

Contents

Preface xv

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 3
 - Microbial Involvement in Energy and Nutrient Flow 3
- 1.3 Human Use of Microorganisms 4
- 1.4 Infectious Diseases and the Human Condition 5
- 1.5 The General Characteristics of Microorganisms 8
 - Cellular Organization 8
 - A Note on Viruses 8
 - Microbial Dimensions: How Small Is Small? 8
 - Lifestyles of Microorganisms 9
- 1.6 The Historical Foundations of Microbiology 9
 - The Development of the Microscope: "Seeing Is Believing" 10
 - The Establishment of the Scientific Method 12
 - The Development of Medical Microbiology 15
- 1.7 Taxonomy: Organizing, Classifying, and Naming Microorganisms 16
 - The Levels of Classification 17
 - Assigning Specific Names 18
 - The Origin and Evolution of Microorganisms 19
 - Systems of Presenting a Universal Tree of Life 20

INSIGHT 1.1 *Historical*

The More Things Change . . . 7

INSIGHT 1.2 *Historical*

The Fall of Superstition and the Rise of Microbiology 12

INSIGHT 1.3 *Discovery*

The Serendipity of the Scientific Method:
Discovering Drugs 17

- Chapter Summary With Key Terms 22
- Multiple-Choice Questions 23
- Concept Questions 23
- Critical Thinking Questions 24
- Internet Search Topics 24

CHAPTER 2

The Chemistry of Biology 25

- 2.1 Atoms, Bonds, and Molecules: Fundamental Building Blocks 26
 - Different Types of Atoms: Elements and Their Properties 27
 - The Major Elements of Life and Their Primary Characteristics 27
 - Bonds and Molecules 30
- 2.2 Macromolecules: Superstructures of Life 39
 - Carbohydrates: Sugars and Polysaccharides 40
 - Lipids: Fats, Phospholipids, and Waxes 42
 - Proteins: Shapers of Life 45
 - The Nucleic Acids: A Cell Computer and Its Programs 47
 - The Double Helix of DNA 48
- 2.3 Cells: Where Chemicals Come to Life 51
 - Fundamental Characteristics of Cells 52
 - Processes That Define Life 52

INSIGHT 2.1 *Microbiology*

Searching for Ancient Life with Isotopes 29

INSIGHT 2.2 *Discovery*

Redox: Electron Transfer and Oxidation-Reduction Reactions 33

INSIGHT 2.3 *Discovery*

Membranes: Cellular Skins 46

- Chapter Summary With Key Terms 54
- Multiple-Choice Questions 55
- Concept Questions 56
- Critical Thinking Questions 56
- Internet Search Topics 57

CHAPTER 3

Tools of the Laboratory: The Methods for Studying Microorganisms 59

- 3.1 Methods of Culturing Microorganisms—The Five I'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 70

3.2 The Microscope: Window on an Invisible Realm 71

- Magnification and Microscope Design 71
- Variations on the Optical Microscope 75
- Electron Microscopy 78
- Preparing Specimens for Optical Microscopes 79

INSIGHT 3.1 Medical

- Animal Inoculation: "Living Media" 65

INSIGHT 3.2 Discovery

- The Evolution in Resolution: Probing Microscopes 81
- Chapter Summary With Key Terms 84
- Multiple-Choice Questions 85
- Concept Questions 86
- Critical Thinking Questions 87
- Internet Search Topics 88

CHAPTER 4**Procaryotic Profiles: The Bacteria and Archaea 89****4.1 Procaryotic Form and Function 90**

- The Structure of a Generalized Procaryotic Cell 90

4.2 External Structures 90

- Appendages: Cell Extension 90

4.3 The Cell Envelope: The Boundary Layer of Bacteria 97

- Differences in Cell Envelope Structure 97
- Structure of the Cell Wall 97
- Mycoplasmas and Other Cell-Wall-Deficient Bacteria 100
- The Gram-Negative Outer Membrane 100
- Cell Membrane Structure 101

4.4 Bacterial Internal Structure 102

- Contents of the Cell Cytoplasm 102
- Bacterial Endospores: An Extremely Resistant Stage 103

4.5 Bacterial Shapes, Arrangements, and Sizes 106

- Classification Systems in the Procaryotae 108

4.6 Survey of Procaryotic Groups with Unusual Characteristics 111

- Unusual Forms of Medically Significant Bacteria 111
- Free-Living Nonpathogenic Bacteria 112
- Archaea: The Other Procaryotes 114

