



教育部 高等教育司 推荐
国外优秀生命科学教学用书

Foundations in Microbiology

Basic Principles

Eighth Edition

微生物学基础

第 8 版 影印版

Kathleen Park Talaro
Barry Chess

Mc
Graw
Hill Education



高等教育出版社
HIGHER EDUCATION PRESS



教育部高等教育司推荐
国外优秀生命科学教学用书

Foundations in Microbiology

Eighth Edition

Basic Principles

微生物学基础

第8版 影印版

W e i S h e n g w u x u e J i c h u

Kathleen Park Talaro

Barry Chess



高等教育出版社·北京
HIGHER EDUCATION PRESS BEIJING

图字：01—2013—0345号

Talaro

Foundations in Microbiology: Basic Principles, 8E

ISBN: 9780077342807

Copyright © 2012 by The McGraw-Hill Companies, Inc.

Original language published by The McGraw-Hill Companies, Inc. All Rights reserved. No part of this publication may be reproduced or distributed by any means, or stored in a database or retrieval system, without the prior written permission of the publisher.

Authorized English language reprint edition jointly published by McGraw-Hill Education (Asia) Co. and Higher Education Press Limited Company. This edition is authorized for sale in the People's Republic of China only, excluding Hong Kong, Macao SAR and Taiwan. Unauthorized export of this edition is a violation of the Copyright Act. Violation of this Law is subject to Civil and Criminal Penalties.

本书英文影印版由高等教育出版社有限公司和美国麦格劳-希尔教育出版(亚洲)公司合作出版。此版本仅限在中华人民共和国境内(但不允许在中国香港、澳门特别行政区和中国台湾地区)销售。未经许可之出口,视为违反著作权法,将受法律之制裁。

未经出版者预先书面许可,不得以任何方式复制或抄袭本书的任何部分。

本书封面贴有 McGraw-Hill 公司防伪标签,无标签者不得销售。

图书在版编目(CIP)数据

微生物学基础:第8版=Foundations in Microbiology:Basic Principles, Eighth Edition:英文/(美)特拉诺(Talaro, K. P.), (美)切丝(Chess, B.)著. —影印本. —北京:高等教育出版社, 2013.1

ISBN 978-7-04-036648-8

I. ①微… II. ①特… ②切… III. ①微生物学-英文 IV. ①Q93

中国版本图书馆CIP数据核字(2013)第001475号

封面图片说明(中国科学院微生物研究所 张立新研究员 惠赠)

一株中国南海深海来源的放线菌:疣孢菌(*Verrucosisspora* sp.), 扫描电镜下的菌体形态,可用于筛选抗结核药物前体。

策划编辑 高新景 责任编辑 高新景 封面设计 张楠 责任印制 朱学忠

| | | | |
|------|-------------------|------|---|
| 出版发行 | 高等教育出版社 | 咨询电话 | 400-810-0598 |
| 社址 | 北京市西城区德外大街4号 | 网 址 | http://www.hep.edu.cn |
| 邮政编码 | 100120 | | http://www.hep.com.cn |
| 刷 印 | 涿州市星河印刷有限公司 | 网上订购 | http://www.landaco.com |
| 开 本 | 889mm×1194mm 1/16 | | http://www.landaco.com.cn |
| 印 张 | 38.5 | 版 次 | 2013年1月第1版 |
| 字 数 | 1100千字 | 印 次 | 2013年1月第1次印刷 |
| 购书热线 | 010-58581118 | 定 价 | 78.00元 |

本书如有缺页、倒页、脱页等质量问题,请到所购图书销售部门联系调换

版权所有 侵权必究

物 料 号 36648-00

微生物学基础

(影印版)

登录以获取更多学习资源!

登录方法:

1. 访问 <http://res.hep.com.cn/36648>
2. 输入数字课程账号(见封底明码)、密码
3. 点击“LOGIN”、“进入 4A”
4. 进入学习中心, 选择课程

账号自登录之日起一年内有效, 过期作废。
使用本账号如有任何问题,
请发邮件至: lifescience@pub.hep.cn

微生物学基础 (影印版)

KATHLEEN PARK TALARO 主编

内容简介 | 纸质教材 | 版权信息 | 联系方式



欢迎登录

账号

密码

LOGIN

■ 内容简介

本学习网站包括《微生物学基础》(第8版)(影印版)一书中所有插图的彩色版, 按书中章节顺序排列。网站中所有彩图均可点击放大并下载, 是对原书的重要补充和扩展, 以方便读者参考使用。

高等教育出版社版权所有 2013

<http://res.hep.com.cn/36648>

教师
服务

本书另配有专供教师使用的PPT。请选用本书作为学生教材的授课教师发邮件至 lifescience@pub.hep.cn, 我们会有专人与您联系, 告知您如何免费获取教师资源, 谢谢!

Brief Contents

- CHAPTER 1
The Main Themes of Microbiology 1
- CHAPTER 2
The Chemistry of Biology 27
- CHAPTER 3
Tools of the Laboratory: Methods of Studying Microorganisms 58
- CHAPTER 4
A Survey of Prokaryotic Cells and Microorganisms 89
- CHAPTER 5
A Survey of Eukaryotic Cells and Microorganisms 123
- CHAPTER 6
An Introduction to Viruses 158
- CHAPTER 7
Microbial Nutrition, Ecology, and Growth 185
- CHAPTER 8
An Introduction to Microbial Metabolism: The Chemical Crossroads of Life 217
- CHAPTER 9
Microbial Genetics 254
- CHAPTER 10
Genetic Engineering: A Revolution in Molecular Biology 291
- CHAPTER 11
Physical and Chemical Agents for Microbial Control 319
- CHAPTER 12
Drugs, Microbes, Host—The Elements of Chemotherapy 351
- CHAPTER 13
Microbe-Human Interactions: Infection and Disease 386
- CHAPTER 14
An Introduction to Host Defenses and Innate Immunities 424
- CHAPTER 15
Adaptive, Specific Immunity and Immunization 452
- CHAPTER 16
Disorders in Immunity 486
- CHAPTER 17
Procedures for Identifying Pathogens and Diagnosing Infections 517

About the Authors

Kathleen Park Talaro is a microbiologist, educator, author, and artist. She has been nurturing her love of microbiology since her youth growing up on an Idaho farm where she was first fascinated by tiny creatures she could just barely see swimming in a pond. This interest in the microbial world led to a biology major at Idaho State University, where she worked as a teaching assistant and scientific illustrator for one of her professors. This was the beginning of an avocation which she continues today—that of lending her artistic hand to interpretation of scientific concepts. She continued her education at Arizona State University, Occidental College, California Institute of Technology, and California State University.

