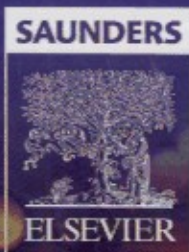
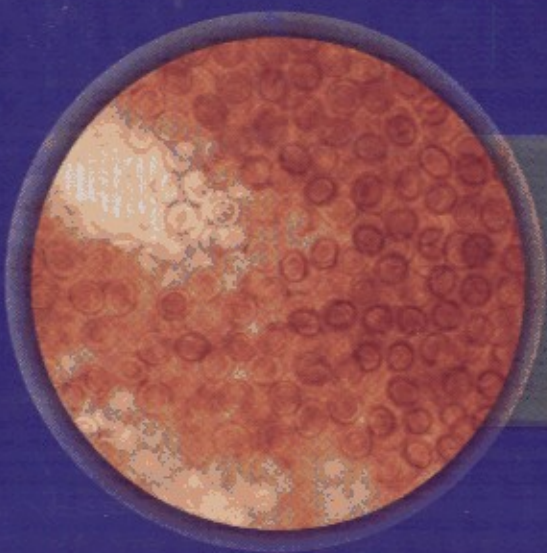


*Textbook of*

# DIAGNOSTIC MICROBIOLOGY

*Third Edition*

CONNIE R. MAHON  
DONALD C. LEHMAN  
GEORGE MANUSELIS



**evolve**

<http://evolve.elsevier.com>

# CONTENTS

## PART I

### INTRODUCTION TO CLINICAL MICROBIOLOGY

#### 1 Bacterial Cell Structure, Physiology, Metabolism, and Genetics, 3

*George Manuselis, Connie R. Mahon*

Significance, 5

Overview of the Microbial World, 5

Classification/Taxonomy, 7

Comparison of Eukaryotic and Prokaryotic Cell Structure, 9

Bacterial Morphology, 13

Microbial Growth and Nutrition, 15

Bacterial Biochemistry and Metabolism, 17

Bacterial Genetics, 21

#### 2 Host-Pathogen Interaction, 28

*Connie R. Mahon*

##### A. The Role of the Usual Microbial Flora, 28

Origin of Microbial Flora, 29

Composition of the Microbial Flora at Different Body Sites, 30

Role of the Microbial Flora in the Pathogenesis of Infectious Disease, 33

Role of the Microbial Flora in the Host Defense against Infectious Disease, 33

##### B. Pathogenesis of Infection, 36

Microbial Factors Contributing to Pathogenesis and Virulence, 37

Host Resistance Factors, 42

Mechanisms by which Microbes May Overcome the Host Defenses, 51

Routes of Transmission, 52

#### 3 The Laboratory Role in Infection Control, 58

*David L. Taylor, George Manuselis*

General Concepts in Infection Control Practice, 59

Outbreak Investigation, 64

Education, 69

Emerging and Reemerging Pathogens, 70

#### 4 Control of Microorganisms, 73

##### A. Disinfection and Sterilization, 73

*Frederic J. Marsik, Michelle M. Jackson*

Sterilization versus Disinfection, 75

Factors That Influence the Degree of Killing, 75

Methods of Disinfection and Sterilization, 77

Disinfectants versus Antiseptics, 79

EPA Regulations on Chemical Surface

Disinfectants, 80

FDA Regulations on Chemical Skin Antiseptics, 85

##### B. Microbiology Safety, 94

*Barbara L. Russell, Becky B. Stone*

General Microbiology Safety, 95

Bioterrorism and the Clinical Microbiology Laboratory, 108

#### 5 Performance Improvement in the Microbiology Laboratory, 112

##### A. Quality Issues in Clinical Microbiology, 112

*Sherry Trevino, Frederic J. Marsik*

General Guidelines for Establishing Quality Control, 114

Performance Improvement, 122

##### B. Putting the Laboratory Test to the Test, 126

*Frederic J. Marsik*

Analytical Analysis of Tests, 127

Clinical Analysis of Tests, 127

Operational Analysis of Tests, 128

Choosing a Laboratory Method, 130

Test Validation, 131

#### 6 Specimen Collection and Processing, 134

*Lauren Roberts*

Basic Principles of Specimen Collection, 135

Preservation, Storage, and Transport of Specimens, 139

Specimen Receipt and Processing, 141

Culture Workup, 146

Nonroutine Specimens, 148

Communication of Laboratory Findings, 148

