

UNIT ONE Microbiology—The Fundamentals

MICROBIOLOGIST'S NOTEBOOK: Solving Microbial Mysteries in Household Products 2

CHAPTER 1 Scope and History of Microbiology 4

Why Study Microbiology? 5

Scope of Microbiology 6

The Microbes 6

The Microbiologists 8

Historical Roots 10

The Germ Theory of Disease 13

Early Studies 13

Pasteur's Further Contributions 14

Koch's Contributions 15

Work Toward Controlling Infections 16

Emergence of Special Fields of Microbiology 17

Immunology 17

Virology 18

Chemotherapy 19

Genetics and Molecular Biology 20

Tomorrow's History 21

Human Genome Project 24

Retracing Our Steps 25 / Terminology Check 26 / Critical Thinking Questions 26 / Self-Quiz 26 / Meet Me on the Web 27

CHAPTER 2 Fundamentals of Chemistry 28

Why Study Chemistry? 28

Chemical Building Blocks and Chemical Bonds 29

Chemical Building Blocks 29

The Structure of Atoms 29

Chemical Bonds 31

Chemical Reactions 33

Water and Solutions 33

Water 33

Solutions and Colloids 34

Acids, Bases, and pH 35

Complex Organic Molecules 36

Carbohydrates 37

Lipids 40

Proteins 42

Nucleoudes and Nucleic Acids 44

Retracing Our Steps 47 / Terminology Check 48 / Critica Thinking Questions 48 / Self-Quiz 40 / Meet Me on the Web 49

CHAPTER 3 Microscopy and Staining 50

Historical Microscopy 51

Principles of Microscopy 51

Metric Units 51

Properties of Light: Wavelength and Resolution 52

Properties of Light: Light and Objects 54

Light Microscopy 56

The Compound Light Microscope 57

Dark-Field Microscopy 57

Phase-Contrast Microscopy 58

Nomarski (Differential Interface Contrast) Microscopy 58

Fluorescence Microscopy 59

Electron Microscopy, 60

Transmission Electron Microscopy 60

Scanning Electron Microscopy 62 Scanning Tunneling Microscopy 63

Techniques of Light Microscopy 63

Preparation of Specimens for the Light Microscope 63

Principles of Staining 65

Retracing Our Steps 68 / Terminology Check 70 / Critical Thinking Questions 70 / Self-Quiz 70 / Meet Me on the

Web 71

CHAPTER 4 Characteristics of Prokaryotic and Eukaryotic Cells 72

Basic Cell Types 73

Prokaryotic Cells 74

Size, Shape, and Arrangement 74

An Overview of Structure 76

The Cell Wall 76

The Cell Membrane 80

Internal Structure 82

External Structure 85

Eukaryotic Cells 89

An Overview of Structure 89

The Plasma Membrane 89

Internal Structure 90

Peroxisomes 93

External Structure 94

Evolution by Endosymbiosis 95

The Movement of Substance Across Membranes 97

Simple Diffusion 97

Facilitated Diffusion 98

Osmosis 98

Active Transport 99

Endocytosis and Exocytosis 99

Retracing Our Steps 102 / Terminology Check 103 / Critical Thinking 104 / Self Quiz / 104 / Meet Me on the Web 105

UNIT TWO Microbial Metabolism, Growth, and Genetics

MICROBIOLOGIST'S NOTEBOOK: Come With Me to TIGR, The Institute for Genomic Research 106