She has taught microbiology and major's biology courses at Pasadena City College for 30 years, during which time she developed new curricula and refined laboratory experiments. She has been an author of, and contributor to, several publications of the William C. Brown Company and McGraw-Hill Publishers since the early 1980s, first illustrating and writing for laboratory manuals and later developing this textbook. She has also served as a coauthor with Kelly Cowan on the first two editions of *Microbiology: A Systems Approach*.

Kathy continues to make microbiology a significant focus of her life and is passionate about conveying the significance and practical knowledge of the subject to everyone, regardless of their profession or position. In addition to her writing, she keeps current attending conferences and participating in the American Society for Microbiology and its undergraduate educational programs. She is gratified by the many supportive notes and letters she has received over the years from book adopters and students.

She lives in Altadena, California with husband Dave Bedrosian and son David. Whenever she can, she spends time with her daughter Nicole, who lives in Wyoming. In her spare time she enjoys photography, reading true crime books, music, crossword puzzles, and playing with her seven rescued kitties.



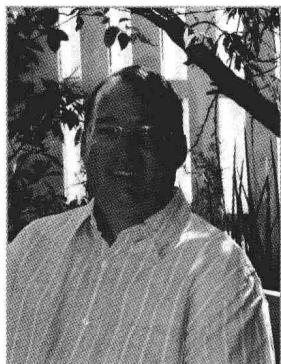
Kathy Talaro (right) and her daughter, Nicole.

Dedication

We wish to dedicate this book to microbes, those ingenious beings that beckon us into another realm that exists beyond our naked eyes. We marvel at their fantastic variety and wild, exotic ways of life. And even after many lifetimes of study, we still have much to learn from the tiny “animalcules” that Leeuwenhoek first saw over 300 years ago in “such enormous numbers that all the water seemed to be alive.”

About the Authors

The addition of two proven educators makes a great learning system even better



Barry Chess has been teaching microbiology at Pasadena City College for 14 years. He received his Bachelor's and Master's degrees from California State University, Los Angeles, and did several years of post-graduate work at the University of California, Irvine, where his research focused on the expression of eukaryotic genes involved in the development of muscle and bone.

At Pasadena City College, Barry developed a new course in human genetics and helped to institute a biotechnology program. He regularly teaches courses in microbiology, general biology, and genetics, and works with students completing independent research projects in biology and microbiology. Over the past several years, Barry's interests have begun to focus on innovative methods of teaching that lead to greater student understanding. He has written cases for the National Center for Case Study Teaching in Science and presented talks at national meetings on the use of case studies in the classroom. In 2009, his laboratory manual, *Laboratory Applications in Microbiology: A Case Study Approach*, was published. He is thrilled and feels very fortunate to be collaborating with Kathy Talaro, with whom he has worked in the classroom for more than a decade, on this eighth edition. Barry is a member of the American Society for Microbiology and regularly attends meetings in his fields of interest, both to keep current of changes in the discipline and to exchange teaching and learning strategies with others in the field.

Writing a textbook takes an enormous amount of time and effort. No textbook author has the time to write a great textbook and also write an entire book's worth of accompanying digital learning tools—at least not with any amount of success or accuracy. In the past, this material has often been built after the text publishes, but hopefully in time for classes to start. With the new digital era upon us, it is time to begin thinking of digital tools differently. In classrooms across the country, thousands of students who are visual learners and



have been using computers, video games, smart phones, music players, and a variety of other gadgets since they could talk are begging for an interactive way to learn their course material. Enter the digital author. With this eighth edition, we are excited to add professor **Heidi Smith** from Front Range Community College to the Talaro/

Chess team. Heidi teaches microbiology and anatomy & physiology and has worked hand-in-hand with the textbook authors, creating online tools that truly complement and enhance the book's content. She ensured that all key topics in the book have interactive, engaging activities spanning levels of Bloom's taxonomy, and tied to Learning Outcomes in the book. Instructors can now assign material based on what they cover in class, assess their students on the Learning Outcomes, and run reports indicating individual and/or class performance on a variety of data. Because of Heidi, we can now offer you a robust digital learning program, tied to Learning Outcomes, to enhance your lecture and lab, whether you run a traditional, hybrid, or fully online course.

*"I am gratified to introduce **Barry Chess**, a professor at Pasadena City College, as my coauthor on this new edition. He promises to bring a fresh eye to this project along with his own expertise in genetics and molecular biology, and a commitment to crafting a high quality product. Barry has an easy, very reader-friendly writing style that complements my own. He is astute and knowledgeable, with a rare ability to get to the heart of complex principles yet keep the reader involved and interested along the way. He often incorporates anecdotes, mnemonic devices, case studies, and analogies for helping students to learn and understand more difficult and abstract concepts."* —Kathleen Park Talaro

The Revision of an Expertly Crafted Learning Tool

What's New in the Eighth Edition?

Changes in the Eighth Edition of *Foundations in Microbiology, Basic Principles*

First and foremost in every revision of *Foundations in Microbiology, Basic Principles* is the careful reading of reviews and correction of any errors followed by the updating of content to ensure that the textbook is at the top of its class in being up-to-date. For example, in the eighth edition, areas of technology and antimicrobial drugs were revised and expanded upon, and all disease statistics have been updated.

Case Files

- All of the chapter Case Files are new except 7, 10, and 19, which have been revamped or expanded.
- The Case Files are now more integrated into the chapter with "Continuing the Case" boxes, a final "Case Perspective", and end-of-chapter Case File questions.

Expected Learning Outcomes and Checkpoints

- The chapter overviews have been replaced with expected learning outcomes that begin every major section of a chapter. These direct the student's learning towards the most important topics in that section.
- Each section of a chapter ends with assessment questions that focus on the Expected Learning Outcomes.

Additional Areas of Change

- For the chapters focusing on the agents of diseases, we have added new "Pathogen Profiles." These are abbreviated snapshots of the major pathogens in the chapter and include a micrograph, a description of the microscopic morphology, identification descriptions, habitat information, virulence factors, primary infections/disease, and control and treatment.
- Technology, antimicrobial drugs, and disease statistics have been updated.
- The eighth edition has over 200 new photographs, over 20 new or greatly revised figures, and a number of new illustrated tables.