#### 7 Microscopic Examination of Infected Materials, 152

*Leona W. Ayers*

Preparation of Samples, 153

Stains, 156

Microscopes, 160

Terminology for Direct Examinations, 160

Examination of Prepared Material, 162

Grading or Classifying Materials, 164

Reports of Direct Examinations, 166

Examples of Sample Observations and Reports, 166

Quality Control in Direct Microscopic Interpretations, 166

#### 8 Use of Colonial Morphology for the Presumptive Identification of Microorganisms, 199

*George Manuselis*

Importance of Colonial Morphology as a Diagnostic Tool, 200

Initial Observation and Interpretation of Cultures, 200

Gross Colony Characteristics Used to Differentiate and Presumptively Identify Microorganisms, 203

Colonies with Multiple Characteristics, 207

Growth of Organisms in Liquid Media, 207

- 9 Biochemical Identification of Gram-Negative Bacteria, 212**  
*Donald C. Lehman*  
Carbohydrate Utilization, 213  
Glucose Metabolism and Its Metabolic Products, 218  
Amino Acid Utilization, 218  
*Miscellaneous Tests, 220*  
Manual Multitest Systems, 224  
Rapid and Automated Identification Systems, 225
- 10 Immunodiagnosis of Infectious Diseases, 234**  
*Donald C. Lehman*  
Antibodies in Serologic Testing, 236  
Antigen Detection, 241  
Principles of Immunologic Assays, 242  
Use of Serologic Testing in Specific Diseases, 259  
Direct Antigen Detection Assays, 264
- 11 Applications of Molecular Diagnostics, 272**  
*Steven D. Mahlen*  
Nucleic Acid Hybridization Techniques, 274  
Nucleic Acid Amplification Procedures, 278  
Strain Typing and Identification, 295  
The Future of Molecular Diagnostics Testing in the Clinical Microbiology Laboratory, 298
- 12 Antibiotic Mechanisms of Action and Resistance, 303**  
*Albert Sheldon*  
Antibiotic Targets and Mechanisms of Action, 304  
Mechanisms of Antibiotic Resistance, 309  
Dissemination, 315
- 13 Antimicrobial Susceptibility Testing, 319**  
**A. Procedures in Antimicrobial Susceptibility Testing, 319**  
*Janet Fick Hindler, James H. Jorgensen*  
Reasons and Indications for Performing Antimicrobial Susceptibility Tests, 321  
Selecting Antimicrobial Agents for Testing And Reporting, 321  
Traditional Antimicrobial Susceptibility Test Methods, 324  
Automated Antimicrobial Susceptibility Test Methods, 340  
Interpretation of In Vitro Antimicrobial Susceptibility Test Results, 345  
Methods of Detecting Antimicrobial-Inactivating Enzymes, 345  
Quality Control of Antimicrobial Susceptibility Tests, 347  
Selecting an Antimicrobial Susceptibility Test Method, 351
- B. Special Antimicrobial Susceptibility Tests, 355**  
*Janet Fick Hindler*  
Minimum Bactericidal Concentration Test, 356  
Time-Kill Assays, 358  
Synergy Tests, 358  
Serum Bactericidal Test, 360  
*Molecular Probes for Identifying Determinants of Antimicrobial Resistance, 360*  
Measurement of Antimicrobial Agents in Serum and Body Fluids, 360

