

Contents

CHAPTER 1 The Main Themes of Microbiology 1

- 1.1 The Scope of Microbiology 2
- 1.2 The Impact of Microbes on Earth: Small Organisms with a Giant Effect 2
 - Microbial Involvement in Energy and Nutrient Flow 4
- 1.3 Human Use of Microorganisms 5
- 1.4 Infectious Diseases and the Human Condition 8
- 1.5 The General Characteristics of Microorganisms 9
 - Cellular Organization 9
 - Microbial Dimensions: How Small Is Small? 11
 - Lifestyles of Microorganisms 12
- 1.6 The Historical Foundations of Microbiology 13
 - The Development of the Microscope: "Seeing Is Believing" 13
 - The Establishment of the Scientific Method 14
 - The Development of Medical Microbiology 16
 - The Discovery of Spores and Sterilization 16
- 1.7 Taxonomy: Organizing, Classifying, and Naming Microorganisms 19
 - The Levels of Classification 19
 - Assigning Specific Names 19
 - The Origin and Evolution of Microorganisms 21
 - Systems of Presenting a Universal Tree of Life 21

■ **INSIGHT 1.1: Discovery**
Martian Microbes and Astrobiology 7

■ **INSIGHT 1.2: Historical**
The More Things Change ... 11

■ **INSIGHT 1.3: Historical**
The Fall of Superstition and the Rise of Microbiology 14

Chapter Summary with Key Terms 24
Multiple-Choice Questions 24
Concept Questions 25
Critical-Thinking Questions 25
Internet Search Topics 26

CHAPTER 2 The Chemistry of Biology 27

- 2.1 Atoms, Bonds, and Molecules: Fundamental Building Blocks 28
 - Different Types of Atoms: Elements and Their Properties 29
 - The Major Elements of Life and Their Primary Characteristics 29
 - Bonds and Molecules 31
- 2.2 Macromolecules: Superstructures of Life 41
 - Carbohydrates: Sugars and Polysaccharides 42

- Lipids: Fats, Phospholipids, and Waxes 45
- Proteins: Shapers of Life 47
- The Nucleic Acids: A Cell Computer and Its Programs 50
- The Double Helix of DNA 50

■ **INSIGHT 2.1: Microbiology**
Searching for Ancient Life with Isotopes 29

Chapter Summary with Key Terms 55
Multiple-Choice Questions 56
Concept Questions 57
Critical-Thinking Questions 58
Internet Search Topics 58

CHAPTER 3 Tools of the Laboratory: The Methods for Studying Microorganisms 59

- 3.1 Methods of Culturing Microorganisms—The Five "T"s 60
 - Inoculation: Producing a Culture 60
 - Isolation: Separating One Species from Another 60
 - Media: Providing Nutrients in the Laboratory 62
 - Incubation, Inspection, and Identification 71
- 3.2 The Microscope: Window on an Invisible Realm 73
 - Magnification and Microscope Design 73
 - Variations on the Optical Microscope 76
 - Electron Microscopy 79
 - Preparing Specimens for Optical Microscopes 81

■ **INSIGHT 3.1: Discovery**
The Uncultured 67

■ **INSIGHT 3.2: Medical**
Animal Inoculation: "Living Media" 71

■ **INSIGHT 3.3: Discovery**
The Evolution in Resolution: Probing Microscopes 82

Chapter Summary with Key Terms 86
Multiple-Choice Questions 86
Concept Questions 87
Critical-Thinking Questions 88
Internet Search Topics 88

CHAPTER 4 An Introduction to Cells and Prokaryotic Cell Structure and Function 89

- 4.1 Characteristics of Cells and Life 90
 - What Is Life? 90
- 4.2 Prokaryotic Profiles: The Bacteria and Archaea 91
 - The Structure of a Generalized Bacterial Cell 91

- 4.3 **External Structures** 91
 Appendages: Cell Extensions 91
- 4.4 **The Cell Envelope: The Boundary Layer of Bacteria** 97
 Differences in Cell Envelope Structure 97
 Structure of Cell Walls 98
 Mycoplasmas and Other Cell-Wall-Deficient Bacteria 102
 Cell Membrane Structure 102
- 4.5 **Bacterial Internal Structure** 103
 Contents of the Cell Cytoplasm 103
 Bacterial Endospores: An Extremely Resistant Life Form 105
- 4.6 **Bacterial Shapes, Arrangements, and Sizes** 107
- 4.7 **Classification Systems in the Prokaryotae** 111
 Bacterial Taxonomy Based on *Bergey's Manual* 112
 Survey of Prokaryotic Groups with Unusual Characteristics 113
 Free-Living Nonpathogenic Bacteria 113
 Unusual Forms of Medically Significant Bacteria 117
- 4.8 **Archaea: The Other Prokaryotes** 117

