglena**, resistance mechanism, 389, 390

**Eukaryotes**, 6
- general structure, 9
- multicellular, 6, 8
- resistance mechanisms, 386–392

**Eurotrium**, 384

**Exosporium**, dormancy, 325–327

**Exotoxins**, 5, 34, 35

**Extreme intrinsic resistance, bacteria with**, 310–312

**Extremophiles**, 312–316

**Facilitated diffusion**, 295

**Fasciola hepatica**, disease associated with, 10

**Fatty acids**, biosynthesis of, 282–283

**Filamentous fungi**, 12
INDEX

Filtration
advantages, 84
biological safety classes, 81f
disadvantages, 84
high-efficiency particulate air (HEPA) filters, 79f, 80, 81f
liquid and gas applications, 78
mode of action, 84
size exclusion capabilities, 83f
spectrum of activity, 82–83
standards and guidelines for disinfection and sterilization, 82
types and applications, 77–82
Flaviviridae, classification, 29
Flavobacterium, isothiazolinone derivatives, 160
Flukes, disease associated with, 10
Fluorine
characteristics of, 115
See also Halogen and halogen-releasing agents
Food and Drug Administration (FDA), 50, 54, 66, 81, 86, 172, 218
Forced displacement, steam, 189, 190f
Formaldehyde
advantages, 94–95
agents releasing, 93f
application, 92–93
disadvantages, 95
high-temperature formaldehyde-alcohol, 225–226
mode of action, 97
reactions with proteins, 266f, 266–267
spectrum of activity, 94
sterilization with low-temperature steam-formaldehyde (LTSF), 222–225
structure, 91, 222
See also Aldehydes
Formulations
biocides, 53–55
definition, 5
components of cleaning, 58
Fumigation, definition, 5
Fungal cell envelope, 13f
Fungi, 8, 11–13
examples of common, 12
examples of fungal toxins, 34
life cycle, 382f
microorganisms, 7
resistance mechanisms, 376–386
spore-bearing structures, 384f
spores, 383, 384f
structures, 11f
Fusarium, mycotoxins, 36

Geminiviridae, plant viruses, 32
Geobacillus
dormancy, 317, 318, 321
extreme resistance, 310
Gram-positive bacteria, 22
heat activity, 67
plasma, 211
Geobacillus stearothermophilus
dormancy, 324
heat sensitivity, 62
hydrogen peroxide sterilization, 227f, 232
microwave radiation, 75
recovery, 329
steam sterilization, 193–194, 195f
Geobacter, intrinsic resistance to heavy metals, 300, 301
Geodermatophilus
radiation, 207
radiation resistance, 311
Germ, definition, 5
Germicidal, definition, 5
Germicide, definition, 5
Germination, definition, 5
Gerstmann-Sträussler-Scheinker syndrome, 33–34
Giardia
chlorine dioxide, 139
hydrogen peroxide, 137
hydrogen peroxide sterilization, 232
iodine disinfection, 117
liquid peracetic acid (PAA) sterilization, 234
N-halamines, 162
peracetic acid (PAA), 139
ultraviolet radiation, 75
Giardia lamblia, classification of, 15
Glutaraldehyde
advantages, 94
applications, 91–92
cross-linking reaction by, 266–268, 267f
disadvantages, 95
mode of action, 95–97
mutations and resistance, 353–355
spectrum of activity, 93–94
structure, 91
See also Aldehydes
Glycocalyx, 21
Glycopeptides
mechanism of action, 250
target of, 249f
Gonyaulax, 13, 34, 389
Gram-negative bacteria
bacterium cell wall, 19f, 20–21, 338f
examples of bacteria, 24–25
intrinsic resistance, 337–341
Gram-positive bacteria
bacterium cell wall, 18, 19f, 20, 334f
chlorhexidine tolerance, 366
examples of bacteria, 22–23
intrinsic resistance, 333–337
multidrug resistance, 364–366

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Gram-positive endospore-forming rods, life cycle of, 318f
Gram staining, 17