- Many chapters have had changes in organization and modifications in their sections and headings.
- Numerous new assessment, writing-to-learn, and critical thinking questions have been added.
- A number of figures now contain insets of micrographs superimposed over a macroscopic photograph.
- Most chapters have new visual challenge questions.
- Figures have been evaluated to improve labeling and proportion and to clarify legends.
- Newly designed chapter opening pages tie in microbes more tightly with the Case Files.

Chapter 1

- New Case File about the exploration for new microbes in the oceans
- Figure on evolution has more illustrations added to the timeline
- Table on the work of microbiologists is revised
- The Introduction to Cells section is reorganized so that all coverage appears in the same area
- New photographs and examples for importance of microbes in natural environments
- New figures of microbes used in bioremediation and biotechnology
- New insight on emerging infections with update and figure on influenza
- Figure on scientific methods has been simplified
- Eight new photographs have been added to this chapter

Chapter 2

- New Case File about the search for life on Mars

Chapter 3

- New Case File introduces basic aspects of diagnosing meningitis
- Figure for tools of the laboratory and methods of studying microorganisms has been revised and an additional step called information gathering has been added to the 5 "I"s
- A new table to accompany this figure summarizes the steps in lab techniques
- Chapter now starts with microscopy, then isolation, identification, culturing and media
- A new introduction to identification techniques and keys has been added
- New information on unculturable has been added to the Insight reading

- Figure on dyes and staining has been revised
- Eleven new photographs have been added to this chapter

Chapter 4

- New Case File about a biofilm infection of a heart valve
- The section on bacterial taxonomy now contains photographs of examples
- Section on characteristics of life has been rewritten and shortened
- A description of type IV pili and motility has been added
- Thirteen new photographs have been added to this chapter

Chapter 5

- New Case File covers the neglected eukaryotic parasites
- The figure of eukaryotic taxonomy has been revised
- Ten new photographs have been added to this chapter

Chapter 6

- New Case File deals with the 2009 epidemic of H1N1 Influenza
- Several virus illustrations have been revised
- The figure on viral penetration has been updated
- Converted the table of virus families to an illustrated table
- Updated the Insight reading on creation of new viruses
- Seven new photographs have been added to this chapter

Chapter 7

- Chapter title changed to: Microbial Nutrition, Ecology, and Growth
- Updated Case File covers the Berkeley Pit with expanded information
- New anchoring figure 7.1 provides overview of the relationship of microbes to the environment
- We consolidated tables and moved text into a single table summarizing the functions of bioelements in microbial physiology
- Discussion on active transport was revised
- New information on *Deinococcus* was added to Insight on life in the extremes
- Six new photographs have been added to this chapter

Chapter 8

- New Case File covers the importance of microbes to ruminants

The Effort of an Expertly Crafted Learning Tool

- Revised the section on estimated amounts of ATP production
- Most of the chapter has been edited to improve flow and accuracy

Chapter 9

- New Case File details the developing drug resistance in *Acinetobacter*
- Extensive rewriting of sections on DNA replication, epigenetics, and regulation of RNA
- New figure 9.6 on DNA replication
- Added a clarification of detecting mutations
- New material on recombination in microbes
- Converted the boxed reading on genetics of animal viruses to regular text

Chapter 10

- Updated Case File on identifying the victims of the World Trade Center disaster
- New introduction to genetic engineering
- Revised figures on actions of endonucleases
- Added FISH figure
- Revised the text and a figure on DNA sequencing
- Added a short section on new “omics”
- Revised tables on genetically modified plants and animals
- Updated discussion on gene therapy
- Revised the descriptions of DNA fingerprinting
- Five new photographs have been added to this chapter

Chapter 11

- New Case File on the outbreak of hepatitis C linked to a Las Vegas clinic
- More details of the levels of resistance among microorganisms
- New discussion of how to select antimicrobial agents
- New figure to show the overall effects of temperature on a microbe's growth and survival
- New figure on the electromagnetic spectrum
- Revised figure on glutaraldehyde
- Replaced tables on thermal effects on microbes with tables of applications of physical agents
- Updated Insight reading on use of antibacterial substances
- Revised discussion of use of germicides
- Nine new photographs have been added to this chapter

Chapter 12

- New Case File about the aftermath of a needle-stick from an AIDS patient

- Revision of figure on effects of penicillin
- Added a Note on special strategies in drug therapy
- Revised the section on anti-HIV drugs
- Revised the table on actions of antiviral drugs
- Added a new figure on transfer of drug resistance
- Revised a figure on natural selection for drug resistance
- Added bacteriophage therapy to Insight reading on alternative therapies
- Updated information on drug resistance
- Four new photographs have been added to this chapter

Chapter 13

- Changed the chapter title to: Microbe-Human Interactions: Infections, Disease, and Epidemiology
- New Case File on outbreak of *Salmonella* food infection
- Added a new Insight reading on the role of the appendix
- New figure on the stages in infection
- New figure to show mechanism of invasion into host cells
- Revision of section on virulence factors
- Added mode of transmission to table on zoonoses
- Revised discussion on incidence and prevalence
- New figure on the percentage of nosocomial infections and the major infectious agents involved in them
- New figures to compare epidemiologic data
- Three new photographs have been added to this chapter

Chapter 14

- Changed the chapter title to: An introduction to Host Defenses and Innate Immunities
- New Case File on chronic granulomatous disease
- Added new material on defensins
- Revised introduction to recognition and surveillance
- Added a Note on chronic edema and filariasis
- Added clarifying information on MALT
- Moved toll-like receptor figure and discussion to phagocytosis section
- Rewrote the section on edema
- Added a new Note on neutrophil NETS that trap microbes
- More coverage on reactive oxygen intermediates
- Simplified coverage of the classical complement pathway

- Added photomicrographs of real WBCs to the figure on blood development
- New figure on lymphatic system
- New figure comparing blood and lymphatic circulations
- Added a dendritic cell to the macrophage maturation figure
- Six new photographs have been added to this chapter

Chapter 15

- New Case File on rabies and rabies immunization
- Moved section on natural, artificial, active, passive immunity to the section following T cell functions
- Revised figure on primary and secondary immune responses
- Replaced cancer cell photograph with two new ones
- Updated vaccination tables
- Clarified antigen and immunogen
- Added explanation of what accounts for the speed of the secondary immune response

Chapter 16

- New Case File about a transfusion reaction and its aftermath
- Six new photographs have been added to this chapter