INSIGHT 4.1: Discovery

Biofilms—The Glue of Life 96

INSIGHT 4.2: Discovery

The Gram Stain: A Grand Stain 98

INSIGHT 4.3: Discovery

Redefining Bacterial Size 115

Chapter Summary with Key Terms 119

Multiple-Choice Questions 120

Concept Questions 121

Critical-Thinking Questions 122

Internet Search Topics 122

CHAPTER 5 Eucaryotic Cells and Microorganisms 123

- 5.1 **The History of Eucaryotes** 124
- 5.2 **Form and Function of the Eucaryotic Cell:**
External Structures 126
 Locomotor Appendages: Cilia and Flagella 126
 The Glycocalyx 127
 Form and Function of the Eucaryotic Cell:
 Boundary Structures 128
- 5.3 **Form and Function of the Eucaryotic Cell:**
Internal Structures 129
 The Nucleus: The Control Center 129
 Endoplasmic Reticulum: A Passageway in the Cell 130
 Golgi Apparatus: A Packaging Machine 130
 Mitochondria: Energy Generators of the Cell 132
 Chloroplasts: Photosynthesis Machines 133
 Ribosomes: Protein Synthesizers 134
 The Cytoskeleton: A Support Network 134
 Survey of Eucaryotic Microorganisms 135
- 5.4 **The Kingdom of the Fungi** 136
 Fungal Nutrition 137
 Organization of Microscopic Fungi 138