*Haemophilus influenzae*, 25
  mutation resistance, 347
  triclosan, 154
Hair follicle, skin structure, 168f
Halforson-Ziegler equation, 42
*Halobacterium*, 27, 28, 316
Halogens and halogen-releasing agents
  advantages, 115–117
  bromine, 111, 117, 118–120, 121
  chemical disinfection, 111–121
  chemistry of chlorine in water, 113f
  chlorine, 111, 116–118, 119, 120–121
  disadvantages, 119–120
  iodine, 111, 115–116, 117, 118, 119, 120
  mode of action, 120–121
  organic chloramines, 113f
  poly(N-vinyl-2-pyrrolidone) (PVPI), 111, 112f
  spectrum of activity, 117–118
  types, 111–115
*Halomonas*, extremophile, 313
Halophiles, 27, 315–316
Heat
  transfer of energy, 270–273
  See also Dry heat sterilization
Heat disinfection, 61–68
  advantages, 67
  applications, 63–65
  disadvantages, 67–68
  microbial lethality, 64f
  microbial sensitivity, 63f
  mode of action, 68
  moist heat resistance of microorganisms, 66f
  spectrum of activity, 66–67
  standards and guidelines on disinfection, 66
  types of, 61–62
*Helicobacter*, 16, 24
*Helicobacter pylori*, pH conditions, 315
Helminths
  associated with disease, 10
  life cycle, 11, 11f
  microorganisms, 7
  structure of, 391f
Hemagglutinins, 29
Hepadnaviridae, viral diseases, 31
Herpes simplex virus, skin infection, 170
Herpesviridae
  classification, 29
  viral diseases, 31
Hexachlorophene
  antimicrobial activity, 149
  applications, 148
  disadvantages, 151
  mode of action, 153f, 154
  structure, 147f
Hexamine, aldehyde release, 93f
High-temperature formaldehyde-alcohol
  advantages, 226
  application, 225–226
  disadvantages, 226
  mode of action, 226
  spectrum of activity, 226
  sterilization, 225–226
  type, 225–226
*Histoplasma capsulatum*, 12, 382
Hydrogen peroxide, peptide bond breakage, 261
Hydrogen peroxide for disinfection, 126, 371
  advantages, 139–140
  applications, 130–134
  biocide as antiseptic, 176
  characteristics, 126
  compounds releasing, 127
  disadvantages, 140–141
  gas generators, 132f, 133f
  mode of action, 142–143
  spectrum of activity, 137–138
  synergistic formulations and processes, 134
  See also Peroxygens and other forms of oxygen
Hydrogen peroxide for sterilization
  advantages, 233
  applications, 228–232
  disadvantages, 233
  gas sterilization processes, 230f
  gas sterilizer, 228, 229f
  mode of action, 233
  spectrum of activity, 232–233
  STERRAD sterilizers, 229–232
  types, 226–228
Hydrophilic, definition, 5
Hydrophobic, definition, 5
*Hymenobacter*, radiation, 207
Hyperthermophiles, 312–316
Inactivation, definition, 5
Infrared radiation, 72
  advantages, 75
  applications, 74
  disadvantages, 76
  mode of action, 77
  spectrum of activity, 75
Intrinsic bacterial resistance mechanisms, 287–329
  bacterial growth curve, 288f
  bacteria with extreme, 310–312
  biofilm development, 304–309, 305f
  capsule and slime layer formation and S-layers, 302–303
  chemotaxis, 289
Intrinsic bacterial resistance mechanisms