CHAPTER 5 Essential Concepts of Metabolism 108

Metabolism An Overview 109

Enzymes 111

Properties of Enzymes 111

Properties of Coenzymes and Cofactors 112

Enzyme Inhibition 113

Factors That Affect Enzyme Reactions 115

Anaerobic Metabolism: Glycolysis and Fermentation. 115

Glycolysis 115

Fermentation 117

Aerobic Metabolism: Respiration 120

The Krebs Cycle 120

Electron Transport and Oxidative Phosphorylation 120

The Significance of Energy Capture 124

Web 193

The Metabolism of Fats and Proteins 125 Fat Metabolism 125 Protein Metabolism, 125 Other Metabolic Processes 126 Photoautotrophy 126 Photoneterotrophy 128 Chemoautotrophy 128 The Uses of Energy 129 Biosynthetic Activities 129 Membrane Transport and Movement 130 Bioluminescence 132 Retracing Our Steps 133 / Terminology Check *134 / Critical Thinking 134 / Self-Quiz 134 / Meet Me on the Web 135 CHAPTER 6 Growth and Culturing of Bacteria 136 Growth and Cell Division 137 Microbial Growth Defined 137 Cell Division 137 Phases of Growth 138 Measuring Bacterial Growth 139 Factors Affecting Bacterial Growth 144 Physical Factors 144 Nutritional Factors 148 Sporulation 150 Other Sporelike Bacterial Structures 152 Culturing Bacteria 152 Methods of Obtaining Pure Cultures 152 Culture Media 153 Methods of Perfoming Multiple Diagnostic Tests 157 Living, But Nonculturable, Organisms 158 Retracing Our Steps 159 / Terminology Check 161 / Critical Thinking Questions 161 / Self-Quiz 161 / Meet Me on the Web 162 CHAPTER 7 Microbial Genetics 163 An Overview of Genetic Processes 164 The Basis of Heredity 164 Nucleic Acids in Information Storage and Transfer 165 Information Transfer 165 DNA Replication 167 Protein Synthesis 168 Transcription 168 Kinds of RNA 169 Translation 171 The Regulation of Metabolism 175 The Significance of Regulatory Mechanisms 175 Categories of Regulatory Mechanisms 175 Feedback Inhibition 175 Enzyme Induction 176 Enzyme Repression 178 Mutations 179 Types of Mutations and Their Effects 179 Phenotypic Variation 180 Spontaneous and Induced Mutations 181 Chemical Mutagens 182 Radiation as a Mutagen 182 The Repair of DNA Damage 183 The Study of Mutations 184 The Ames Test 187 Retracing Our Steps 190 / Terminology Check 191 / Critical Thinking Questions 191 / Self-Quiz 192 / Meet Me on the

CHAPTER 8 Gene Transfer and Genetic Engineering 194

The Types and Significance of Gene Transfer 195

Transformation 195

The Discovery of Transformation 195

The Mechanism of Transformation 196

The Significance of Transfomation 197

Transduction 197

The Discovery of Transduction 197

The Mechanisms of Transduction 198

The Significance of Transduction 200

Conjugation 201

The Discovery of Conjugation 201

The Mechanisms of Conjugation 201

The Significance of Conjugation 204

Gene Transfer Mechanisms Compared 205 Plasmids 205

Characteristics of Plasmids 205

Resistance Plasmids 206

Transposons 207

Bacteriocinogens 208

Genetic Engineering 209

Genetic Fusion 209

Protoplast Fusion 209

Gene Amplification 210

Recombinant DNA Technology 210

Hybridomas 215

Weighing the Risks and Benefits of Recombinant DNA 215 Retracing Our Steps 217 / Terminology Check 218 / Critical Thinking Questions 219 / Self-Quiz 219 / Meet Me on the Web 220

UNITERRET The Roster of Microbes and Multicellular Parasites.

MICROBIOLOGIST'S NOTEBOOK Carter Center Hoped for Eradication of Guinea Worm from World by 2000 221

CHAPTER 9 An Introduction to Taxonomy: The Bacteria 223

Taxonomy: The Science of Classification 224

Linnaeus, the Father of Taxonomy 224

Using a Taxonomic Key 225

Problems in Taxonomy 226

Developments Since Linnaeus's Time 227

The Five-Kingdom Classification System 227

Kingdom Monera 228

Kingdom Protista 230

Kingdom Fungi 231

Kingdom Plantae 231

Kingdom Animalia 231

The Three-Domain Classification System. 232

The Evolution of Prokaryotic Organisms 232

The Tree of Life is Replaced by a Shrub 233

The Archaea 236

Classification of Viruses 237

The Search for Evolutionary Relationships 237

Special Methods Needed for Prokaryotes 237

Numerical Taxonomy 239

Genetic Homology 239

Other Techniques 242
The Significance of Findings 242

Bacterial Taxonomy and Nomenclature 243

Criteria for Classifying Bacteria 243

The History and Significance of Bergey's Manual 245

Problems Associated with Bacterial Taxonomy 247

Bacterial Nomenclature 247

Bacteria by Section of Bergey's Manual, First Edition 247

Bacterial Taxonomy and You 247

Retracing Our Steps 251 / Terminology Check 253 / Critical Thinking 253 / Self-Quiz 253 / Meet Me on the Web 254