Chapter 17

- Changed chapter title to: Procedures for Identifying Pathogens and Diagnosing Infections
- New Case File outlines a nosocomial *Vibrio* infection and includes tables used to narrow the identification of the pathogen involved
- Expanded flowchart for genera in infections
- New figure on pulse-field gel electrophoresis
- Expanded section on selection of media for isolation
- Six new photographs have been added to this chapter

Acknowledgments

We find ourselves excited and very enthusiastic about the transformations we have made in this edition, along with the addition of a dedicated CONNECT website that fully integrates with the features of the book. As with prior revisions, it has been a pleasure and a comfort to work with an energized and talented publishing team, most of whom are familiar friends. The finished product would not have been possible without the able support and input of senior developmental editor, Kathleen Loewenberg, sponsoring editor Lynn Breithaupt, and marketing manager Amy Reed. We are fortunate once again to have the highly competent Jayne Klein as senior project manager. Other dedicated and hard-working personnel are the photo research coordinator, Carrie Burger; photo researcher, Danny Meldung at Photo Affairs; C.J. Patterson, the copy editor; and the book designer, Tara McDermott, who has so artfully showcased the microbes throughout this edition. Special appreciation goes to Heidi Smith for her capable and diligent efforts to develop the digital assets for the new CONNECT website.

We owe a debt to the hundreds of reviewers who, through the years, have provided valuable insights into chapter organization, content, accuracy, and “teachability,” and who have made a lasting imprint on many facets of this book. This revision is no exception. We have been fortunate in having a wide spectrum of microbiology specialists with helpful and insightful critiques and valuable feedback. Several of these reviewers deserve particular mention for providing substantive reviews above and beyond the usual expectations. Many thanks to Benjie Blair, *Jacksonville State University*; Susan Bornstein-Forst, *Marian University*; Deborah V. Harbour, *College of Southern Nevada*; Luis Materon, *University of Texas, Pan American*; Mark Pilgrim, *College of Coastal Georgia*; Luis Rodriguez, *San Antonio College*; David J. Schwartz, *Houston Community College*; Kristine Snow, *Fox Valley Technical College*; James Doyle, *Paradise Valley Community College*; and Louise Thai, *University of Missouri*.

For the users of this book, we hope that you enjoy your explorations in the world of microbiology and that this fascinating science will leave a lasting impression on you. Although the book has been carefully inspected to weed out errors, no work in progress is ever perfect, and there will always be a few that slip through. If you detect any missing or misspelled words, missing labels, mistakes in content, or other errata, do not hesitate to contact the publisher, sales representative, or authors (ktalaro@aol.com or bxchess@Pasadena.edu).

—Kathy Talaro and Barry Chess

Reviewers

Joel Adams-Stryker, *Evergreen Valley College*
Michelle Alexander, *Baptist College of Health Sciences*
Lois Anderson, *Minnesota State University*
Sandra Barnes, *Housatonic Community College*
Melody Bell, *Vernon College*
Benjie Blair, *Jacksonville State University*
Ramaraj Boopathy, *Nicholls State University*
Susan Bornstein-Forst, *Marian University*
Carroll Bottoms, *Collin County Community College*
Danita Bradshaw-Ward, *Eastfield College*
Ana L. Dowey, *Palomar College*
James Doyle, *Paradise Valley Community College*
P. K. Duggal, *Maple Woods Community College*
Frances Duncan, *Pensacola Junior College*
Susan Finazzo, *Georgia Perimeter College*
Christina Gan, *Highline Community College*
Constance Hallberg, *University of Kansas*
Deborah Harbour, *College of Southern Nevada*
Julie Harless, *Lone Star College – Montgomery*
Randall Harris, *William Carey University*
Amy Helms, *Collin County Community College*
Jennifer A. Herzog, *Herkimer County Community College*
Phyllis Higley, *College of Saint Mary*
Kendricks Hooker, *Baptist College of Health Sciences*
Sheela Huddle, *Harrisburg Area Community College*
Dena Johnson, *Tarrant County College, Northwest*
Dennis Kitz, *Southern Illinois University*
Marcie Lehman, *Shippensburg University*
Terri J. Lindsey, *Tarrant County College South*
Danny Loosemore, *Northcentral Technical College*
Luis Materon, *The University of Texas Pan American*
Ethel Matthews, *Midland College*
Elizabeth McPherson, *The University of Tennessee*
Steven Obenauf, *Broward College*
Jean Petri, *Western Technical College*
Marcia Pierce, *Eastern Kentucky University*
Mark Pilgrim, *College of Coastal Georgia*
Teri Reiger, *University of Wisconsin–Oshkosh*
Jackie Reynolds, *Richland College*
Luis Rodriguez, *San Antonio College*
Benjamin Rowley, *University of Central Arkansas*
Mark A. Schneegurt, *Wichita State University*
David Schwartz, *Houston Community College, Southwest*
Timothy Secott, *Minnesota State University*
Heidi R. Smith, *Front Range Community College*
Kristine Snow, *Fox Valley Technical College*
Tracey Steeno, *Northeast Wisconsin Technical College*
Louise Thai, *University of Missouri*
Sanjay Tiwary, *Hinds Community College*
Diane Vorbroke, *Cincinnati State Technical and Community College*
Delon Washo-Krupps, *Arizona State University*
Ronald Weiss, *Marian University*

A Note to the Student

Tips on learning to gain understanding

Most of you are probably taking this course as a prerequisite to nursing, dental hygiene, medicine, pharmacy, optometry, physician assistant, or other health science programs. Because you are preparing for professions that involve interactions with patients, you will be concerned with infection control and precautions, which in turn requires you to think about microbes and how to manage them. This means you must not only be knowledgeable about the characteristics of bacteria, viruses, and other microbes, their physiology, and primary niches in the world, but you must also have a grasp of disease transmission, the infectious process, disinfection procedures, and drug treatments. You will need to understand how the immune system interacts with microorganisms and the effects of immunization. All of these areas bring their own vocabulary and language—much of it new to you—and mastering it will require time, motivation, and preparation. A valid question students often ask is: “How can I learn this information to increase my success in the course as well as retain it for the future?”

Right from the first, you need to be guided by how your instructor has organized your course. Since there is more information than could be covered in one semester or quarter, your instructor will select what he/she wants to emphasize and construct a reading and problem assignment that corresponds to lectures and discussion sessions. Many instructors have a detailed syllabus or study guide that directs the class to specific content areas and vocabulary words. Others may have their own website to distribute assignments and even sample exams. Whatever materials are provided, this should be your primary guide in preparing to study.