(continued)
dormancy, 316–327
efflux mechanisms, 295–299
enzymatic and chemical protection, 299–300
extremophiles, 312–316
general stationary-phase phenomena, 288–289
Gram-negative bacteria, 337–341
Gram-positive bacteria, 333–337
to heavy metals, 300–302
motility, 289
mycobacteria, 329–333
revival mechanisms, 327–329
stress responses, 289–295
In-use testing, efficacy, 45–46
Iodine, 111
advantages, 118
antiseptics in washes, 181–182
applications, 115–116
characteristics, 111
chemistry in water, 112f
disadvantages, 119
mode of action, 120
spectrum of activity, 117
See also Halogen and halogen-releasing agents
Isoniazid
spectrum of activity and mode of action, 250
target of, 249f
Isopropanol, 97. See also Alcohols
Isothiazolinone derivatives, 159–160
Klebsiella
capsules and slime layers, 303
plasmid-mediated resistance, 362
silver resistance, 358
skin floras, 169
Klebsiella pneumoniae, 1, 350
Kocuria, radiation, 207, 311
Lactobacillus, 20, 23
Lactococcus, 22
Lactococcus lactis, 365
Legionella
biofilm formation, 304
chlorine disinfection, 117
copper disinfection, 124
electrolyzed water sterilization, 236
Gram-negative bacteria, 24
heat activity, 66
heat sensitivity, 62
peracetic acid (PAA), 135
resistance mechanisms, 387
silver disinfection, 123
ultraviolet radiation, 75
Legionella pneumophila
biofilm formation, 307
intrinsic resistance, 337
Leishmania
antimicrobial dyes, 103
diamides, 108
diamidines, 107
resistance mechanisms, 386
skin infection, 170
Leishmania donovani, 15
Leptothrix, Gram-negative bacteria, 25
Lipids
macromolecules, 253, 256f
temperature extremes, 273
Lipopopolysaccharides (LPSs), 20–21, 26, 36f
Listeria
chlorine disinfection, 116
essential oils, 109
Gram-positive bacteria, 23
plasmid-mediated efflux pumps, 365
Listeria monocytogenes
intrinsic resistance, 335–336
plasmid-mediated resistance, 360
Low-temperature steam-formaldehyde (LTSF)
advantages, 225
applications, 222–224
disadvantages, 225
mode of action, 225
spectrum of activity, 225
standards and guidelines for sterilization, 224
sterilization cycle, 223f
sterilization system, 223f
sterilizer, 224f
types, 222–224
Macrolides
mechanism of action, 250
target of, 249f
Macromolecules
amino acids, 252, 253f
cross-linking or coagulating agents, 263–270
fatty acids, 254–255, 255f
lipids, 253, 256f
nucleic acids, 255, 257f
nucleotides, 255, 257f
oxidizing agents, 257–263
polynucleotides, 255, 258f
polysaccharides, 253, 254f
proteins, 252, 253f
structure-disrupting agents, 276–279
structures of, 251–255
transfer of energy, 270–276
Material safety data sheet (MSDS), definition, 5
Mechanisms. See Acquired bacterial resistance mechanisms; Intrinsic bacterial resistance mechanisms
Mechanisms of action
antifungal drugs, 251
antiparasitic drugs, 251, 252
antivirals, 251, 252
cross-linking or coagulating agents, 263–270
general, 255–256
oxidizing agents, 257–263
structure-disrupting agents, 276–283
transfer of energy, 270–276
See also Mode of action
Mercury resistance, bacteria, 355–358
Metals
advantages, 124
applications, 122–123
biocides as antiseptics, 176
chemical disinfection, 121–126
copper compounds, 121
disadvantages, 124–125
intrinsic resistance to heavy metals, 300–302
mode of action, 125–126, 276, 277–279
resistance mechanisms, 355–363
silver compounds, 121–122
spectrum of activity, 123–124
types, 121–122
See also Copper; Silver
Methanogens, 27
Methicillin-resistant Staphylococcus aureus (MRSA)
antimicrobial enzymes, 164
bacteriophages, 165
biguanides, 106
diamides, 108
hydrogen peroxide, 131
intrinsic resistance, 336
phenolics, 149
Methylobacterium
intrinsic resistance, 337
radiation, 207
radiation resistance, 311
Methylobacterium radiotolerans, intrinsic resistance, 340
Methylococcus, enzymatic and chemical protection, 299
Micelles, structures of, 56f, 156f
Microbial growth
pH conditions, 315f
salt conditions, 315f
Microbial resistance
biocides, 36, 37
microorganisms, 36–38
Microbial resistance mechanisms
biocide-microorganism interaction, 285–287
eukaryotes, 386–392
fungus resistance, 376–380
plasmids and/or transposon-mediated, 355–366
prion resistance, 372–376
viral resistance, 366–372
See also Acquired bacterial resistance mechanisms; Intrinsic bacterial resistance mechanisms
Microbiology, 6, 7, 169
Micrococcus, skin floras, 169
Micrococcus lysodeikticus, glutaraldehyde treatment, 267
Microorganisms
advantages and disadvantages, 8
antimicrobial enzymes, proteins, and peptides, 163–165
choosing biocidal process or product, 52–53
disinfection vs. sterilization, 50–52
evaluation of efficacy, 38–50
extremophiles, 312–316
macromolecular structure, 251–255
microbial resistance, 36–38
rate of inactivation in sterilization process, 51f
revival mechanisms of, 327–329
types of, 7
See also Efficacy evaluation
Microparticles, 162–163
Microscopy efficacy, 49–50
Microsporum
anilide disinfection, 100
antimicrobial dyes, 102
fungus resistance, 385
Microwave radiation, 72–73
advantages, 75–76