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 113

- Chapter Summary With Key Terms 116
- Multiple-Choice Questions 116

- Concept Questions 117
- Critical Thinking Questions 118
- Internet Search Topics 118

CHAPTER 5**Eucaryotic Cells and Microorganisms 119****5.1 The History of Eucaryotes 120****5.2 Form and Function of the Eucaryotic Cell: External Structures 122**

- Locomotor Appendages: Cilia and Flagella 122
- The Glycocalyx 123
- Form and Function of the Eucaryotic Cell: Boundary Structures 123

5.3 Form and Function of the Eucaryotic Cell: Internal Structures 125

- The Nucleus: The Control Center 125
- Endoplasmic Reticulum: A Passageway in the Cell 125
- Golgi Apparatus: A Packaging Machine 127
- Mitochondria: Energy Generators of the Cell 128
- Chloroplasts: Photosynthesis Machines 129
- Ribosomes: Protein Synthesizers 130
- The Cytoskeleton: A Support Network 130
- Survey of Eucaryotic Microorganisms 131

5.4 The Kingdom of the Fungi 131

- Fungal Nutrition 131
- Organization of Microscopic Fungi 132
- Reproductive Strategies and Spore Formation 134
- Fungal Classification 136
- Fungal Identification and Cultivation 138
- The Roles of Fungi in Nature and Industry 138

5.5 The Protists 139

- The Algae: Photosynthetic Protists 139
- Biology of the Protozoa 140

5.6 The Parasitic Helminths 146

- General Worm Morphology 146
- Life Cycles and Reproduction 146
- A Helminth Cycle: The Pinworm 147
- Helminth Classification and Identification 148
- Distribution and Importance of Parasitic Worms 148

INSIGHT 5.1 Historical

- The Extraordinary Emergence of Eucaryotic Cells 121

INSIGHT 5.2 Discovery

- The Many Faces of Fungi 133

- Chapter Summary With Key Terms 149
- Multiple-Choice Questions 150
- Concept Questions 151
- Critical Thinking Questions 151
- Internet Search Topics 152

CHAPTER 6**An Introduction to the Viruses 153**

- 6.1 The Search for the Elusive Viruses 154
- 6.2 The Position of Viruses in the Biological Spectrum 154
- 6.3 The General Structure of Viruses 155
 - Size Range 155
 - Viral Components: Capsids, Nucleic Acids, and Envelopes 156
- 6.4 How Viruses Are Classified and Named 163
- 6.5 Modes of Viral Multiplication 163
 - Multiplication Cycles in Animal Viruses 163
 - The Multiplication Cycle in Bacteriophages 172
- 6.6 Techniques in Cultivating and Identifying Animal Viruses 174
 - Using Live Animal Inoculation 174
 - Using Bird Embryos 175
 - Using Cell (Tissue) Culture Techniques 175
- 6.7 Medical Importance of Viruses 177
- 6.8 Other Noncellular Infectious Agents 178
- 6.9 Treatment of Animal Viral Infections 179

INSIGHT 6.1 Discovery

A Positive View of Viruses 157

INSIGHT 6.2 Medical

Republication Strategies in Animal Viruses 168

INSIGHT 6.3 Discovery

Artificial Viruses Created! 177

INSIGHT 6.4 Medical

Uncommon Facts About the Common Cold 178

Chapter Summary With Key Terms 179

Multiple-Choice Questions 180

Concept Questions 181

Critical Thinking Questions 182

Internet Search Topics 182

CHAPTER 7**Elements of Microbial Nutrition, Ecology, and Growth 183**

- 7.1 Microbial Nutrition 184
 - Chemical Analysis of Microbial Cytoplasm 184
 - Sources of Essential Nutrients 187
 - Transport Mechanisms for Nutrient Absorption 191
 - The Movement of Water: Osmosis 191
 - The Movement of Molecules: Diffusion and Transport 193
 - Endocytosis: Eating and Drinking by Cells 196

7.2 Environmental Factors That Influence Microbes 196

- Temperature Adaptations 197
- Gas Requirements 198
- Effects of pH 200
- Osmotic Pressure 201
- Miscellaneous Environmental Factors 201
- Ecological Associations Among Microorganisms 201
- Interrelationships Between Microbes and Humans 203

7.3 The Study of Microbial Growth 204

- The Basis of Population Growth: Binary Fission 204
- The Rate of Population Growth 204
- The Population Growth Curve 205
- Stages in the Normal Growth Curve 206
- Other Methods of Analyzing Population Growth 208