Reproductive Strategies and Spore Formation 140

Fungal Classification 143

Fungal Identification and Cultivation 145

The Roles of Fungi in Nature and Industry 145

5.5 The Protists 146

The Algae: Photosynthetic Protists 146

Biology of the Protozoa 147

5.6 The Parasitic Helminths 153

General Worm Morphology 153

Life Cycles and Reproduction 153

A Helminth Cycle: The Pinworm 154

Helminth Classification and Identification 155

Distribution and Importance of Parasitic

Worms 155

INSIGHT 5.1: Historical

The Extraordinary Emergence of Eucaryotic Cells 125

INSIGHT 5.2: Discovery

Fungi: A Force of Nature 139

Chapter Summary with Key Terms 156

Multiple-Choice Questions 156

Concept Questions 157

Critical-Thinking Questions 158

Internet Search Topics 158

CHAPTER 6 An Introduction to the Viruses 159

6.1 **The Search for the Elusive Viruses** 160

6.2 **The Position of Viruses in the Biological Spectrum** 160

6.3 **The General Structure of Viruses** 161

Size Range 161

Viral Components: Capsids, Nucleic Acids, and Envelopes 162

6.4 **How Viruses Are Classified and Named** 168

6.5 **Modes of Viral Multiplication** 170

Multiplication Cycles in Animal Viruses 170

The Multiplication Cycle in Bacteriophages 175

6.6 **Techniques in Cultivating and Identifying Animal Viruses** 178

Using Cell (Tissue) Culture Techniques 178

Using Bird Embryos 179

Using Live Animal Inoculation 180

6.7 **Medical Importance of Viruses** 180

6.8 **Prions and Other Nonviral Infectious Particles** 181

6.9 **Detection and Treatment of Animal Viral Infections** 182

INSIGHT 6.1: Discovery

An Alternate View of Viruses 161

INSIGHT 6.2: Discovery

Artificial Viruses Created! 180

INSIGHT 6.3: Medical

Uncommon Facts About the Common Cold 181

Chapter Summary with Key Terms 183

Multiple-Choice Questions 184

Concept Questions 185

Critical-Thinking Questions 186

Internet Search Topics 186

CHAPTER 7 Elements of Microbial Nutrition, Ecology, and Growth 187

7.1 Microbial Nutrition 188

Chemical Analysis of Microbial Cytoplasm 190

Sources of Essential Nutrients 190

Transport: Movement of Chemicals Across the Cell

Membrane 195

The Diffusion of Water: Osmosis 196

Endocytosis: Eating and Drinking by Cells 198

7.2 Environmental Factors That Influence Microbes 200

Adaptations to Temperature 200

Gas Requirements 203

Effects of pH 205

Osmotic Pressure 205

Miscellaneous Environmental Factors 205

Ecological Associations Among Microorganisms 206

Interrelationships Between Microbes and

Humans 208

7.3 The Study of Microbial Growth 209

The Basis of Population Growth: Binary Fission 209

The Rate of Population Growth 209

The Population Growth Curve 211

Stages in the Normal Growth Curve 211

Other Methods of Analyzing Population Growth 213

INSIGHT 7.1: Discovery

Dining with an Ameba 189

INSIGHT 7.2: Discovery

Light-Driven Organic Synthesis 193

INSIGHT 7.3: Discovery

Life in the Extremes 201

INSIGHT 7.4: Discovery

Cashing in on "Hot" Microbes 203

INSIGHT 7.5: Discovery

Mutualism: Merging Life Forms 206

INSIGHT 7.6: Microbiology

Steps in a Viable Plate Count—Batch Culture Method 212

Chapter Summary with Key Terms 215

Multiple-Choice Questions 216

Concept Questions 216

Critical-Thinking Questions 217

Internet Search Topics 218

CHAPTER 8 Microbial Metabolism 219

8.1 The Metabolism of Microbes 220

Enzymes: Catalyzing the Chemical Reactions of Life 220

Regulation of Enzymatic Activity and Metabolic Pathways 228

8.2 The Pursuit and Utilization of Energy 230

Cell Energetics 230

A Closer Look at Biological Oxidation and Reduction 231

Adenosine Triphosphate: Metabolic Money 232

8.3 Pathways of Bioenergetics 233

Catabolism: An Overview of Nutrient Breakdown and Energy Release 234

Energy Strategies in Microorganisms 235

Pyruvic Acid—A Central Metabolite 238

The Tricarboxylic Acid Cycle—A Carbon and Energy Wheel 238

The Respiratory Chain: Electron Transport and Oxidative Phosphorylation 241

Summary of Aerobic Respiration 244

Anaerobic Respiration 245

The Importance of Fermentation 245

8.4 Biosynthesis and the Crossing Pathways of Metabolism 248

The Frugality of the Cell—Waste Not,

Want Not 248

INSIGHT 8.1: Discovery

Enzymes as Biochemical Levers 221

INSIGHT 8.2: Discovery

Unconventional Enzymes 222

INSIGHT 8.3: Discovery

The Enzyme Name Game 226

INSIGHT 8.4: Historical

Pasteur and the Wine-to-Vinegar Connection 246

INSIGHT 8.5: Discovery

Fermentation and Biochemical Testing 247

Chapter Summary with Key Terms 250

Multiple-Choice Questions 251

Concept Questions 252

Critical-Thinking Questions 253

Internet Search Topics 254

CHAPTER 9 Microbial Genetics 255

9.1 Introduction to Genetics and Genes:

Unlocking the Secrets of Heredity 256

The Nature of the Genetic Material 256

The DNA Code: A Simple Yet Profound Message 258

The Significance of DNA Structure 261

DNA Replication: Preserving the Code and Passing It On 261

9.2 Applications of the DNA Code:

Transcription and Translation 264

The Gene-Protein Connection 264

The Major Participants in Transcription and Translation 265

Transcription: The First Stage of Gene

Expression 267

Translation: The Second Stage of Gene Expression 268

Eucaryotic Transcription and Translation:

Similar Yet Different 272

The Genetics of Animal Viruses 273

9.3 Genetic Regulation of Protein Synthesis and Metabolism 274

The Lactose Operon: A Model for Inducible Gene Regulation in Bacteria 276

A Repressible Operon 277

Antibiotics That Affect Transcription and Translation 277

- 9.4 Mutations: Changes in the Genetic Code** 278
 Causes of Mutations 279
 Categories of Mutations 279
 Repair of Mutations 280
 The Ames Test 281
 Positive and Negative Effects of Mutations 281

- 9.5 DNA Recombination Events** 282
 Transmission of Genetic Material in Bacteria 282

INSIGHT 9.1: Discovery

- The Packaging of DNA: Winding, Twisting, and Coiling 257

INSIGHT 9.2: Historical

- Deciphering the Structure of DNA 259

INSIGHT 9.3: Discovery

- Revising Some Rules of Genetics 266

INSIGHT 9.4: Medical

- Replication Strategies in Animal Viruses 274

Chapter Summary with Key Terms 287

Multiple-Choice Questions 288

Concept Questions 289

Critical-Thinking Questions 290

Internet Search Topics 290

CHAPTER 10 Genetic Engineering 291

- 10.1 Basic Elements and Applications of Genetic Engineering** 292

- 10.2 Tools and Techniques of Genetic Engineering** 292
 Practical Properties of DNA 292