applications, 74
disadvantages, 76
mode of action, 77
spectrum of activity, 75
Minimum effective concentration (MEC), definition, 5
Minimum inhibitory concentration (MIC), determination of, 38–39
Minimum recommended concentration (MRC), definition, 5
Mode of action
acid disinfection, 89
alcohols, 99
aldehyde disinfection, 95–97
alkali disinfection, 91
anilides, 100–101
antimicrobial dyes, 103–104
biguanides, 106–107
chlorine dioxide, 143
diamides, 108
dry heat sterilization, 200
electrolyzed water sterilization, 238–239
epoxides, 222, 263
essential oils and plant extracts, 110–111
filtration, 84
halogens, 120–121
heat disinfection, 68
high-temperature formaldehyde-alcohol sterilization, 226
hydrogen peroxide, 142–143
hydrogen peroxide sterilizer, 233
Mode of action (continued)
low-temperature steam–formaldehyde, 225
ozone, 142
peracetic acid (PAA), 143
phenolics, 158–159
radiation, 76–77
radiation sterilization, 209
steam sterilization, 197
Moist-heat sterilization. See Steam sterilization
MRSA. See Methicillin-resistant Staphylococcus aureus (MRSA)
Mucor, chloroxylenol, 150
Multidrug resistance (MDR), 352
bacteria, 363–365
Multiplicity reactivation, 371
Mutational resistance, 344–355
Mycobacteria
\begin{itemize}
  \item cell wall, 19f, 21, 26, 330f
  \item cell wall structures, 27
  \item intrinsic resistance of, 329–333
\end{itemize}
Mycobacterium
\begin{itemize}
  \item bacteria, 16
  \item dormancy, 317
  \item Gram-positive bacteria, 23
  \item heat activity, 66
  \item multiple antibiotic resistance, 347
  \item resistance mechanisms, 387
  \item stress response, 291
\end{itemize}
Mycobacterium abscessus, intrinsic resistance, 331, 333
Mycobacterium avium
\begin{itemize}
  \item intrinsic resistance, 329–331, 333
  \item mutation resistance, 353
\end{itemize}
Mycobacterium avium-intracellulare
\begin{itemize}
  \item aldehyde disinfection, 93
  \item biguanides, 107
  \item intrinsic resistance, 330
\end{itemize}
Mycobacterium bovis, intrinsic resistance, 330–331
Mycobacterium chelonae
\begin{itemize}
  \item aldehyde disinfection, 93, 96
  \item biofilm formation, 304, 308
  \item intrinsic resistance, 330, 332
  \item mutation resistance, 354
\end{itemize}
Mycobacterium chimaera, 308
Mycobacterium fortuitum, 304, 330, 333
Mycobacterium gordonae, 333, 354
Mycobacterium kansasii, 331
Mycobacterium leprae, 331
Mycobacterium luteus, 335
Mycobacterium marinum, 331
Mycobacterium massiliense, 333
Mycobacterium phlei, 330
Mycobacterium smegmatis
\begin{itemize}
  \item intrinsic resistance, 332
  \item triclosan, 154
\end{itemize}
Mycobacterium tuberculosis
\begin{itemize}
  \item biofilm formation, 308
  \item cells of, 26f
  \item cell wall, 19f, 21, 26
  \item filtration, 78
  \item generation time, 289
  \item heat sensitivity, 62
  \item mutation resistance, 353
  \item triclosan, 154
  \item ultraviolet radiation, 75
\end{itemize}
Mycoplasma
\begin{itemize}
  \item examples of pathogenic, 17
  \item microorganisms, 7
  \item simple representation of cell, 16f
\end{itemize}
Mycoplasma pneumoniae, 14
Mycotoxins, 36
Myxobacteria, Gram-negative bacteria, 25
Myxococcus, gliding bacteria, 289
Naegleria, chlorine dioxide, 139
Nanoparticles, 162–163
Neisseria, Gram-negative bacteria, 24
Neisseria gonorrhoeae, 24, 347
Nematodes, disease associated with, 10
Nerve fiber, skin structure, 168f
Neuraminidases, 29
N-halamines
\begin{itemize}
  \item antimicrobial surfaces, 161
  \item chlorine-based, 162f
  \item halogen-releasing agents, 161–162
\end{itemize}
Nitrogen dioxide, 126
\begin{itemize}
  \item characteristics, 129
  \item chemical sterilization, 242–245
  \item gas sterilizer, 243f
  \item sterilization process, 244f
\end{itemize}
Nocardiaceae
\begin{itemize}
  \item cell wall, 26
  \item dormancy, 326
  \item Gram-positive, 20
  \item Gram-positive bacteria, 23
  \item Norwalk virus, viral persistence, 368
  \item Noxythiolin, aldehyde release, 93f
  \item Nucleic acid, heat denaturation, 271–272, 272f
\end{itemize}
Onchocerca volvulus
\begin{itemize}
  \item disease associated with, 10
  \item skin infection, 170
\end{itemize}
Orthomyxoviridae, viral diseases, 31
Ortho-phthalaldehyde (OPA)
\begin{itemize}
  \item advantages, 94
  \item applications, 91–92
  \item disadvantages, 95
  \item medical device disinfection with, 92f
  \item mode of action, 95–97, 268–269
  \item mutations and resistance, 353–355
  \item spectrum of activity, 93–94
  \item structure, 91
See also Aldehydes
Oxidizing agents
  major target sites for, 259f
  mode of action, 257–263
Oxygen
  compounds releasing, 127
  See also Ozone; Peroxygens and other forms of oxygen
OxyR (cellular protein), stress response, 292
Ozone, 126
  advantages, 139
  applications, 129–130
  characteristics, 127
  disadvantages, 140
  generators, 130f
  mode of action, 142
  spectrum of activity, 136–137
  sterilization, 240–242
  sterilizer, 241f
  See also Peroxygens and other forms of oxygen