The next consideration involves your own learning style and what works best for you. To be successful, you must commit essential concepts and terminology to memory. A list of how we retain information called the “pyramid of learning” has been proposed by Edgar Dale: We remember about 10% of what we read; 20% of what we hear; 50% of what we see and hear; 70% of what we discuss with others; 80% of what we experience personally; and 95% of what we teach to someone else.

“The Talaro textbook not only gives a clearly-written, accurate verbal account of the workings of the microbial world, but also incorporates detailed and colorful figures and tables to give the students a visual picture of the life of microbes and the illnesses of microbiology. I love this textbook.”

—Diane K. Vorbroker, Cincinnati State Technical and Community College

There are clearly many ways to go about assimilating information—but mainly, you need to become involved in reading, writing, drawing simple diagrams, and discussion or study with others. This means reading alone will not gather the most important points from a chapter. You must attend lecture and laboratory sessions to listen to your instructors or teaching assistants explain the material. Notes

taken during lecture can be re-written or outlined to organize the main points. This begins the process of laying down memory. You should go over concepts with others—perhaps a tutor or study group—and even take on the role of the teacher-presenter part of the time. It is with these kind of interactions that you will not just rote memorize words but *understand* the ideas and be able to apply them later.

A way to assess your understanding and level of learning is to test yourself. You may use the exam questions in the text, on the CONNECT website, or make up your own. LearnSmart, available within the CONNECT site, is an excellent way to map your own, individualized learning program. It tracks what you know and what you don’t know and creates questions just for you based on your progress.

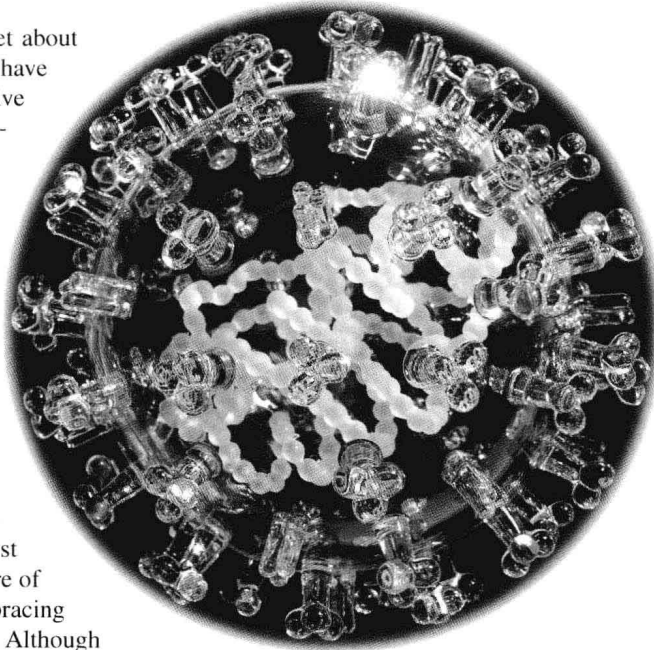
Another big factor in learning is the frequency of studying. It is far more effective to spend an hour or so each day for two weeks than a marathon cramming session on one weekend. If you approach the subject in small bites and remain connected with the terminology and topics, over time it will become yours and you will find that the pieces begin to fit together. In the final analysis, the process of learning comes down to self-motivation and attitude. There is a big difference between forcing yourself to memorize something to get by and really wanting to know and understand it. Therein is the key to most success and achievement, no matter what your final goals. And though it is true that mastering the subject matter in this textbook requires time and effort, millions of students will affirm how worthwhile it has been in their professions and everyday life.

Beginning the Journey

The beauty of microorganisms

If you were taking a survey of people on the street about their impression of microorganisms, you would not have to look very far to find someone with a rather negative vision, probably gleaned from commercials, of unsightly, disease-causing germs swarming around everywhere, lying in waiting for unsuspecting victims. But we'd like to think that, after looking through a microscope focused on a drop of pond water, most people would have their eyes opened, both literally and figuratively, by the astonishing images they see. A glimpse of the microbial world often surprises us with unusual and bizarre forms of great beauty and complexity, from the crystalline perfection of a virus to fantastic colors and shapes of algae. It is with this realization that we are featuring magnified views of interesting and striking microorganisms set in the context of a case study at the start of most chapters. Even our cover, depicting a glass sculpture of the H1N1 influenza virus, reflects a trend of embracing microorganisms as an inspiration for artistic works. Although a major intent of this textbook is to promote your understanding of the effects of microbes on humans and their involvement in diseases, we also aspire to communicate our appreciation and awe for these tiniest creatures and to provide insights into the tremendous impact they have on every facet of the earth. It is our hope that, in time, you too will become an advocate for microorganisms and help educate others about their importance, and perhaps even their beauty. Happy reading. . .

—*Kathleen Park Talaro and Barry Chess*



"I would have to say that this text is sophisticated, logically written, illustrated effectively, and very comprehensive. The chapters I reviewed were well written and very comprehensive. The chapter on metabolism was superb."

—*Luis A. Rodriguez, San Antonio College*

Contents

CHAPTER 1

The Main Themes of Microbiology 1

- 1.1 The Scope of Microbiology 2
- 1.2 General Characteristics of Microorganisms and Their Roles in the Earth's Environments 2
 - The Origins of Microorganisms 2
 - The Cellular Organization of Microorganisms 4
 - Microbial Dimensions: How Small Is Small? 5
 - Microbial Involvement in Energy and Nutrient Flow 6
- 1.3 Human Use of Microorganisms 8
- 1.4 Microbial Roles in Infectious Diseases 10
- 1.5 The Historical Foundations of Microbiology 11
 - The Development of the Microscope:
"Seeing Is Believing" 12
 - The Establishment of the Scientific Method 14
 - The Development of Medical Microbiology 16
 - The Discovery of Spores and Sterilization 16
- 1.6 Taxonomy: Organizing, Classifying, and Naming Microorganisms 18
 - The Levels of Classification 18
 - Assigning Specific Names 19
- 1.7 The Origin and Evolution of Microorganisms 20
 - Systems for Presenting a Universal Tree of Life 21