- 10.3 Methods in Recombinant DNA Technology:**
How to Imitate Nature 300

Technical Aspects of Recombinant DNA and Gene Cloning 300

Construction of a Recombinant, Insertion into a Cloning Host, and Genetic Expression 302

- 10.4 Biochemical Products of Recombinant DNA Technology** 302

- 10.5 Genetically Modified Organisms** 304
 Recombinant Microbes: Modified Bacteria and Viruses 304

Transgenic Plants 305

Transgenic Animals: Engineering Embryos 306

- 10.6 Genome Analysis: Fingerprints and Genetic Testing** 307

DNA Fingerprinting: A Unique Picture of a Genome 309

- INSIGHT 10.1: Discovery**
 Okay, the Genome's Sequenced—What's Next? 297

- INSIGHT 10.2: Discovery**
 Of Mice and Men (and Herbicide-Resistant Plants) 306

- INSIGHT 10.3: Microbiology**
 A Moment to Think 309

Chapter Summary with Key Terms 312

Multiple-Choice Questions 313

Concept Questions 313

Critical-Thinking Questions 314

Internet Search Topics 314

CHAPTER 11 Physical and Chemical Agents for Microbial Control 315

- 11.1 Controlling Microorganisms** 316

General Considerations in Microbial Control 316

Relative Resistance of Microbial Forms 316

Terminology and Methods of Microbial Control 317

What Is Microbial Death? 319

How Antimicrobial Agents Work: Their Modes of Action 321

- 11.2 Methods of Physical Control** 322

Heat as an Agent of Microbial Control 322

The Effects of Cold and Dessiccation 326

Radiation as a Microbial Control Agent 326

Sterilization by Filtration: Techniques for Removing Microbes 328

- 11.3 Chemical Agents in Microbial Control** 330

Choosing a Microbicidal Chemical 330

Factors That Affect the Germicidal Activity of Chemicals 332

Germicidal Categories According to Chemical Group 332

INSIGHT 11.1: Historical

Microbial Control in Ancient Times 317

INSIGHT 11.2: Microbiology

Pathogen Paranoia: "The Only Good Microbe Is a Dead Microbe" 330

INSIGHT 11.3: Medical

The Quest for Sterile Skin 336

INSIGHT 11.4: Microbiology

Decontaminating Congress 340

Chapter Summary with Key Terms 341

Multiple-Choice Questions 342

Concept Questions 343

Critical-Thinking Questions 343

Internet Search Topics 344

CHAPTER 12 Drugs, Microbes, Host—The Elements of Chemotherapy 345

- 12.1 Principles of Antimicrobial Therapy** 346

The Origins of Antimicrobial Drugs 346

- 12.2 Interactions Between Drug and Microbe** 348

Mechanisms of Drug Action 348

- 12.3 Survey of Major Antimicrobial Drug Groups** 354

Antibacterial Drugs That Act on the Cell Wall 354

Antibiotics That Damage Bacterial Cell Membranes 357

Drugs That Act on DNA or RNA 357

Drugs That Interfere with Protein Synthesis 358

Drugs That Block Metabolic Pathways 359

Agents to Treat Fungal Infections 360

Antiparasitic Chemotherapy 360

Interactions Between Microbes and Drugs: The Acquisition of

Drug Resistance 364

New Approaches to Antimicrobial Therapy 367

12.4 Interaction Between Drug and Host 370
Toxicity to Organs 370
Allergic Responses to Drugs 370
Suppression and Alteration of the Microflora by Antimicrobials 370

12.5 Considerations in Selecting an Antimicrobial Drug 372
Identifying the Agent 372
Testing for the Drug Susceptibility of Microorganisms 372
The MIC and Therapeutic Index 373

INSIGHT 12.1: Historical
From Witchcraft to Wonder Drugs 347

INSIGHT 12.2: Discovery
A Modern Quest for Designer Drugs 355

INSIGHT 12.3: Discovery
Household Remedies—From Apples to Zinc 363

INSIGHT 12.4: Medical
The Rise of Drug Resistance 368

Chapter Summary with Key Terms 377
Multiple-Choice Questions 378
Concept Questions 379
Critical-Thinking Questions 379
Internet Search Topics 380