CHAPTER 10 Viruses 255

General Characteristics of Viruses 256

What Are Viruses? 256

Components of Viruses 256

Sizes and Shapes 257

Host Range and Specificity of Viruses 258

Origins of Viruses 259

Classification of Viruses 259

RNA Viruses 261

DNA Viruses 263

Viral Replication 265

General Characteristics of Replication 265

Replication of Bacteriophages 265

Lysogeny 269

Replication of Animal Viruses 271

Latent Viral Infections 274

Culturing of Animal Viruses 274

Development of Culturing Methods 274

Types of Cell Cultures 275

Viruses and Teratogenesis 276

Viruslike Agents: Viroids and Prions 277

Viroids 277

Prions 278

Viruses and Cancer 279

Human Cancer Viruses 279

How Cancer Viruses Cause Cancer 280

Oncogenes 280

Retracing Our Steps 281 / Terminology Check 282 / Critical Thinking 283 / Self-Quiz 283 / Meet Me on the Web 284

CHAPTER 11 Eukaryotic Microorganisms

and Parasites 285

Principles of Parasitology 286

The Significance of Parasitism 286

Parasites in Relation to Their Hosts 286

Protists 287

Characteristics of Protists 287

The Importance of Protists 287

Classification of Protists 288

Fungi 292

Characterictics of Fungi 292

The Importance of Fungi 294

Classification of Fungi 296

Helminths 300

Characteristics of Helminths 300

Parasitic Helminths 301

Arthropods 301

Characteristics of Arthropods 305 Classification of Arthropods 306 Retracing Our Steps 308 / Terminology Check 309 / Critical Thinking 309 / Self-Quiz 309 / Meet Me on the Web 310

UNIT FOUR Control of Microorganisms

MICROBIOLOGIST'S NOTEBOOK Who's Winning—The Pharmacists, or the Nacrobes? 311

CHAPTER 12 Sterilization and Disinfection 313

Principles of Sterilization and Disinfection 314

The Control of Microbial Growth 314

Chemical Antimicrobial Agents 315

The Potency of Chemical Agents 315

Evaluating the Effectiveness of Chemical Agents 315

Disinfectant Selection 316

Mechanisms of Action of Chemical Agents 316

Specific Chemical Antimicrobial Agents 316

Physical Antimicrobial Agents 322

Principles and Applications of Heat Killing 323

Dry Heat, Moist Heat, and Pasteurization 323

Refrigeration, Freezing, Drying, and Freeze-Drying 327

Radiation 328

Sonic and Ultrasonic Waves 329

Filtration 330

Osmotic Pressure 331

Retracing Our Steps 333 / Terminology Check 334 / Critical Thinking 334 / Self-Quiz 334 / Meet Me on the Web 335

CHAPTER 13 Antimicrobial Therapy 336

Antimicrobial Chemotherapy 336

The History of Chemotherapy 337

General Properties of Antimicrobial Agents 338

Selective Toxicity 338

The Spectrum of Activity 338

Modes of Action 339

Kinds of Side Effects 342

The Resistance of Microorganisms 342

Determining Microbial Sensitivities to Antimicrobial Agents 346

The Disk Diffusion Method 346

The Dilution Method 346

Serum Killing Power 347

Automated Methods 347

Attributes of an Ideal Antimicrobial Agent 347

Antibacterial Agents 348

Inhibitors of Cell Wall Synthesis 348

Disrupters of Cell Membranes 350

Inhibitors of Protein Synthesis 351

Inhibitors of Nucleic Acid Synthesis 353

Antimetabolites and Other Antibacterial Agents 354

Antifungal Agents 354

Antiviral Agents 355

Antiprotozoan Agents 358

Antihelminthic Agents 359

Special Problems with Drug-Resistant Hospital Infections 362 Retracing Our Steps 363 / Terminology Check 364 / Critical Thinking 365 / Self-Quiz 365 / Meet Me on the Web 366