Papovaviridae, viral diseases, 31
Parachlamydia, intrinsic resistance, 340
Paramaecium
  classification of, 15
  copper disinfection, 124
Parametric control, concept of, 49
Parasite, definition, 5
Parvoviridae
  classification, 29
  viral diseases, 31
Passive diffusion, 295
Pasteurellaceae, Gram-negative bacteria, 25
Pasteurization, 5, 64–65
Pathogen, definition, 5
Penicillin
  mechanisms of action, 341, 342f
  spectrum of activity and mode of action, 250
Penicillium
  acid disinfection, 88
  chloroxylenol, 150
  mycotoxins, 36
Penicillium chrysogenum, 12
Penicillium roquefortii, 12
Peptidoglycan, 18, 329–330
  basic structure of, 20f
  mycobacterial cell wall structure, 330f
Peracetic acid (PAA), 126
  advantages, 140
  applications, 134–135
  characteristics, 26–127
  disadvantages, 141
  gaseous PAA sterilization, 239–240
  generation of, 128f
  liquid, for sterilization, 234
  mode of action, 143
peptide bond breakage, 261
  spectrum of activity, 138–139
  temperature and sporicidal efficacy, 138f
  See also Peroxygens and other forms of oxygen
Peroxygens and other forms of oxygen
  advantages, 139–140
  applications, 129–136
  disadvantages, 140–142
  modes of action, 142–143
  spectrum of activity, 136–139
  types, 126–129
  See also Chlorine dioxide; Hydrogen peroxide for disinfection; Ozone; Peracetic acid (PAA)
Persistence, definition, 168
pH, microorganisms, 314–315
Phages, 165
Phenolics
  advantages, 145–146
  applications, 144–145
  chemical disinfection, 143–147
  disadvantages, 146
  disinfectants, 145f
  mode of action, 269–270
  modes of action, 146–147, 263
  spectrum of activity, 145
  structures, 143
  types, 144
  See also Antiseptic phenolics
Phychrobacter, extremophile, 313
Physical disinfection
  cold temperatures, 68
  filtration, 77–84
  heat, 61–68
  radiation, 68–77
Physical sterilization
  dry heat, 197–200
  plasma, 209–211
  pulsed electric fields, 214
  pulsed light, 211–213
  radiation, 200–209
  steam (moist-heat), 185–197
  supercritical fluids, 213–214
Phytophthora infestans, 12
Picornaviridae, viral diseases, 31
Piezophiles, 27
Pinus, essential oils, 109
Pityrosporum, salicylic acid, 150
Pityrosporum ovale, zinc pyrithione, 159
Plain soap, definition, 168
Plant extracts. See Essential oils and plant extracts
Plasma
  generation with oxygen gas, 210f
  physical sterilization, 209–211
Plasmid-encoded resistance, biocides, 355–366
Plasmodium
resistance mechanisms, 386–387
triclosan, 154
Plasmodium falciparum
classification of, 15
resistance mechanisms, 386
triclosan, 149, 150, 349
Pleomorphic, differentiation of, 17
Pneumocystis
diamides, 108
diamidines, 107
Poliovaccines, 368
Polioviruses, 368, 370
Polyhexamethylbiguanides (PHMBs), 104–106
Polymyxin B
spectrum of activity and mode of action, 250
target of, 249f
Poxviridae
classification, 29
viral diseases, 31
Preoperative preparation, definition, 168
Preservation, definition, 5
Pressure pulsing, 189, 190f
Pressure-vacuum pulsing, 189, 190f
Prions, 33–34
disinfection and sterilization methods against, 373
mechanisms of resistance, 374f
microorganisms, 7
proposed secondary structure, 33f
resistance mechanisms, 372–376
steam sterilization cycles for inactivation, 196
term, 32
theory of, 33f
Proflavine, 102f
Prokaryotes, 14–28
archaea, 26–28
basic structure of bacterial cell, 18f, 19f
eubacteria, 14, 16–18, 20–21, 26
eukaryotes and, 8
general structure, 9
Gram-negative bacteria examples, 24–25
Gram-positive bacteria examples, 22–23
Propionibacterium
Gram-positive bacteria, 23
salicylic acid, 150
skin florases, 169
Propionibacterium acnes
bacteria, 16
biofilm formation, 304
hydrogen peroxide, 131, 138
skin infection, 170
Propylene oxide, 215, 216
spectrum of activity, 219–221
See also Epoxides
Proteins, biocides changing, 282
Proteus, intrinsic resistance, 337, 339
Proteus mirabilis, chlorhexidine, 350
Protochlamydia, intrinsic resistance, 340
Protozoa, 13–14
classification of, 15
microorganisms, 7
Providencia stuartii
chlorhexidine, 181
intrinsic resistance, 339
Pseudomonas