CHAPTER 13 Microbe–Human Interactions 381

13.1 We Are Not Alone 382
Contact, Colonization, Infection, Disease 382
Resident Flora: The Human as a Habitat 382
Indigenous Flora of Specific Regions 384
Flora of the Human Skin 384
Flora of the Gastrointestinal Tract 386
Flora of the Respiratory Tract 387
Flora of the Genitourinary Tract 387

13.2 Major Factors in the Development of an Infection 388
Becoming Established: Step One—Portals of Entry 390
The Requirement for an Infectious Dose 393
Becoming Established: Step Two—Attaching to the Host 394
Becoming Established: Step Three—Surviving Host Defenses 394
Causing Disease 395
The Process of Infection and Disease 399
Signs and Symptoms: Warning Signals of Disease 401
The Portal of Exit: Vacating the Host 402
The Persistence of Microbes and Pathologic Conditions 403

13.3 Sources and Spread of Microbes 403
Reservoirs: Where Pathogens Persist 403
The Acquisition and Transmission of Infectious Agents 406
Nosocomial Infections: The Hospital as a Source of Disease 408
Universal Blood and Body Fluid Precautions 409

13.4 Epidemiology: The Study of Disease in Populations 410
Who, When, and Where? Tracking Disease in the Population 410

INSIGHT 13.1: Discovery
Life Without Flora 389

INSIGHT 13.2: Medical
Laboratory Biosafety Levels and Classes of Pathogens 391

INSIGHT 13.3: Historical
Human Guinea Pigs 396

INSIGHT 13.4: Medical
A Quick Guide to the Terminology of Infection and Disease 401

INSIGHT 13.5: Medical
Koch's Postulates: Solving the Puzzle of New Diseases 414

Chapter Summary with Key Terms 415
Multiple-Choice Questions 416
Concept Questions 417
Critical-Thinking Questions 418
Internet Search Topics 418

CHAPTER 14 Nonspecific Host Defenses 419

14.1 Defense Mechanisms of the Host in Perspective 420
Barriers at the Portal of Entry: A First Line of Defense 420

14.2 Structure and Function of the Organ of Defense and Immunity 422
The Communicating Body Compartments 423

14.3 Actions of the Second Line of Defense 431
Recognition: Activation of the Innate Immunological Response 432
The Inflammatory Response: A Complex Concert of Reactions to Injury 432
The Stages of Inflammation 433
Phagocytosis: Partner to Inflammation and Immunity 438
Interferon: Antiviral Cytokines and Immune Stimulants 439
Complement: A Versatile Backup System 441
Overall Stages in the Complement Cascade 441
Summary of Host Defenses 443

INSIGHT 14.1: Medical
When Inflammation Gets Out of Hand 434

INSIGHT 14.2: Medical
The Dynamics of Inflammatory Mediators 436

INSIGHT 14.3: Medical
Some Facts About Fever 437

Chapter Summary with Key Terms 444
Multiple-Choice Questions 444
Concept Questions 445
Critical-Thinking Questions 446
Internet Search Topics 446