UNIT FIVE Host-Microbe Interactions

MICROBIOLOGIST'S NOTEBOOK Fighting Disease at the Zoo: No Monkey Business 367

ominante II (NO 1 p.1.)	
CHAPTER 14 Host-Microbe Relationships	Retracing Our Steps 442 / Terminology Check 443 / Critical
and Disease Processes 369	Thinking 443 / Self-Quiz 443 / Meet Me on the Web 444
Host-Microbe Relationships 370	CHAPTER 17 Immunology I: Basic Principles of
Symbiosis 371	
Contamination, Infection, and Disease 371	Specific Immunity and Immunization 445
Pathogens, Pathogenicity, and Virulance 371	Immunology and Immunity 446 Types of Immunity 446
Normal (Indigenous) Microflora 372 Koch's Postulates 375	Acquired Immunity 446
Kinds of Disease 375	Active and Passive Immunity 446
Infectious and Noninfectious Diseases 376	Characteristics of the Immune System 447
Classification of Diseases 376	Antigens and Antibodies 447
Communicable and Noncommunicable Diseases 376	Cells and Tissues of the Immune System 449
The Disease Process 377	Dual Nature of the Immune System 450
How Microbes Cause Disease 377	General Properties of Immune Responses 450
Signs, Symptoms, and Syndromes 384	Humoral Immunity 453
Types of Infectious Disease 384	Properties of Antibodies (Immunoglobulins) 453
Stages of an Infectious Disease 385	Primary and Secondary Responses 456
Intectious Diseases—Past, Present, and Future 388	Kinds of Antigen-Antibody Reactions 456
Retracing Our Steps 390 / Terminology Check 391 / Critical	Monoclonal Antibodies 458
Thinking / Self-Quiz 391 / Meet Me on the Web 392	Cell-Mediated Immunity 459
· · · · · · · · · · · · · · · · · · ·	The Cell-Mediated Immune Reaction 459
CHAPTER 15 Epidemiology and Nosocomial	How Killer Cells Kill 463
Infections 393	The Role of Activated Macrophages 463
Epidemiology 394	Superantigens 463
What Is Epidemiology? 394	Factors That Modify Immune Responses 463
Diseases in Populations 394	Immunization 465
Epidemiologic Studies 396	Active Immunization 465
Reservoirs of Infection 399	Hazards of Vaccines 467
Portals of Entry 401	Passive Immunization 469
Portals of Exit 401	Future of Immunization 470
Modes of Disease Transmission 403	Immunity to Various Kinds of Pathogens 470
Disease Cycles 406	Bacteria 470
Herd Immunity 407	Viruses 470
Controlling Disease Fransmission 408	Fungi 472
Public Health Organizations 410	Protozoa and Helminths 472
Notifiable Diseases 412	Retracing Our Steps 474 / Terminology Check 476 / Critical
Nosocomial Infections 413	Thinking 476 / Self-Quiz 476 / Meet Me on the Web 477
The Epidemiology of Nosocomial Infections 413	CHAPTER 18 Immunology II: Immunological
Preventing and Controlling Nosocomial Infections 418	
Retracing Our Steps 419 / Terminology Check 420 / Critical	Disorders and Tests 478
Thinking 421 / Self-Quiz 421 / Meet Me on the Web 421	Overview of Immunological Disorders 479
CHAPTER 16 Nonspecific Host Defenses	Hypersensitivity 479
and Host Systems 423	Immunodeficiency 479
Nonspecific and Specific Host Defenses 424	Immediate (Type I) Hypersensitivity 479 Allergen 480
Physical Barriers 424	Mechanism of Immediate Hypersensitivity 480
Cellular Defenses 425	Localized Anaphylaxis 482
Defensive Cells 423	Generalized Anaphylaxis 482
Phagocytes 427	Genetic Factors in Allergy 483
The Process of Phagocytosis 427	Treatment of Allergies 484
Extracellular Killing 429	Cytotoxic (Type II) Hypersensitivity 48.
The Lymphatic System 429	Mechanism of Cytotoxic Reactions 485
Inflammation 432	Examples of Cytotoxic Reactions 486
Characteristics of Inflammation 432	Immune Complex (Type III) Hypersensitivity 488
The Acute Inflammatory Process 432	Mechanism of Immune Complex Disorders 488
Repair and Regeneration 434	Examples of Immune Complex Disorders 488
Chronic Inflammation 434	Cell-Mediated (Type IV) Hypersensitivity 489
Fever 434	Mechanism of Cell-Mediated Reactions 489
Molecular Defenses 435	Examples of Cell-Mediated Disorders 490
Interferon 435	Autoimmune Disorders 493
Complement 437	Autoimmunization 493
Acute Phase Response 441	Examples of Autoimmune Disorders 494