acid disinfection, 88
alcohol disinfection, 98
aldehyde disinfection, 94
antimicrobial enzymes, 164
bacteria, 16
biofilm formation, 304, 307, 309
bisphenols, 149–150
capsules and slime layers, 303
chloroxylenol, 182
copper resistance, 360
diamides, 108
efflux, 296–298
electrolyzed water sterilization, 236
endotoxins, 35
enzymatic and chemical protection, 299,
299–300
essential oils, 109
extremophile, 313
Gram-negative bacteria, 24
intrinsic resistance to heavy metals, 301–302
intrinsic resistance, 337
isothiazolinone derivatives, 160
mercury resistance, 356
multiple antibiotic resistance, 347
plasmid-mediated resistance, 361, 363
radiation, 206
silver resistance, 358, 360
stress response, 290
triclosan, 154, 349
wound infection, 174
Pseudomonas aeruginosa
antiseptic phenolics, 147
biguanides, 105, 107
biofilm formation, 304, 306, 308
copper disinfection, 123
diamides, 108
efflux, 298–299
intrinsic resistance, 337–340
mutation resistance, 351–353, 355
plasmid-mediated resistance, 361
skin infection, 170
triclosan, 154, 349
Pseudomonas putida, efflux, 298
Pseudomonas stutzerchl
chlorhexidine, 350
silver disinfection, 124
Psychrophiles, 312–314
Pulsed electric fields, sterilization, 214
Pulsed light, physical sterilization, 211–213
Pyritinones, 159, 176
Pyrococcus, 28, 207, 311
Pyrogen, definition, 5
Pyrolobus fumarii, extremophile, 313
Pyronema, fungal resistance, 385
Pyronema domestica: epoxide for sterilization, 220, 221
fungal resistance, 381
Quaternary ammonium compounds (QACs) and surfactants
advantages, 158
antimicrobial efficacy, 157–158
applications, 156–157
basic structure, 157f
biocide as antiseptic, 176
chemical disinfection, 155–159
disadvantages, 158
mode of action, 158–159, 280–281
mutations and resistance, 352–353
QAC-based disinfectants, 157f
types, 155–156
Quinolones
mechanism of action, 250
target of, 249f
Radiation
advantages, 75–76
applications, 73–74
bacteria with extreme intrinsic resistance, 310–312
Deinococcus radiodurans survival of, 311f
disadvantages, 76
electromagnetic radiation, 69–70
infrared, 72, 74, 75, 76, 77
ionizing and nonionizing, 274f
isotopes, 68–69
microwave, 72–73, 74, 75–76, 77
mode of action, 76–77
spectrum of activity, 74–75
transfer of energy, 273–276
types, 71
ultraviolet, 71–72, 73–74, 74–75, 76–77
Radiation sterilization
advantages, 208
applications, 203–206
cesium-137 (137Cs), 201, 202
cobalt-60 (60Co) generation and decay, 201f
disadvantages, 208–209
generation of X-rays, 202f
iridium-192 (192Ir), 201–202
mode of action, 209
spectrum of activity, 206–208
types, 200–203
Ralstonia eutropha, plasmid-mediated resistance, 360, 361
Reference microorganism, definition, 5
Resistance, definition, 5
Retroviridae
classification, 29
viral diseases, 31
Revival mechanisms, microorganisms, 327–329
Rhabdoviridae, viral diseases, 31
Rhodoturula, fungal resistance, 379, 380, 382
Ribonucleic acid (RNA)
heat denaturation, 271
polynucleotides, 255, 257f
radiation, 274–275
viruses, 369–372
Rickettsia
Gram-negative bacteria, 25
intrinsic resistance, 340
microorganisms, 7
Rickettsia prowazekii, 21
Rickettsia typhi, 21
Rubrobacter
radiation, 207
radiation resistance, 311
Saccharomyces, 12
acid disinfection, 88
intrinsic resistance to heavy metals, 301
Saccharomyces cerevisiae, 12
fungal resistance, 378–379
isothiazolinone derivatives, 160
plasmid-mediated resistance, 362
Safety data sheet (SDS), definition, 5
Salicylic acid
applications, 149
biocide as antiseptic, 176
disadvantages, 152
mode of action, 154–155
structure, 147
Salmonella
biguanides, 105
chlorine disinfection, 116
endotoxins, 35
flagella, 289
Gram-negative bacteria, 25
intrinsic resistance, 340
silver resistance, 358–360
stress response, 290
triclosan tolerance, 346–347
Salmonella enterica, chlorhexidine, 351
Salmonella enterica serovar Typhi, chlorine, 116
Salmonella enterica serovar Typhimurium, radiation, 208
Salmonella enterica, serovar Typhimurium 338
SAL (sterility assurance level), definition, 5, 51
Sanitization, definition, 5
Schistosoma, disease associated with, 10