INSIGHT 7.1 Discovery

Dining with an Amoeba 185

INSIGHT 7.2 Discovery

Life in the Extremes 186

INSIGHT 7.3 Discovery

Light-Driven Organic Synthesis 190

INSIGHT 7.4 Discovery

Cashing in on "Hot" Microbes 198

INSIGHT 7.5 Discovery

Life Together: Mutualism 202

INSIGHT 7.6 Discovery

Steps in a Viable Plate Count—Batch Culture Method 207

Chapter Summary With Key Terms 209

Multiple-Choice Questions 210

Concept Questions 211

Critical Thinking Questions 212

Internet Search Topics 212

CHAPTER 8**Microbial Metabolism: The Chemical Crossroads of Life 213****8.1 The Metabolism of Microbes 214**

- Enzymes: Catalyzing the Chemical Reactions of Life 214
- Regulation of Enzymatic Activity and Metabolic Pathways 222

8.2 The Pursuit and Utilization of Energy 224

- Cell Energetics 225
- A Closer Look at Biological Oxidation and Reduction 226
- Adenosine Triphosphate: Metabolic Money 226

8.3 Pathways of Bioenergetics 228

- Catabolism: An Overview of Nutrient Breakdown and Energy Release 228

- Energy Strategies in Microorganisms 228
- Pyruvic Acid—A Central Metabolite 233
- The Tricarboxylic Acid Cycle—A Carbon and Energy Wheel 233
- The Respiratory Chain: Electron Transport and Oxidative Phosphorylation 235
- Summary of Aerobic Respiration 238
- Anaerobic Respiration 239
- The Importance of Fermentation 239

8.4 Biosynthesis and the Crossing Pathways of Metabolism 242

- The Frugality of the Cell—Waste Not, Want Not 242

INSIGHT 8.1 *Discovery*

- Enzymes as Biochemical Levers 216

INSIGHT 8.2 *Discovery*

- Unconventional Enzymes 217

INSIGHT 8.3 *Discovery*

- The Enzyme Name Game 221

INSIGHT 8.4 *Historical*

- Pasteur and the Wine-to-Vinegar Connection 241

INSIGHT 8.5 *Discovery*

- Fermentation and Biochemical Testing 242

Chapter Summary With Key Terms 244

Multiple-Choice Questions 245

Concept Questions 246

Critical Thinking Questions 247

Internet Search Topics 248

CHAPTER 9

Microbial Genetics 249

9.1 Introduction to Genetics and Genes: Unlocking the Secrets of Heredity 250

- The Nature of the Genetic Material 250
- The DNA Code: A Simple Yet Profound Message 251
- The Significance of DNA Structure 255
- DNA Replication: Preserving the Code and Passing It On 256

9.2 Applications of the DNA Code: Transcription and Translation 259

- The Gene-Protein Connection 259
- The Major Participants in Transcription and Translation 260
- Transcription: The First Stage of Gene Expression 262
- Translation: The Second Stage of Gene Expression 262
- Eucaryotic Transcription and Translation: Similar Yet Different 267
- The Genetics of Animal Viruses 268

9.3 Genetic Regulation of Protein Synthesis and Metabolism 269

- The Lactose Operon: A Model for Inducible Gene Regulation in Bacteria 269

A Repressible Operon 270

Antibiotics That Affect Transcription and Translation 271

9.4 Mutations: Changes in the Genetic Code 272

- Causes of Mutations 272
- Categories of Mutations 273
- Repair of Mutations 273
- The Ames Test 274
- Positive and Negative Effects of Mutations 275

9.5 DNA Recombination Events 276

- Transmission of Genetic Material in Bacteria 276

INSIGHT 9.1 *Discovery*

- The Packaging of DNA: Winding, Twisting, and Coiling 252

INSIGHT 9.2 *Historical*

- Deciphering the Structure of DNA 253

INSIGHT 9.3 *Discovery*

- Small RNAs: An Old Dog Shows Off Some New (?) Tricks 262

Chapter Summary With Key Terms 282

Multiple-Choice Questions 282

Concept Questions 283

Critical Thinking Questions 284

Internet Search Topics 284

CHAPTER 10

Genetic Engineering: A Revolution in Molecular Biology 285

10.1 Basic Elements and Applications of Genetic Engineering 286

10.2 Tools and Techniques of Genetic Engineering 287

DNA: An Amazing Molecule 287

10.3 Methods in Recombinant DNA Technology: How to Imitate Nature 294

Technical Aspects of Recombinant DNA and Gene Cloning 295

Construction of a Recombinant, Insertion into a Cloning Host, and Genetic Expression 296