CHAPTER 2

The Chemistry of Biology 27

- 2.1 Atoms: Fundamental Building Blocks of All Matter in the Universe 28
 - Different Types of Atoms: Elements and Their Properties 28
 - The Major Elements of Life and Their Primary Characteristics 30
- 2.2 Bonds and Molecules 31
 - Covalent Bonds: Molecules with Shared Electrons 32
 - Ionic Bonds: Electron Transfer among Atoms 33
 - Electron Transfer and Oxidation–Reduction Reactions 35
- 2.3 Chemical Reactions, Solutions, and pH 36
 - Formulas, Models, and Equations 36
 - Solutions: Homogeneous Mixtures of Molecules 37
 - Acidity, Alkalinity, and the pH Scale 38
- 2.4 The Chemistry of Carbon and Organic Compounds 39
 - Functional Groups of Organic Compounds 41
 - Organic Macromolecules: Superstructures of Life 41

2.5 Molecules of Life: Carbohydrates 41

- The Nature of Carbohydrate Bonds 43
- The Functions of Carbohydrates in Cells 44

2.6 Molecules of Life: Lipids 45

- Membrane Lipids 45
- Miscellaneous Lipids 45

2.7 Molecules of Life: Proteins 47

- Protein Structure and Diversity 49

2.8 The Nucleic Acids: A Cell Computer and Its Programs 51

- The Double Helix of DNA 51
- Making New DNA: Passing on the Genetic Message 52
- RNA: Organizers of Protein Synthesis 52
- ATP: The Energy Molecule of Cells 53

CHAPTER 3

Tools of the Laboratory: Methods of Studying Microorganisms 58

3.1 Methods of Microbial Investigation 59

3.2 The Microscope: Window on an Invisible Realm 59

- Magnification and Microscope Design 61
- Variations on the Optical Microscope 64
- Electron Microscopy 67
- Preparing Specimens for Optical Microscopes 69

3.3 Additional Features of the Six "I's" 74

- Inoculation: Growth and Identification of Cultures 75
- Isolation Techniques 75
- Identification Techniques 76

3.4 Media: Foundations of Culturing 78

- Types of Media 79
- Physical States of Media 79
- Chemical Content of Media 80
- Media to Suit Every Function 81

CHAPTER 4

A Survey of Prokaryotic Cells and Microorganisms 89

4.1 Basic Characteristics of Cells and Life Forms 90

- What Is Life? 90

4.2 Prokaryotic Profiles: The Bacteria and Archaea 91

- The Structure of a Generalized Bacterial Cell 91
- Cell Extensions and Surface Structures 91

- 4.3 The Cell Envelope: The Boundary Layer of Bacteria 97**
 - Basic Typed of Cell Envelopes 97
 - Structure of Cell Walls 98
 - Mycoplasmas and Other Cell-Wall-Deficient Bacteria 101
 - Cell Membrane Structure 101
- 4.4 Bacterial Internal Structure 102**
 - Contents of the Cell Cytoplasm 102
 - Bacterial Endospores: An Extremely Resistant Life Form 104
- 4.5 Bacterial Shapes, Arrangements, and Sizes 106**
- 4.6 Classification Systems of Prokaryotic Domains: Archaea and Bacteria 110**
 - Bacterial Taxonomy Based on *Bergey's Manual* 110
- 4.7 Survey of Prokaryotic Groups with Unusual Characteristics 113**
 - Free-Living Nonpathogenic Bacteria 113
 - Unusual Forms of Medically Significant Bacteria 117
 - Archaea: The Other Prokaryotes 118

CHAPTER 5

A Survey of Eukaryotic Cells and Microorganisms 123

- 5.1 The History of Eukaryotes 124**
- 5.2 Form and Function of the Eukaryotic Cell: External Structures 124**
 - Locomotor Appendages: Cilia and Flagella 126
 - The Glycocalyx 127
 - Form and Function of the Eukaryotic Cell: Boundary Structures 128
- 5.3 Form and Function of the Eukaryotic Cell: Internal Structures 128**
 - The Nucleus: The Control Center 128
 - Endoplasmic Reticulum: A Passageway in the Cell 129
 - Golgi Apparatus: A Packaging Machine 129
 - Mitochondria: Energy Generators of the Cell 132
 - Chloroplasts: Photosynthesis Machines 133
 - Ribosomes: Protein Synthesizers 133
 - The Cytoskeleton: A Support Network 133
- 5.4 Eukaryotic-Prokaryotic Comparisons and Taxonomy of Eukaryotes 134**
 - Overview of Taxonomy 134
- 5.5 The Kingdom of the Fungi 135**
 - Fungal Nutrition 136
 - Organization of Microscopic Fungi 138
 - Reproductive Strategies and Spore Formation 138
 - Fungal Classification 141
 - Fungal Identification and Cultivation 143
 - Fungi in Medicine, Nature, and Industry 143
- 5.6 Survey of Protists: Algae 144**
 - The Algae: Photosynthetic Protists 145

- 5.7 Survey of Protists: Protozoa 146**
 - Protozoan Form and Function 146
 - Protozoan Identification and Cultivation 147
 - Important Protozoan Pathogens 149
- 5.8 Parasitic Helminths 152**
 - General Worm Morphology 152
 - Life Cycles and Reproduction 153
 - A Helminth Cycle: The Pinworm 154
 - Helminth Classification and Identification 154
 - Distribution and Importance of Parasitic Worms 154

CHAPTER 6

An Introduction to Viruses 158

- 6.1 Overview of Viruses 159**
 - Early Searches for the Tiniest Microbes 159
 - The Position of Viruses in the Biological Spectrum 159
- 6.2 The General Structure of Viruses 160**
 - Size Range 161
 - Viral Components: Capsids, Nucleic Acids, and Envelopes 162
- 6.3 How Viruses Are Classified and Named 167**
- 6.4 Modes of Viral Multiplication 169**
 - Multiplication Cycles in Animal Viruses 169
- 6.5 The Multiplication Cycle in Bacteriophages 174**
 - Lysogeny: The Silent Virus Infection 175
- 6.6 Techniques in Cultivating and Identifying Animal Viruses 177**
 - Using Cell (Tissue) Culture Techniques 177
 - Using Bird Embryos 178
 - Using Live Animal Inoculation 179
- 6.7 Viral Infection, Detection, and Treatment 179**
- 6.8 Prions and Other Nonviral Infectious Particles 180**