CHAPTER 15 Adaptive, Specific Immunity and Immunization 447

15.1 Specific Immunity: The Adaptive Line of Defense 448

A General Scheme for Classifying Immunities 448

An Overview of Specific Immune Responses 450

15.2 Development of the Immune Response System 452

Markers on Cell Surfaces Involved in Recognition of Self and Nonself 452

The Origin of Diversity and Specificity in the Immune Response 453

15.3 Lymphocyte Responses and Antigens 455

Specific Events in B-Cell Maturation 455

Specific Events in T-Cell Maturation 456

Entrance and Processing of Antigens and Clonal Selection 456

15.4 Cooperation in Immune Reactions to Antigens 457

The Role of Antigen Processing and Presentation to Lymphocytes 458

15.5 B-Cell Responses 459

Activation of B Lymphocytes: Clonal Expansion and Antibody Production 459

Products of B Lymphocytes: Antibody Structure and Functions 459

Monoclonal Antibodies: Useful Products from Cancer Cells 463

15.6 T-Cell Responses 464

Cell-Mediated Immunity (CMI) 464

15.7 Immunization: Methods of Manipulating Immunity for Therapeutic Purposes 468

Passive Immunization 468

Artificial Active Immunity: Vaccination 469

Development of New Vaccines 469

Route of Administration and Side Effects of Vaccines 473

To Vaccinate: Why, Whom, and When? 473

INSIGHT 15.1: Historical

Breast Feeding: The Gift of Antibodies 450

INSIGHT 15.2: Medical

Monoclonal Antibodies: Variety Without Limit 465

INSIGHT 15.3: Historical

The Lively History of Active Immunization 472

Chapter Summary with Key Terms 477

Multiple-Choice Questions 478

Concept Questions 479

Critical-Thinking Questions 480

Internet Search Topics 480

CHAPTER 16 Disorders in Immunity 481

16.1 The Immune Response: A Two-Sided Coin 482

Overreactions to Antigens: Allergy/Hypersensitivity 483

16.2 Type I Allergic Reactions: Atopy and Anaphylaxis 483

Modes of Contact with Allergens 484

The Nature of Allergens and Their Portals of Entry 484

Mechanisms of Type I Allergy: Sensitization and Provocation 484

Cytokines, Target Organs, and Allergic Symptoms 486

Specific Diseases Associated with IgE- and Mast Cell-Mediated Allergy 488

Anaphylaxis: An Overpowering Systemic Reaction 489

Diagnosis of Allergy 489

Treatment and Prevention of Allergy 490

16.3 Type II Hypersensitivities: Reactions That Lyse Foreign Cells 492

The Basis of Human ABO Antigens and Blood Types 492

Antibodies Against A and B Antigens 493

The Rh Factor and Its Clinical Importance 494

Other RBC Antigens 495

16.4 Type III Hypersensitivities: Immune Complex Reactions 496

Mechanisms of Immune Complex Disease 496

Types of Immune Complex Disease 496

16.5 Immunopathologies Involving T Cells 497

Type IV Delayed-Type Hypersensitivity 497

T Cells and Their Role in Organ Transplantation 499

Types of Transplants 501

16.6 Autoimmune Diseases—An Attack on Self 502

Genetic and Gender Correlation in Autoimmune Disease 502

The Origins of Autoimmune Disease 502

Examples of Autoimmune Disease 503

16.7 Immunodeficiency Diseases: Hyposensitivity of the Immune System 505

Primary Immunodeficiency Diseases 506

Secondary Immunodeficiency Diseases 507

16.8 The Function of the Immune System in Cancer 508

INSIGHT 16.1: Medical

Of What Value Is Allergy? 488

INSIGHT 16.2: Medical

Why Doesn't a Mother Reject Her Fetus? 496

INSIGHT 16.3: Medical

Pretty, Pesky, Poisonous Plants 498

INSIGHT 16.4: Medical

The Gift of Life: Bone Marrow Transplantation 501

INSIGHT 16.5: Discovery

An Answer to the Mystery of David 508

Chapter Summary with Key Terms 509

Multiple-Choice Questions 511

Concept Questions 511

Critical-Thinking Questions 512

Internet Search Topics 512

CHAPTER 17 Diagnosing Infections 513

17.1 Preparation for the Survey of Microbial Diseases 514

Phenotypic Methods 514

Genotypic Methods 514

Immunological Methods 514

17.2 On the Track of the Infectious Agent: Specimen Collection 514

Overview of Laboratory Techniques 515

17.3 **Phenotypic Methods** 517
Immediate Direct Examination of Specimen 517
Cultivation of Specimen 517

17.4 **Genotypic Methods** 520
DNA Analysis Using Genetic Probes 520
Nucleic Acid Sequencing and rRNA Analysis 520
Polymerase Chain Reaction 520
G + C Base Composition 520

17.5 **Immunological Methods** 520
General Features of Immune Testing 521
Agglutination and Precipitation Reactions 523
The Western Blot for Detecting Proteins 525
Complement Fixation 526
Miscellaneous Serological Tests 527
Fluorescent Antibodies and Immunofluorescence Testing 527
Immunoassays: Tests of Great Sensitivity 527
Tests That Differentiate T Cells and B Cells 529
In Vivo Testing 530
A Viral Example 530

INSIGHT 17.1: Medical
New Guidelines for Enteric Cultures 518

INSIGHT 17.2: Medical
When Positive Is Negative: How to Interpret Serological
Test Results 523

Chapter Summary with Key Terms 532
Multiple-Choice Questions 533
Concept Questions 533
Critical-Thinking Questions 534
Internet Search Topics 534

APPENDIX A A-1
APPENDIX B B-1
APPENDIX C C-1
APPENDIX D D-1
APPENDIX E E-1
Glossary G-1
Credits CR-1
Index I-1