Examples of Autoimmune Disorders 494

XXİ

Transplantation 496

Histocompatibility Antigens 496

Transplant Rejection 497

Tolerance of Fetus During Pregnancy 497

Immunosuppression 498

Drug Reactions 499

Immunodeficiency Diseases 500

Primary Immunodeficiency Diseases 500

Secondary (or Acquired) Immunodeliciency

Diseases 501

Immunological Tests 506

The Precipitin Test 506

Agglutination Reactions 507

Tagged Antibody Tests 510

Retracing Our Steps 513 / Terminology Check 515 / Critical Thinking Questions 516 / Self-Quiz 516 / Meet Me on the Web 517

UNIT SIX Infectious Diseases of Human Organ Systems

MICROBIOLOGIST'S NOTEBOOK Controlling Nosocomial Infections in a Burn Unit 518

CHAPTER 19 Diseases of the Skin and Eyes;

Wounds and Bites 520

The Skin, Mucous Membranes, and Eyes 521

The Skin 521

Mucous Membranes 521

The Eyes 522

Normal Microflora of the Skin 522

Diseases of the Skin 523

Bacterial Skin Diseases 523

Viral Skin Diseases 526

Fungal Skin Diseases 532

Other Skin Diseases 534

Diseases of the Eyes 535

Bacterial Eye Diseases 535

Viral Eye Diseases 537

Parasitic Eye Diseases 538

Wound and Bites 540

Wound Infections 540

Other Anaerobic Infections 540

Anthropod Bites and Diseases 540

Retracing Our Steps 544 / Terminology Check 545 / Critical Thinking 545 / Self-Quiz 545 / Meet Me on the Web 546

CHAPTER 20 Urogenital and Sexually Transmitted Diseases 547

Components of the Urogenital System 547

The Urinary System 548

The Female Reproductive System 549

The Male Reproductive System 549

Normal Microflora of the Urogenital System 550

Urogenital Diseases Usually Not Transmitted Sexually 551

Bacterial Urogenital Diseases 551

Parasitic Urogenital Diseases 556

Sexually Transmitted Diseases 556

Acquired Immune Deficiency Syndrome (AIDS) 536

Bacterial Sexually Transmitted Diseases 556

Viral Sexually Transmitted Diseases 556

Retracing Our Steps 573 / Terminology Check 574 / Critical Thinking 574 / Self-Quiz 574 / Meet Me on the Web 575

CHAPTER 21 Diseases of the Respiratory

System 576

Components of the Respiratory System 577
The Upper Respiratory Tract 578

The Lower Respiratory Tract 578

The Fars 578

Normal Microflora of the Respiratory System 579

Diseases of the Upper Repiratory Tract 580

Bacterial Upper Respiratory Diseases 580

Viral Upper Respiratory Diseases 583

Diseases of the Lower Respiratory Tract 585

Bacterial Lower Respiratory Diseases 585

Viral Lower Respiratory Diseases 595

Fungal Respiratory Diseases 601

Parasitic Respiratory Diseases 603

Retracing Our Steps 605 / Terminology Check 606 / Critical Thinking 606 / Self-Quiz 606 / Meet Me on the Web 607

CHAPTER 22 Oral and Gastrointestinal

Diseases 608

Components of the Digestive System 609

The Mouth 610

The Stomach 610

The Small intestine 610

The Large Intestine 610

Normal Microflora of the Mouth and Digestive System 610

Diseases of the Oral Cavity 611

Bacterial Diseases of the Oral Cavity 611

Viral Diseases of the Oral Cavity 615

Gastrointestinal Diseases Caused by Bacteria 616

Bacterial Food Poisoning 616

Bacterial Enteritis and Enteric Fevers 617

Bacterial Infections of the Stomach, Esophagus,

and Intestines 625

Bacterial Infections of the Gallbladder and Biliary Tract 626

Gastrointestinal Diseases Caused by Other Pathogens 628

Viral Gastrointestinal Diseases 628

Protozoan Gastrointestinal Diseases 631

Effects of Fungal Toxins 633

Helminth Gastrointestinal Diseases 634

Retracing Our Steps 642 / Terminology Check 642 / Critical Thinking 642 / Self-Quiz 642 / Meet Me on the Web 644