CHAPTER 7

Microbial Nutrition, Ecology, and Growth 185

- 7.1 Microbial Nutrition 186**
 - Chemical Analysis of Cell Contents 188
 - Forms, Sources, and Functions of Essential Nutrients 188
 - Classification of Nutritional Types 188
- 7.2 Transport: Movement of Substances across the Cell Membrane 193**
 - Diffusion and Molecular Motion 193
 - The Diffusion of Water: Osmosis 194
 - Adaptations to Osmotic Variations in the Environment 195
 - The Movement of Solutes across Membranes 196
 - Active Transport: Bringing in Molecules against a Gradient 196
 - Endocytosis: Eating and Drinking by Cells 196

7.3 Environmental Factors That Influence Microbes 198

- Adaptations to Temperature 199
- Gas Requirements 201
- Effects of pH 202
- Osmotic Pressure 203
- Miscellaneous Environmental Factors 203

7.4 Ecological Associations among Microorganisms 203

- Interrelationships between Microbes and Humans 206

7.5 The Study of Microbial Growth 207

- The Basis of Population Growth: Binary Fission 207
- The Rate of Population Growth 207
- Determinants of Population Growth 209
- Other Methods of Analyzing Population Growth 211

CHAPTER 8**An Introduction to Microbial Metabolism: The Chemical Crossroads of Life 217****8.1 The Metabolism of Microbes 218**

- Enzymes: Catalyzing the Chemical Reactions of Life 218
- Regulation of Enzymatic Activity and Metabolic Pathways 225

8.2 The Pursuit and Utilization of Energy 227

- Cell Energetics 227

8.3 Pathways of Bioenergetics 231

- Catabolism: An Overview of Nutrient Breakdown and Energy Release 231
- Energy Strategies in Microorganisms 231
- Aerobic Respiration 233
- Pyruvic Acid—A Central Metabolite 235
- The Krebs Cycle—A Carbon and Energy Wheel 235
- The Respiratory Chain: Electron Transport and Oxidation Phosphorylation 237
- Summary of Aerobic Respiration 240
- Anaerobic Respiration 241
- The Importance of Fermentation 241

8.4 Biosynthesis and the Crossing Pathways of Metabolism 244

- The Frugality of the Cell—Waste Not, Want Not 244
- Assembly of the Cell 245

8.5 Photosynthesis: The Earth's Lifeline 247

- Light-Dependent Reactions 247
- Light-Independent Reactions 248
- Other Mechanisms of Photosynthesis 249

CHAPTER 9**Microbial Genetics 254****9.1 Introduction to Genetics and Genes: Unlocking the Secrets of Heredity 255**

- The Nature of the Genetic Material 255

The Structure of DNA: A Double Helix with Its Own Language 256

DNA Replication: Preserving the Code and Passing It On 259

9.2 Applications of the DNA Code: Transcription and Translation 263

- The Gene-Protein Connection 263
- The Major Participants in Transcription and Translation 264
- Transcription: The First Stage of Gene Expression 265
- Translation: The Second Stage of Gene Expression 267
- Eukaryotic Transcription and Translation: Similar yet Different 270

9.3 Genetic Regulation of Protein Synthesis and Metabolism 273

- The Lactose Operon: A Model for Inducible Gene Regulation in Bacteria 273
- A Repressible Operon 273
- Non-Operon Control Mechanisms 274

9.4 Mutations: Changes in the Genetic Code 276

- Causes of Mutations 277
- Categories of Mutations 278
- Repair of Mutations 278
- The Ames Test 279
- Positive and Negative Effects of Mutations 279

9.5 DNA Recombination Events 280

- Transmission of Genetic Material in Bacteria 280

9.6 The Genetics of Animal Viruses 286

- Replication Strategies in Animal Viruses 286

CHAPTER 10**Genetic Engineering: A Revolution in Molecular Biology 291****10.1 Basic Elements and Applications of Genetic Engineering 292**

- Tools and Techniques of DNA Technology 292

10.2 Recombinant DNA Technology: How to Imitate Nature 301

- Technical Aspects of Recombinant DNA and Gene Cloning 301
- Construction of a Recombinant, Insertion into a Cloning Host, and Genetic Expression 302
- Protein Products of Recombinant DNA Technology 304

10.3 Genetically Modified Organisms 305

- Recombinant Microbes: Modified Bacteria and Viruses 306
- Recombination in Multicellular Organisms 307

10.4 Genetic Treatments: Introducing DNA into the Body 309

- Gene Therapy 309
- DNA Technology as Genetic Medicine 311

10.5 Genome Analysis: Fingerprints and Genetic Testing 312

- DNA Fingerprinting: A Unique Picture of a Genome 312

CHAPTER 11

Physical and Chemical Agents for Microbial Control 319

- 11.1 Controlling Microorganisms 320**
 - General Considerations in Microbial Control 320
 - Relative Resistance of Microbial Forms 320
 - Terminology and Methods of Microbial Control 322
 - What Is Microbial Death? 323
 - How Antimicrobial Agents Work: Their Modes of Action 325
- 11.2 Physical Methods of Control: Heat 326**
 - Effects of Temperature on Microbial Activities 327
 - The Effects of Cold and Desiccation 329
- 11.3 Physical Methods of Control: Radiation 331**
 - Radiation as a Microbial Control Agent 331
 - Modes of Action of Ionizing versus Nonionizing Radiation 331
 - Ionizing Radiation: Gamma Rays, X Rays, and Cathode Rays 332
 - Nonionizing Radiation: Ultraviolet Rays 333
- 11.4 Using Filtration to Remove Microbes 334**
 - Applications of Filtration Sterilization 334
- 11.5 Chemical Agents in Microbial Control 335**
 - Choosing a Microbicidal Chemical 336
 - Factors That Affect the Germicidal Activity of Chemicals 337
 - Categories of Chemical Agents 338

CHAPTER 12

Drugs, Microbes, Host—The Elements of Chemotherapy 351

- 12.1 Principles of Antimicrobial Therapy 352**
 - The Origins of Antimicrobial Drugs 352
 - Interactions between Drugs and Microbes 354
- 12.2 Survey of Major Antimicrobial Drug Groups 359**
 - Antibacterial Drugs That Act on the Cell Wall 359
 - Antibiotics That Damage Bacterial Cell Membranes 363
 - Drugs That Act on DNA or RNA 363
 - Drugs That Interfere with Protein Synthesis 363
 - Drugs That Block Metabolic Pathways 365
- 12.3 Drugs to Treat Fungal, Parasitic, and Viral Infections 366**
 - Antifungal Drugs 366
 - Antiparasitic Chemotherapy 366
- 12.4 Interactions between Microbes and Drugs: The Acquisition of Drug Resistance 370**
 - How Does Drug Resistance Develop? 371
 - Specific Mechanisms of Drug Resistance 371
 - Natural Selection and Drug Resistance 373