10.4 Biochemical Products of Recombinant DNA Technology 298

10.5 Genetically Modified Organisms 299

Recombinant Microbes: Modified Bacteria and Viruses 299

Transgenic Plants: Improving Crops and Foods 302

Transgenic Animals: Engineering Embryos 303

10.6 Genetic Treatments: Introducing DNA into the Body 304

Gene Therapy 304

Antisense and Triplex DNA Technology: Genetic Medicines 305

10.7 Genome Analysis: Maps, Fingerprints, and Family Trees 307

Genome Mapping and Screening: An Atlas of the Genome 307

DNA Fingerprinting: A Unique Picture of a Genome 308

INSIGHT 10.1 *Discovery*

Okay, the Genome's Sequenced—What's Next? 292

INSIGHT 10.2 *Microbiology*

A Moment to Think 300

INSIGHT 10.3 *Discovery*

Better Bioterrorism Through Biotechnology? 301

Chapter Summary With Key Terms 311

Multiple-Choice Questions 312

Concept Questions 313

Critical Thinking Questions 313

Internet Search Topics 314

CHAPTER 11**Physical and Chemical Control of Microbes 315****11.1 Controlling Microorganisms 316**

General Considerations in Microbial Control 316

Relative Resistance of Microbial Forms 316

Terminology and Methods of Microbial Control 318

What Is Microbial Death? 319

How Antimicrobial Agents Work: Their Modes of Action 320

11.2 Methods of Physical Control 322

Heat As an Agent of Microbial Control 322

The Effects of Cold and Dessication 326

Radiation As a Microbial Control Agent 327

Sterilization by Filtration: Techniques for Removing Microbes 329

11.3 Chemical Agents in Microbial Control 331

Choosing a Microbicidal Chemical 331

Factors That Affect the Germicidal Activity of Chemicals 332

Germicidal Categories According to Chemical Group 334

INSIGHT 11.1 *Historical*

Microbial Control in Ancient Times 317

INSIGHT 11.2 *Microbiology*

Pathogen Paranoia: "The Only Good Microbe Is a Dead Microbe" 331

INSIGHT 11.3 *Medical*

The Quest for Sterile Skin 338

INSIGHT 11.4 *Microbiology*

Decontaminating Congress 342

Chapter Summary With Key Terms 343

Multiple-Choice Questions 344

Concept Questions 345

Critical Thinking Questions 345

Internet Search Topics 346

CHAPTER 12**Drugs, Microbes, Host—The Elements of Chemotherapy 347****12.1 Principles of Antimicrobial Therapy 348**

The Origins of Antimicrobial Drugs 350

12.2 Interactions Between Drug and Microbe 350

Mechanisms of Drug Action 350

12.3 Survey of Major Antimicrobial Drug Groups 354

Antibacterial Drugs 357

Synthetic Antibacterial Drugs 361

Agents to Treat Fungal Infections 362

Antiparasitic Chemotherapy 362

Antiviral Chemotherapeutic Agents 363

Interactions Between Microbes and Drugs: The Acquisition of Drug Resistance 366

New Approaches to Antimicrobial Therapy 369

12.4 Interaction Between Drug and Host 372

Toxicity to Organs 372

Allergic Responses to Drugs 374

Suppression and Alteration of the Microflora by Antimicrobials 374

12.5 Considerations in Selecting an Antimicrobial Drug 374

Identifying the Agent 374

Testing for the Drug Susceptibility of Microorganisms 375

The MIC and Therapeutic Index 376

An Antimicrobial Drug Dilemma 378

INSIGHT 12.1 *Historical*

From Witchcraft to Wonder Drugs 349

INSIGHT 12.2 *Discovery*

A Modern Quest for Designer Drugs 352

INSIGHT 12.3 *Discovery*

Household Remedies—From Apples to Zinc 365

INSIGHT 12.4 *Medical*

The Rise of Drug Resistance 370

Chapter Summary With Key Terms 379

Multiple-Choice Questions 381

Concept Questions 381

Critical Thinking Questions 382

Internet Search Topics 382

CHAPTER 13**Microbe-Human Interactions: Infection and Disease 383****13.1 The Human Host 384**