CHAPTER 23 Cardiovascular, Lymphatic, and Systemic Diseases 645

The Cardiovascular System 646

The Heart and Blood Vessels 646

The Blood 646

Normal Microflora of the Cardiovascular System 646

Cardiovascular and Lymphatic Diseases 647

Bacterial Septicemias and Related Diseases 647

Helminthic Diseases of the Blood and Lymph 649

Systemic Diseases 652

Bacterial Systemic Diseases 652

Rickettsial and Related Systemic Diseases 661

Viral Systemic Diseases 665

Protozoan Systemic Diseases 670

Retracing Our Steps 675 / Terminology Check 677 / Critical Thinking 677 / Self-Quiz 677 / Meet Me on the Web 678

CHAPTER 24 Diseases of the Nervous System 679

Components of the Nervous System 680

Normal Microflora of the Nervous System 680

Diseases of the Brain and Meninges 680

Bacterial Diseases of the Brain and Meninges 680

Viral Diseases of the Brain and Meninges 682

Other Diseases of the Nervous System 686

Bacterial Nerve Diseases 686

Viral Nerve Diseases 691

Prion Diseases of the Nervous System 693

Parasitic Diseases of the Nervous System 696

Retracing Our Steps 699 / Terminology Check 700 / Critical Thinking 700 / Self-Quiz 700 / Meet Me on the Web 701

UNIT SIMEN Environmental and Applied Microbiology

MICROBIOLOGIST'S NOTEBOOK: Visit to a Mushroom Farm 702

CHAPTER 25 Environmental Microbiology 704

Fundamentals of Ecology 705

The Nature of Ecosystems 705

The Flow of Energy in Ecosystems 705

Biogeochemical Cycles 705

The Water Cycle 706

The Carbon Cycle 706

The Nitrogen Cycle and Nitrogen Bacteria 708

The Sulfur Cycle and Sulfur Bacteria 711

Other Biogeochemical Cycles 713

Air 713

Microorganisms Found in Air 715

Methods for Controlling Microorganisms in Air 715

Seil 715

Components of Soil 716

Microorganisms in Soil 716

Soil Pathogens 718

Water 718

Freshwater Environments 718

Marine Environments 719

Water Pollution 721

Water Purification 723

Sewage Treatment 725

Primary Treatment 726

Secondary Treatment 726

Tertiary Treatment 727

Septic Tanks 728

Bioremediation 728

Retracing Our Steps 731 / Terminology Check 732 / Critical Thinking 732 / Self-Quiz 732 / Meet Me on the Web 733

CHAPTER 26 Applied Microbiology 734

Microorganisms Found in Food 735

Grains 735

Fruits and Vegetables 735

Meats and Poultry 736

Fish and Shellfish 1737

Milk 738

Other Edible Subsances 739

Preventing Disease Transmission and Food Spoilage 741

Food Preservation 742

Drying and Lyophilization 743

Pasteurization of Milk 745

Standards for Food and Milk Production 746

Microorganisms as Food and in Food Production 747

Algae, Fungi, and Bacteria as Food 747

Food Production 747

Beer, Wine, and Spirits 752

Industrial and Pharmaceutical Microbiology 754

Useful Metabolic Processes 754

Problems of Industrial Microbiology 754

Useful Organic Products 755

Simple Organic Compounds 755

Antibiotics 755

Enzymes 757

Amino Acids 757

Other Biological Products 757

Microbiological Mining 758

Microbiological Waste Disposal 759

Retracing Our Steps 759 / Terminology Check 760 / Critical Thinking 761 / Self-Quiz 761 / Meet Me on the Web 762

APPENDICES

- A Metric System Measurements, Conversions, and Math Tools A-1
- B Classification of Bacteria and Viruses A-4
- C Word Roots Commonly Encountered in Microbiology A-15
- D Safety Precautions in the Handling of Clinical Specimens A-18
- E Metabolic Pathways A-19

GLOSSARY G-1

CRITICAL THINKING QUESTIONS ANSWERS Ans-1

SELF-QUIZ ANSWERS Ans-6

PHOTO CREDITS PC-1

INDEX I-1