Schizosaccharomyces, 12, 385
Sebaceous gland, skin structure, 168f
Secondary metabolites, definition, 5
Serratia, silver resistance, 358
Serratia marcescens
biofilm formation, 307
mutants, 344, 350, 353
Shigella, endotoxins, 35
Silver, 121
advantages, 124
antimicrobial surfaces, 161
applications, 123
characteristics, 121–122
disadvantages, 124–125
mode of action, 125–126, 278–279
silver sulfadiazine, 122f
spectrum of activity, 124
Skin
antiseptic applications, 169–177
common or notable infections, 170
cross-section of structure, 168f
microbiology, 169
penetration of chlorhexidine, 180f
pretreatment prior to surgical intervention, 173–174
routine hygiene, 170–173
structure of, 168–169
treatment of infections, 174–176
treatment of oral and other membranes, 177
Soil, definition, 5
Spaulding classification, 52
Sphacia, hydrogen peroxide, 138, 232
Spirals, differentiation of, 17
Sporulation, definition, 5
Sporulation process, 322f
Stachybotrys, mycotoxins, 36
Staphylococcus
antimicrobial dyes, 103
bacteriophages, 165
biofilms, 309
bisphenols, 150
diamides, 108
Gram-positive, 20
heat, 62
intrinsic resistance, 334–337
multiple antibiotic resistance, 347
mutation resistance, 345
phenolics, 146
resistance mechanisms, 387
skin floras, 169
wound infection, 174
Staphylococcus aureus
bactericidal activity of glutaraldehyde, 267
biofilm formation, 304
copper disinfection, 123
efflux, 297–298
Gram-positive bacteria, 22, 333
intrinsic resistance, 337
mutants, 345
peptidoglycan, 18
plasmid-mediated resistance, 360, 363
silver disinfection, 123
skin infection, 169, 170
susceptibility to antiseptics and disinfectants, 362
triclosan, 152, 154, 345
Staphylococcus epidermidis
biofilm formation, 304
capsules and slime layers, 303
Gram-positive bacteria, 22
plasmid-mediated resistance, 365
skin floras, 169
Staphylococcus xylosus, plasmid-mediated resistance, 360
-Static, definition, 5–6
Steam sterilization, 185–197
advantages, 196
air removal, 189–190
applications, 192–193
cycles for prion inactivation, 196
disadvantages, 196–197
downward-displacement autoclaves, 188
forced displacement, 189
mode of action, 197
pressure pulsing, 189
pressure-vacuum pulsing, 189
prions, 373
relationship between steam temperature and pressure, 186f
spectrum of activity, 193–196
standards and guidelines for, 194
steam purity, 191
types, 187–192
upward-displacement autoclaves, 187–188
vacuum and pressure-pulsing autoclaves, 188–189
water content, 190–191
Sterile, definition, 6
Sterile barrier system, definition, 6
Sterilization
importance of cleaning, 57–59
microorganisms, 50–52
standards and guidelines, 54
water quality, 59–60
Sterilizer, definition, 6
Sterilizing agent, definition, 6
Streptococcus
antimicrobial enzymes, 164
heat, 62
intrinsic resistance, 334–335
isothiazolinoine derivatives, 160
phenolics, 146
Streptococcus mutans
biofilm formation, 304
capsules and slime layers, 303
chlorhexidine resistance, 366  
glycocalyx structures, 21  
*Streptococcus pneumoniae*  
eflux, 297–298  
glycocalyx structures, 21  
*Streptococcus pyogenes*, skin infection, 170  
*Streptococcus sanguis*, chlorhexidine resistance, 366  
*Streptococcus sobrinus*, biofilm formation, 304  
*Streptomycetes*  
dormancy, 326  
Gram-positive bacteria, 20, 23  
life cycle of, 326f  
stress response, 291  
*Streptomyces coelicolor*, dormancy, 326  
*Streptomycin*, 23, 250, 358  
*Stumbo-Murphy-Cochran equation*, 42  
*Sulfapyridine*, spectrum of activity and mode of action, 250  
*Sulfonamides*  
acquired resistance mechanisms, 343  
mechanism of action, 250  
target of, 249f  
Supercritical fluids, sterilization, 213–214  
Surfaces, biocides integrated into, 160–162  
Surface testing, antimicrobial activity, 43–44  
*Surfactants*  
classification of, 156  
mode of action, 280–281  
structures of, 56f, 156f  
types, 155–156, 276  
See also Quaternary ammonium compounds (QACs) and surfactants  
Surgical scrub, definition, 168  
Suspension testing, efficacy, 38–43  
Sweat gland, skin structure, 168f  