Contact, Infection, Disease—A Continuum 384

Resident Flora: The Human As a Habitat 384

Indigenous Flora of Specific Regions 386

13.2 The Progress of an Infection 387

- Becoming Established: Step One—Portals of Entry 388
- The Size of the Inoculum 392
- Becoming Established: Step Two—Attaching to the Host 392
- Becoming Established: Step Three—Surviving Host Defenses 393
- Causing Disease 394
- The Process of Infection and Disease 397
- Signs and Symptoms: Warning Signals of Disease 398
- The Portal of Exit: Vacating the Host 399
- The Persistence of Microbes and Pathologic Conditions 400

13.3 Epidemiology: The Study of Disease in Populations 401

- Who, When, and Where? Tracking Disease in the Population 401
- Reservoirs: Where Pathogens Persist 404
- How and Why? The Acquisition and Transmission of Infectious Agents 407
- Nosocomial Infections: The Hospital As a Source of Disease 409
- Universal Blood and Body Fluid Precautions 410
- Which Agent Is the Cause? Using Koch's Postulates to Determine Etiology 411

INSIGHT 13.1 *Discovery*

Life Without Flora 389

INSIGHT 13.2 *Medical*

Laboratory Biosafety Levels and Classes of Pathogens 391

INSIGHT 13.3 *Medical*

The Classic Stages of Clinical Infections 396

INSIGHT 13.4 *Medical*

A Quick Guide to the Terminology of Infection and Disease 398

INSIGHT 13.5 *Historical*

The History of Human Guinea Pigs 413

Chapter Summary With Key Terms 413

Multiple-Choice Questions 414

Concept Questions 415

Critical Thinking Questions 416

Internet Search Topics 416

CHAPTER 14

Nonspecific Host Defenses 417

- 14.1 Defense Mechanisms of the Host in Perspective 418
 - Barriers at the Portal of Entry: A First Line of Defense 419
- 14.2 The Second and Third Lines of Defense: An Overview 421
- 14.3 Systems Involved in Immune Defenses 422
 - The Communicating Body Compartments 423

14.4 The Second Line of Defense 430

- The Inflammatory Response: A Complex Concert of Reactions to Injury 430
- The Stages of Inflammation 431
- Phagocytosis: Cornerstone of Inflammation and Specific Immunity 436
- Interferon: Antiviral Cytokines and Immune Stimulants 439
- Complement: A Versatile Backup System 440
- Overall Stages in the Complement Cascade 440

INSIGHT 14.1 *Medical*

When Inflammation Gets Out of Hand 432

INSIGHT 14.2 *Medical*

The Dynamics of Inflammatory Mediators 435

INSIGHT 14.3 *Medical*

Some Facts About Fever 436

Chapter Summary With Key Terms 442

Multiple-Choice Questions 443

Concept Questions 443

Critical Thinking Questions 444

Internet Search Topics 444

CHAPTER 15

Specific Immunity and Immunization 445

- 15.1 Specific Immunity: The Third and Final Line of Defense 446
- 15.2 An Overview of Specific Immune Responses 448
 - Development of the Dual Lymphocyte System 448
 - Entrance and Presentation of Antigens and Clonal Selection 448
 - Activation of Lymphocytes and Clonal Expansion 448
 - Products of B Lymphocytes: Antibody Structure and Functions 448
 - How T Cells Respond to Antigen: Cell-Mediated Immunity (CMI) 448
 - Essential Preliminary Concepts for Understanding Immune Reactions 449
 - Markers on Cell Surfaces Involved in Recognition of Self and Nonself 449
 - The Origin of Diversity and Specificity in the Immune Response 450
- 15.3 The Lymphocyte Response System in Depth 452
 - Entrance and Processing of Antigens and Clonal Selection 453
- 15.4 Cooperation in Immune Reactions to Antigens 454
- 15.5 B-Cell Response 456
 - Activation of B Lymphocytes: Clonal Expansion and Antibody Production 456
 - Products of B Lymphocytes: Antibody Structure and Functions 456

- 15.6 T-Cell Response 464
 - Cell-Mediated Immunity (CMI) 464
- 15.7 A Practical Scheme for Classifying Specific Immunities 466
- 15.8 Immunization: Methods of Manipulating Immunity for Therapeutic Purposes 468