12.5 Interactions between Drugs and Hosts 374

- Toxicity to Organs 374
- Allergic Responses to Drugs 376
- Suppression and Alteration of the Microflora by Antimicrobials 376

12.6 Considerations in Selecting an Antimicrobial Drug 377

- Identifying the Agent 377
- Testing for the Drug Susceptibility of Microorganisms 377
- The MIC and the Therapeutic Index 379
- Patient Factors in Choosing an Antimicrobial Drug 380

CHAPTER 13

Microbe-Human Interactions: Infection, Disease, and Epidemiology 386

13.1 We Are Not Alone 387

- Contact, Colonization, Infection, Disease 387
- Resident Microbiota: The Human as a Habitat 388
- Indigenous Microbiota of Specific Regions 390
- Colonizers of the Human Skin 390
- Microbial Residents of the Gastrointestinal Tract 391
- Inhabitants of the Respiratory Tract 392
- Microbiota of the Genitourinary Tract 393

13.2 Major Factors in the Development of an Infection 394

- Becoming Established: Phase One—Portals of Entry 396
- The Requirement for an Infectious Dose 399
- Attaching to the Host: Phase Two 399
- Invading the Host and Becoming Established: Phase Three 399

13.3 The Outcomes of Infection and Disease 404

- The Stages of Clinical Infections 404
- Patterns of Infection 405
- Signs and Symptoms: Warning Signals of Disease 406
- The Portal of Exit: Vacating the Host 407
- The Persistence of Microbes and Pathologic Conditions 408

13.4 Origins and Transmission Patterns of Infectious Microbes 408

- Reservoirs: Where Pathogens Persist 409
- The Acquisition and Transmission of Infectious Agents 411
- Nosocomial Infections: The Hospital as a Source of Disease 413
- Universal Blood and Body Fluid Precautions 414

13.5 Epidemiology: The Study of Disease in Populations 415

- Who, When, and Where? Tracking Disease in the Population 415

CHAPTER 14

An Introduction to Host Defenses and Innate Immunities 424

14.1 Overview of Host Defense Mechanisms 425

- Barriers at the Portal of Entry: An Inborn First Line of Defense 425

14.2 Structure and Function of the Organs of Defense and Immunity 427

How Do White Blood Cells Carry Out Recognition and Surveillance? 428

Compartments and Connections of the Immune System 428

14.3 Second Line Defenses: Inflammation 437

The Inflammatory Response: A Complex Concert of Reactions to Injury 437

The Stages of Inflammation 437

14.4 Second Line Defenses: Phagocytosis, Interferon, and Complement 443

Phagocytosis: Partner to Inflammation and Immunity 443

Interferon: Antiviral Cytokines and Immune Stimulants 445

Complement: A Versatile Backup System 446

Overall Stages in the Complement Cascade 446

An Outline of Major Host Defenses 447

CHAPTER 15

Adaptive, Specific Immunity and Immunization 452

15.1 Specific Immunity: The Adaptive Line of Defense 453

An Overview of Specific Immune Responses 453

Development of the Immune Response System 453

15.2 Lymphocyte Maturation and the Nature of Antigens 459

Specific Events in B-Cell Maturation 459

Specific Events in T-Cell Maturation 459

Characteristics of Antigens and Immunogens 459

15.3 Cooperation in Immune Reactions to Antigens 461

The Role of Antigen Processing and Presentation 461

B-Cell Responses 463

Monoclonal Antibodies: Useful Products from Cancer Cells 468

15.4 T-Cell Responses 468

Cell-Mediated Immunity (CMI) 468

15.5 A Classification Scheme for Specific, Acquired Immunities 472

Defining Categories by Mode of Acquisition 472

1. Natural Activity Immunity: Getting an Infection 472

2. Natural Passive Immunity: Mother to Child 472

Artificial Immunity: Immunization 473

15.6 Immunization: Methods of Manipulating Immunity for Therapeutic Purposes 474

Artificial Passive Immunization 475

Artificial Active Immunity: Vaccination 475

Development of New Vaccines 476

Routes of Administration and Side Effects of Vaccines 479

To Vaccinate: Why, Whom, and When? 480

CHAPTER 16

Disorders in Immunity 486

16.1 The Immune Response: A Two-Sided Coin 487

Overreactions to Antigens: Allergy/Hypersensitivity 487

16.2 Type I Allergic Reactions: Atopy and Anaphylaxis 488

Modes of Contact with Allergens 489

The Nature of Allergens and Their Portals of Entry 489

Mechanisms of Type I Allergy: Sensitization and Provocation 490

Cytokines, Target Organs, and Allergic Symptoms 491

Specific Diseases Associated with IgE- and Mast-Cell-Mediated Allergy 493

Anaphylaxis: An Overpowering Systemic Reaction to Allergens 494

Diagnosis of Allergy 494

Treatment and Prevention of Allergy 495

16.3 Type II Hypersensitivities: Reactions That Lyse Foreign Cells 497

The Basis of Human ABO Antigens and Blood Types 497

Antibodies against A and B Antigens 498

The Rh Factor and Its Clinical Importance 499

Other RBC Antigens 500

16.4 Type III Hypersensitivities: Immune Complex Reactions 501

Mechanisms of Immune Complex Diseases 501

Types of Immune Complex Disease 502

16.5 Immunopathologies Involving T Cells 502

Type IV Delayed-Type Hypersensitivity 502

T Cells and Their Role in Organ Transplantation 504

Practical Examples in Transplantation 505

16.6 Autoimmune Diseases—An Attack on Self 506

Genetic and Gender Correlation in Autoimmune Disease 506

The Origins of Autoimmune Disease 506

Examples of Autoimmune Disease 507

16.7 Immunodeficiency Diseases: Compromised Immune Responses 509

Primary Immunodeficiency Diseases 509

Secondary Immunodeficiency Diseases 511

16.8 The Function of the Immune System in Cancer 511

CHAPTER 17

Procedures for Identifying Pathogens and Diagnosing Infections 517

17.1 An Overview of Clinical Microbiology 518

Phenotypic Methods 518

Genotypic Methods 518

Immunologic Methods 518

On the Track of the Infectious Agent: Specimen Collection 519