**PART II****LABORATORY IDENTIFICATION OF SIGNIFICANT ISOLATES**

- 14 Staphylococci, 367**  
*Linda S. Harrison*  
General Characteristics, 368  
Clinically Significant Species, 369  
Laboratory Diagnosis, 373  
Antimicrobial Susceptibility, 378
- 15 Streptococcus, Enterococcus, and other Catalase-Negative Gram-Positive Cocci, 382**  
*Donald C. Lehman, Connie R. Mahon, Kalavati Suvarna*  
General Characteristics of *Streptococcus* and *Enterococcus*, 383  
Clinically Significant Streptococci and *Streptococcus*-like Organisms, 395
- 16 Corynebacterium and Other Non-Spore-Forming Gram-Positive Rods, 410**  
*Linda L. Ross*  
*Corynebacterium*, 411  
*Listeria monocytogenes*, 417  
*Erysipelothrix rhusiopathiae*, 420  
*Lactobacillus*, 421
- 17 Aerobic Gram-Positive Bacilli, 425**  
*Ribhi Shawa*  
*Bacillus*, 426  
Aerobic Actinomycetes, 431
- 18 Neisseria Species and Moraxella catarrhalis, 438**  
*Karen S. Long, George Manuselis*  
General Characteristics, 439  
Pathogenic *Neisseria* Species, 439  
Nonpathogenic *Neisseria* Species, 454
- 19 Haemophilus and Other Fastidious Gram-Negative Bacilli, 462**  
**A. Haemophilus, HACEK Group, and Similar Microorganisms, 462**  
*George Manuselis, Tracy MacGill*  
*Haemophilus*, 463  
HACEK Group, 470  
*Capnocytophaga*, 476  
*Dysgonomonas*, 477  
*Pasteurella*, 477  
*Brucella*, 477  
*Francisella*, 480
- B. Legionella, 485**  
*Bardwell J. Eberly, A. Christian Whelen*  
General Characteristics, 486  
Clinical Significance, 486  
Laboratory Diagnosis, 487  
Antimicrobial Susceptibility, 492
- C. Bordetella, 495**  
*A. Christian Whelen, Bardwell J. Eberly*  
General Characteristics, 496  
Clinically Significant Species, 496