INSIGHT 15.1 Medical

- Monoclonal Antibodies: Variety Without Limit 463

INSIGHT 15.2 Historical

- Breast Feeding: The Gift of Antibodies 468

INSIGHT 15.3 Historical

- The Lively History of Active Immunization 469

Chapter Summary With Key Terms 479

Multiple-Choice Questions 480

Concept Questions 480

Critical Thinking Questions 481

Internet Search Topics 482

CHAPTER 16

Disorders in Immunity 483

- 16.1 The Immune Response: A Two-Sided Coin 484
 - Overreactions to Antigens: Allergy/Hypersensitivity 484
- 16.2 Type I Allergic Reactions: Atopy and Anaphylaxis 486
 - Epidemiology and Modes of Contact with Allergens 486
 - The Nature of Allergens and Their Portals of Entry 486
 - Mechanisms of Type I Allergy: Sensitization and Provocation 487
 - Cytokines, Target Organs, and Allergic Symptoms 488
 - Specific Diseases Associated with IgE- and Mast Cell-Mediated Allergy 490
 - Anaphylaxis: An Overpowering Systemic Reaction 491
 - Diagnosis of Allergy 492
 - Treatment and Prevention of Allergy 492
- 16.3 Type II Hypersensitivities: Reactions That Lyse Foreign Cells 494
 - The Basis of Human ABO Antigens and Blood Types 494
 - Antibodies Against A and B Antigens 495
 - The Rh Factor and Its Clinical Importance 497
 - Other RBC Antigens 499
- 16.4 Type III Hypersensitivities: Immune Complex Reactions 499
 - Mechanisms of Immune Complex Disease 499
 - Types of Immune Complex Disease 499
- 16.5 Type IV Hypersensitivities: Cell-Mediated (Delayed) Reactions 500
 - Delayed-Type Hypersensitivity 501
 - T Cells and Their Role in Organ Transplantation 502

16.6 An Inappropriate Response Against Self, or Autoimmunity 505

- Genetic and Gender Correlation in Autoimmune Disease 505
- The Origins of Autoimmune Disease 506
- Examples of Autoimmune Disease 506

16.7 Immunodeficiency Diseases: Hyposensitivity of the Immune System 508

- Primary Immunodeficiency Diseases 508
- Secondary Immunodeficiency Diseases 511

INSIGHT 16.1 Medical

- Of What Value Is Allergy? 490

INSIGHT 16.2 Medical

- Why Doesn't a Mother Reject Her Fetus? 497

INSIGHT 16.3 Medical

- Pretty, Pesky, Poisonous Plants 501

INSIGHT 16.4 Medical

- The Mechanics of Bone Marrow Transplantation 504

INSIGHT 16.5 Discovery

- An Answer to the Bubble Boy Mystery 511

Chapter Summary With Key Terms 512

Multiple-Choice Questions 513

Concept Questions 513

Critical Thinking Questions 514

Internet Search Topics 514

CHAPTER 17

Diagnosing Infections 515

- 17.1 Preparation for the Survey of Microbial Diseases 516
 - Phenotypic Methods 516
 - Genotypic Methods 516
 - Immunological Methods 517
- 17.2 On the Track of the Infectious Agent: Specimen Collection 517
 - Overview of Laboratory Techniques 518
- 17.3 Phenotypic Methods 520
 - Immediate Direct Examination of Specimen 520
 - Cultivation of Specimen 520
- 17.4 Genotypic Methods 522
 - DNA Analysis Using Genetic Probes 522
 - Nucleic Acid Sequencing and rRNA Analysis 522
 - Polymerase Chain Reaction 523
 - G + C Base Composition 523
- 17.5 Immunological Methods 523
 - General Features of Immune Testing 523
 - Agglutination and Precipitation Reactions 524
 - The Western Blot for Detecting Proteins 528
 - Complement Fixation 529

- Miscellaneous Serological Tests 529
- Fluorescent Antibodies and Immunofluorescence Testing 530
- Immunoassays: Tests of Great Sensitivity 531
- Tests That Differentiate T Cells and B Cells 533
- In Vivo* Testing 534
- A Viral Example 534

INSIGHT 17.1 *Discovery*

The Uncultured 517

INSIGHT 17.2 *Medical*

When Positive Is Negative: How to Interpret Serological Test Results 526

- Chapter Summary With Key Terms 536
- Multiple-Choice Questions 537
- Concept Questions 537
- Critical Thinking Questions 538
- Internet Search Topics 538