*Taenia saginata*, disease associated with, 10  
*Talaromyces*, 384  
Tapeworms, disease associated with, 10  
*Taurolin*, aldehyde release, 93f  
*Tetracycline*  
acquired resistance mechanisms, 343  
mechanism of action, 250  
target of, 249f  
*Thermococcus*, radiation, 207  
*Thermococcus gammatolerans*, radiation resistance, 311  
*Thermocrinis ruber*, heat activity, 67  
Thermophiles, 27, 312–316  
*Thermoplasma*, 27  
*Thermotoga maritima*, heat activity, 67  
*Thermus aquaticus*, heat activity, 67  
*Thiobacillus*, mercury resistance, 356  
*Thiomonas*, intrinsic resistance to heavy metals, 301–302  

Time-kill (D-value) determinations, 39–42  
Titanium dioxide, 160–161  
antimicrobial surfaces, 161  
nanoparticles, 163  
Tolerance, definition, 6  
Toxins, 34–36  
*Toxoplasma*, resistance mechanisms, 387  
*Toxoplasma gondii*  
classification of, 15  
life cycle of, 16f  
triclosan, 149, 150  
Transposons, bacterial resistance, 342–343  
Trematodes, disease associated with, 10  
*Treponema*, 24  
*Treponema palladium*, generation time, 289  
*Treponema pallidum*, skin infection, 170  
*Trichophyton*  
acid disinfection, 88  
anilide disinfection, 100  
antimicrobial dyes, 102  
esential oils, 110  
salicylic acid, 150  
*Trichophyton mentagrophytes*, 12  
Triclocarban, 100  
Triclosan  
advantages, 150–151  
antimicrobial surfaces, 161  
antiseptic in wash, 182–183  
applications, 148–149  
bacterial tolerance, 346f  
disadvantages, 151–152  
mode of action, 152–154, 282–283  
mutation resistance of bacteria, 345–347  
structure, 147f  
*Trypanosoma*  
diamides, 108  
triclosan, 154  
*Trypanosoma brucei*, triclosan, 149, 150  
*Trypanosoma gambiense*, classification of, 15  
Ultra-high-temperature (UHT) processing, 64–65  
Ultraviolet (UV) radiation, 71–72  
advantages, 75  
aplications, 73–74  
disadvantages, 76  
mode of action, 76–77  
representation of, 71f  
spectrum of activity, 74–75  
types, 72  
Unicellular fungi, 12  
Upward-displacement autoclaves, 187–188  
Validation, definition, 6  
Vancomycin, spectrum of activity and mode of action, 250  
Varicella-zoster virus, skin infection, 170
Veillonella, 17, 25
Verification, definition, 6
Viable, definition, 6
Vibrio
dormancy, 317
Gram-negative bacteria, 25
stress response, 291
Vibrio cholerae, chlorine, 116
Vibrionaceae, Gram-negative bacteria, 25
Vibrio parahaemolyticus, mutation resistance, 347
Viral resistance, mechanisms, 366–372
Viruses, 28–33
basic structure, 28f
capsid, 369
classification of viral families, 29
enveloped, 28–29, 368–369
examples of viral diseases, 31
microorganisms, 7
nonenveloped, 28, 369–370
particles, 368–369
resistance mechanisms, 366–372
typical life cycle, 30f
Water
quality, 59–60
See also Electrolyzed water
Wound, definition, 168
Wucheria bancrofti, disease associated with, 10
Xenopus laevis, antimicrobial peptides, 165
Yersinia, Gram-negative bacteria, 25
Zinc pyrithione, 159, 176
Z value, 62, 64f