- Laboratory Diagnosis, 497  
Antimicrobial Susceptibility, 499
- 20 Enterobacteriaceae, 502**  
*Kimberly E. Walker, Amy J. Horneman, Connie R. Mahon, George Manuseelis*  
General Characteristics, 503  
Opportunistic Members of the Family  
  Enterobacteriaceae and Associated Infections, 505  
Primary Intestinal Pathogens of the Family  
  Enterobacteriaceae, 518  
New Genera of the Family Enterobacteriaceae, 524  
Laboratory Diagnosis of Enterobacteriaceae, 527
- 21 *Vibrio*, *Aeromonas*, and *Campylobacter* Species, 542**  
*Deborah Ann Josko*  
*Vibrio*, 543  
*Aeromonas*, 549  
*Plesiomonas*, 552  
*Campylobacter* and *Campylobacter*-like Species, 555
- 22 Nonfermenting and Miscellaneous Gram-Negative Bacilli, 564**  
*Geri S. Hall*  
General Characteristics of Nonfermenters, 565  
Clinically Significant Nonfermentative Gram-Negative Bacilli, 571  
Less Commonly Encountered Nonfermentative Gram-Negative Bacilli, 577
- 23 Anaerobes of Clinical Importance, 587**  
*Paul G. Engelkirk, Janet Duben-Engelkirk*  
Important Concepts in Anaerobic Bacteriology, 588  
Frequently Encountered Anaerobes and Their Associated Diseases, 594  
Specimen Selection, Collection, Transport, and Processing, 602  
Procedures for Identifying Anaerobic Isolates, 613  
Antimicrobial Susceptibility Testing, 634  
Treating Anaerobe-Associated Diseases, 639
- 24 The Spirochetes, 642**  
*Jason Barnhill, A. Christian Whelen*  
Leptospire, 643  
Borreliae, 645  
Treponemes, 647
- 25 *Chlamydia*, *Mycoplasma*, and *Ureaplasma*, 653**  
*Connie R. Mahon, Donald C. Lehman*
- A. *Chlamydia*, 653**  
General Characteristics, 655  
*Chlamydia trachomatis*, 655  
*Chlamydophila (Chlamydia) pneumoniae*, 663  
*Chlamydophila (Chlamydia) psittaci*, 665
- B. *Mycoplasma* and *Ureaplasma*, 669**  
General Characteristics, 670  
Clinical Infections, 670  
Laboratory Diagnosis, 673  
Antimicrobial Susceptibility, 679  
Interpretation of Laboratory Results, 679
- 26 *Mycobacterium tuberculosis* and other Nontuberculous Mycobacteria, 683**  
*Avery Goodwin*  
General Characteristics, 685  
Safety Considerations, 685  
Specimen Collection and Processing, 686  
Digestion and Decontamination of Specimens, 688  
Concentration, 690  
Staining for Acid-Fast Bacilli, 690  
Culture Media and Isolation Methods, 691  
Laboratory Identification, 694  
Immunodiagnosis, 704  
Clinical Significance of the *Mycobacterium tuberculosis* Complex, 704  
Clinical Significance and Differentiation of Nontuberculous Mycobacteria, 707  
*Mycobacterium leprae*, 714
- 27 Medically Significant Fungi, 718**  
*Annette W. Fothergill*  
General Characteristics, 719  
Taxonomy, 722  
Mycoses, 723  
Clinically Significant Species, 724  
Laboratory Diagnosis of Fungi, 748  
Immunodiagnosis of Fungal Infections, 757  
Antifungal Susceptibility, 757
- 28 Diagnostic Parasitology, 761**  
*Linda A. Smith*  
General Concepts in Parasitology Laboratory Methods, 762  
Medically Important Parasitic Agents, 769
- 29 Clinical Virology, 826**  
*William F. Nauschuetz, Sarah L. Learmonth*  
Characteristics of Viruses, 827  
Laboratory Diagnosis of Viral Infections, 828  
Double-Stranded DNA Viruses, 834  
Single-Stranded DNA Viruses, 841  
Double-Stranded RNA Viruses, 841  
Single-Stranded RNA Viruses, 842  
Hepatitis Viruses, 854  
Prions, 860  
Antiviral Therapy, 860
- 30 Agents of Bioterror, 864**  
*William F. Nauschuetz*  
Biosafety Levels, 864  
General Characteristics of Bioterror Agents, 865  
History of Criminal Use of Microbial Agents, 866  
The Laboratory Response Network, 867  
Agents of Bioterror, 868
- 31 Biofilms: Architects of Disease, 884**  
*John G. Thomas, Donald C. Lehman*  
Microbial Biofilms Defined, 885  
Architecture of Biofilms, 888  
Biofilm Properties, 888  
Mechanisms of Pathogenicity, 889  
Diseases Associated with Biofilms, 890  
Laboratory Consequences Associated with Biofilms, 893  
Potential Interventions, 893