CHAPTER 18

Infectious Diseases Affecting the Skin and Eyes 539

- 18.1 The Skin and Eyes 540
- 18.2 The Skin and Its Defenses 540
- 18.3 Normal Flora of the Skin 541
- 18.4 The Surface of the Eye and Its Defenses 541
- 18.5 Normal Flora of the Eye 542
- 18.6 Skin Diseases Caused by Microorganisms 543
 - Acne 543
 - Impetigo 544
 - Cellulitis 547
 - Staphylococcal Scalded Skin Syndrome (SSSS) 547
 - Gas Gangrene 548
 - Hansen's Disease (Leprosy) 551
 - Vesicular or Pustular Rash Diseases 553
 - Maculopapular Rash Diseases 558
 - Wartlike Eruptions 562
 - Larger Pustular Skin Lesions 564
 - Ringworm (Cutaneous Mycoses) 565
 - Superficial Mycosis 568
- 18.7 Eye Diseases Caused by Microorganisms 568
 - Conjunctivitis 568
 - Trachoma 570
 - Keratitis 570
 - River Blindness 570

INSIGHT 18.1 *Medical*

The Skin Predators: *Staphylococcus* and *Streptococcus* 550

INSIGHT 18.2 *Historical*

Smallpox: An Ancient Scourge Revisited 556

INSIGHT 18.3 *Medical*

Naming Skin Lesions 559

- Chapter Summary With Key Terms 574
- Multiple-Choice Questions 575
- Concept Questions 576
- Critical Thinking Questions 576
- Internet Search Topics 576

CHAPTER 19

Infectious Diseases Affecting the Nervous System 577

- 19.1 The Nervous System and Its Defenses 578
- 19.2 Normal Flora of the Nervous System 579
- 19.3 Nervous System Diseases Caused by Microorganisms 580
 - Meningitis 580
 - Neonatal Meningitis 586
 - Meningoencephalitis 586
 - Acute Encephalitis 589
 - Subacute Encephalitis 591
 - Rabies 595
 - Poliomyelitis 597
 - Tetanus 601
 - Botulism 603
 - African Sleeping Sickness 605

INSIGHT 19.1 *Discovery*

Baby Food and Meningitis 588

INSIGHT 19.2 *Medical*

A Long Way from Egypt: West Nile Virus in the United States 590

INSIGHT 19.3 *Historical*

Polio 599

INSIGHT 19.4 *Discovery*

Botox: No Wrinkles. No Headaches. No Worries? 605

- Chapter Summary With Key Terms 609
- Multiple-Choice Questions 610
- Concept Questions 611
- Critical Thinking Questions 611
- Internet Search Topics 612

CHAPTER 20

Infectious Diseases Affecting the Cardiovascular and Lymphatic Systems 613

- 20.1 The Cardiovascular and Lymphatic Systems and Their Defenses 614
 - The Cardiovascular System 614