## PART III

### LABORATORY DIAGNOSIS OF INFECTIOUS DISEASES: AN ORGAN SYSTEM APPROACH

- 32 Upper and Lower Respiratory Tract Infections, 899**  
*Dylan Slotar, James L. Cook*  
General Concepts of Infectious Diseases of the Respiratory Tract, 900  
Anatomic Characterization of the Respiratory Tract, 904  
Virulence Factors of Pathogenic Organisms, 905  
Upper Respiratory Tract Infections, 905  
Lower Respiratory Tract Infections, 914  
Respiratory Tract Infections in the Immunocompromised Host, 929
- 33 Skin and Soft Tissue Infections, 935**  
*Raymond A. Smego, Jr.*  
Skin and Skin Structures, 936  
Clinical Infections, 936
- 34 Gastrointestinal Infections and Food Poisoning, 957**  
*Maximo Brito, David Quimby, Connie R. Mahon, George Manuselis*  
General Concepts in Evaluating Gastrointestinal Infections and Food Poisoning, 958  
Anatomic Considerations, 958  
A Practical Approach to Diagnosis of the Patient with Diarrhea, 960  
Clinical Presentations and Pathogenic Mechanisms of Acute Diarrhea, 961  
Common Viral, Bacterial, and Parasitic Pathogens, 963  
Other Complications of Diarrheal Infections, 970  
Toxic Agents of Food Poisoning, 970  
Laboratory Diagnosis of Gastrointestinal Pathogens, 971  
Treatment and Prevention of Diarrhea, 976
- 35 Infections of the Central Nervous System, 979**  
*Sumati Nambiar, Kalavati Suvarna*  
General Concepts Related to Infections of the Central Nervous System, 980  
Infections of the Central Nervous System, 981  
Laboratory Diagnosis of Central Nervous System Infections, 990
- 36 Bacteremia and Sepsis, 995**  
*Sherry Trevino, David Ross*  
General Concepts Related to Bacteremic Infections, 996  
Epidemiology, 997  
Microbiology, 998  
Pathogenesis, 999  
Clinical Aspects of Bacteremia, 1000  
Laboratory Diagnosis, 1002  
Treatment, 1006  
Prevention, 1007
- 37 Urinary Tract Infections, 1010**  
*Augusto M. Alonto*  
The Urinary System, 1011  
Epidemiology and Risk Factors, 1012  
Clinical Signs and Symptoms, 1015  
Etiology of Urinary Tract Infections, 1015  
Laboratory Diagnosis, 1019  
Microbial Detection, 1022  
Interpretation of Results, 1026  
Susceptibility Reporting, 1027
- 38 Sexually Transmitted Diseases, 1031**  
*Kevin M. McNabb*  
Common Exudative Sexually Transmitted Infections, 1032  
Common Ulcerative Sexually Transmitted Infections, 1039
- 39 Infections in Special Patient Populations, 1047**  
*John H. Powers, Michelle M. Jackson*  
Malignancy, 1049  
Acquired Immunodeficiency Syndrome, 1051  
Complement Deficiency, 1051  
Burns and Surgery, 1051  
Antimicrobial Therapy, 1052  
Organ Transplantation, 1052  
Postsplenectomy, 1052  
Aging, 1052
- 40 Zoonotic and Rickettsial Diseases, 1055**  
*William F. Nauschuetz*  
Zoonotic Infections Transmitted By Scratches, Bites, or Other Contact with Domestic or Wild Animals, 1057  
Zoonotic Infections Transmitted by Direct Contact or Inhalation, 1061  
Emerging Zoonoses, 1065  
The Rickettsiae, 1065  
Family Rickettsiaceae, 1066
- 41 Ocular Infections, 1072**  
*Darlene Miller*  
General Concepts Related to Ocular Infections, 1073  
Infections of the Conjunctivae (Conjunctivitis), 1076  
Infections of the Lids (Blepharitis), 1082  
Infections of the Cornea (Keratitis), 1083  
Infections of the Sclera and Episclera (Scleritis and Episcleritis), 1087  
Infections of the Orbit (Preseptal and Orbital Cellulitis), 1087  
Infections of the Lacrimal Apparatus, 1088  
Infections of the Intraocular Chambers (Endophthalmitis), 1089  
Infections of the Uveal Tract (Uveitis), 1090  
Infections of the Retina (Retinitis), 1091  
Scleral Buckle Infections, 1093  
Biofilm-Centered Ocular Infections, 1093  
Laboratory Diagnosis of Ocular Infections, 1093  
Ocular Therapy, 1100

**APPENDIXES, 1105**

---

**Appendix A, 1105***Maribeth L. Flaws, 1105*

Selected Bacteriologic Culture Media, 0000

**Appendix B, 1129***Maribeth L. Flaws, 1129*

Selected Mycology Media, Fluids, and Stains, 1129

**Appendix C, 1133**

Answers to Learning Assessment Questions, 1133

**Glossary, 1155****Index, 1173**