The Lymphatic System 615

Defenses of the Cardiovascular and Lymphatic Systems 615

20.2 Normal Flora of the Cardiovascular and Lymphatic Systems 616

20.3 Cardiovascular and Lymphatic System Diseases Caused by Microorganisms 616

Endocarditis 617

Septicemias 618

Plague 619

Tularemia 621

Infectious Mononucleosis 622

Lyme Disease 624

Hemorrhagic Fever Diseases 626

Nonhemorrhagic Fever Diseases 628

Malaria 631

Anthrax 635

HIV Infection and AIDS 636

Adult T-Cell Leukemia and Hairy-Cell Leukemia 645

INSIGHT 20.1 Medical

Atherosclerosis 616

INSIGHT 20.2 Medical

The Arthropod Vectors of Infectious Disease 626

INSIGHT 20.3 Medical

AIDS-Defining Illnesses (ADIs) 638

Chapter Summary With Key Terms 649

Multiple-Choice Questions 651

Concept Questions 651

Critical Thinking Questions 651

Internet Search Topics 652

CHAPTER 21

Infectious Diseases Affecting the Respiratory System 653

21.1 The Respiratory Tract and Its Defenses 654

21.2 Normal Flora of the Respiratory Tract 654

21.3 Upper Respiratory Tract Diseases Caused by Microorganisms 656

Rhinitis, or the Common Cold 656

Sinusitis 657

Acute Otitis Media (Ear Infection) 657

Pharyngitis 658

Diphtheria 662

21.4 Diseases Caused by Microorganisms Affecting the Upper and Lower Respiratory Tract 664

Whooping Cough 664

Respiratory Syncytial Virus Infection 665

Influenza 666

21.5 Lower Respiratory Tract Diseases Caused by Microorganisms 668

Tuberculosis 668

Pneumonia 674

INSIGHT 21.1 Medical

Fungal Lung Diseases 669

INSIGHT 21.2 Discovery

Bioterror in the Lungs 678

Chapter Summary With Key Terms 684

Multiple-Choice Questions 685

Concept Questions 686

Critical Thinking Questions 686

Internet Search Topics 686

CHAPTER 22

Infectious Diseases Affecting the Gastrointestinal Tract 687

22.1 The Gastrointestinal Tract and Its Defenses 688

22.2 Normal Flora of the Gastrointestinal Tract 689

22.3 Gastrointestinal Tract Diseases Caused by Microorganisms 690

Tooth and Gum Infections 690

Dental Caries (Tooth Decay) 690

Periodontal Diseases 692

Periodontitis 692

Necrotizing Ulcerative Gingivitis and Periodontitis 694

Mumps 694

Gastritis and Gastric Ulcers 696

Acute Diarrhea 697

Acute Diarrhea with Vomiting (Food Poisoning) 709

Chronic Diarrhea 710

Hepatitis 715

Helminthic Intestinal Infections 719

INSIGHT 22.1 Medical

Stools: To Culture or Not to Culture? 700

INSIGHT 22.2 Discovery

A Little Water, Some Sugar and Salt, Save Millions of Lives 706

INSIGHT 22.3 Medical

Microbes Have Fingerprints, Too 712

INSIGHT 22.4 Discovery

Treating Inflammatory Bowel Disease with Worms? 721

Chapter Summary With Key Terms 731

Multiple-Choice Questions 733

Concept Questions 733

Critical Thinking Questions 734

Internet Search Topics 734

CHAPTER 23

Infectious Diseases Affecting the Genitourinary System 735

- 23.1 The Genitourinary Tract and Its Defenses 736
- 23.2 Normal Flora of the Genitourinary Tract 737
 - Normal Flora of the Male Genital Tract 737
 - Normal Flora of the Female Genital Tract 738
- 23.3 Urinary Tract Diseases Caused by Microorganisms 739
 - Urinary Tract Infections (UTIs) 739
 - Leptospirosis 740
 - Urinary Schistosomiasis 741
- 23.4 Reproductive Tract Diseases Caused by Microorganisms 742
 - Vaginitis and Vaginosis 742
 - A Note About HIV and Hepatitis B and C 746
 - Discharge Diseases with Major Manifestation in the Genitourinary Tract 746
 - Genital Ulcer Diseases 750
 - Wart Diseases 758
 - Molluscum Contagiosum 760
 - Group B Streptococcus "Colonization"—Neonatal Disease 761

INSIGHT 23.1 Medical

Pelvic Inflammatory Disease and Infertility 745

INSIGHT 23.2 Discovery

The Hidden Epidemic—Sexually Transmitted Diseases 753

INSIGHT 23.3 Medical

The Pap Smear 759

- Chapter Summary With Key Terms 763
- Multiple-Choice Questions 764
- Concept Questions 765
- Critical Thinking Questions 765
- Internet Search Topics 766

CHAPTER 24

Environmental and Applied Microbiology 767

- 24.1 Ecology: The Interconnecting Web of Life 768
 - The Organization of Ecosystems 769
 - Energy and Nutritional Flow in Ecosystems 770
 - Ecological Interactions Between Organisms in a Community 772

The Natural Recycling of Bioelements 773

Atmospheric Cycles 773

Sedimentary Cycles 778

Soil Microbiology: The Composition of the Lithosphere 779

Aquatic Microbiology 781

24.2 Applied Microbiology and Biotechnology 789

24.3 Microorganisms and Food 789

Microbial Fermentations in Food Products from Plants 789

Microbes in Milk and Dairy Products 792

Microorganisms as Food 794

Microbial Involvement in Food-Borne Diseases 794

Prevention Measures for Food Poisoning and Spoilage 795

24.4 General Concepts in Industrial Microbiology 799

From Microbial Factories to Industrial Factories 800

Substance Production 801

INSIGHT 24.1 Discovery

Greenhouse Gases, Fossil Fuels, Cows, Termites, and Global Warming 775

INSIGHT 24.2 Discovery

Cute Killer Whale—Or Swimming Waste Dump? 780

INSIGHT 24.3 Microbiology

Bioremediation: The Pollution Solution? 782

INSIGHT 24.4 Discovery

Wood or Plastic: On the Cutting Edge of Cutting Boards 796

Chapter Summary With Key Terms 803

Multiple-Choice Questions 804

Concept Questions 805

Critical Thinking Questions 805

Internet Search Topics 806

APPENDIX A: Exponents A-1

APPENDIX B: Significant Events in Microbiology B-1

APPENDIX C: Answers to Multiple-Choice Questions and Selected Matching Questions C-1

Glossary G-1

Credits C-1

Index I-1