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J. 帕 克

(原书第十版·影印版)

Brock 微生物生物学

BROCK BIOLOGY OF MICROORGANISMS

(Tenth Edition)



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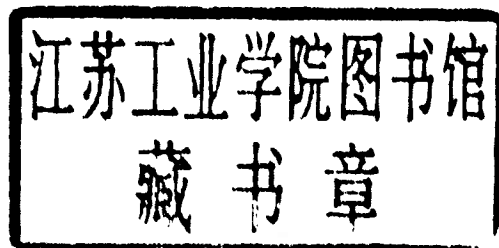
BROCK BIOLOGY OF MICROORGANISMS

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内 容 简 介

本书为《Brock 微生物生物学》(原书第十版)的影印版,涵盖了微生物学的许多新进展,展现了一个全新的组织结构和表达方式,同时也保留了以往版本的精华以便灵活适应新世纪的教学手段。本书共六个部分:微生物学原理,进化微生物学和微生物的多样性,代谢多样性和微生物生态学,免疫、病原和寄主的响应,微生物疾病和微生物在工业生产和科学研究中的应用,其知识全面、内容丰富。

本书适用于高等院校微生物专业的本科生、研究生和科研人员,也可供分子生物学、细胞生物学、生物技术等相关研究领域的教学、科研人员或技术人员参考使用。

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BROCK

BIOLOGY OF MICROORGANISMS

Michael T. Madigan dedicates this book to four individuals who departed this life in 2001. First, my mother Myrtle (February 28, 2001); she was a loving mother who raised a good family and encouraged me to go to college at a rather critical stage in my upbringing. Second, Charles Maas (the Colonel) (March 8, 2001), my best friend for over 35 years; oh how I wish you could have enjoyed those retirement years that we dreamed about over a beer on more than one occasion. Third, my father-in-law Bart Spear (June 29, 2001); a man of so many talents who left behind so many good memories. And finally, King, the wonder horse (November 9, 2001); his spirit and zest for life were inspirational to everyone who knew him. I miss all of you guys a lot.

*"Wishing you were somehow here again; wishing you were somehow near.
Sometimes it seemed, if I just dreamed, somehow you would be here."
Christine Daaé, The Phantom of the Opera, Act II, Scene 5.*

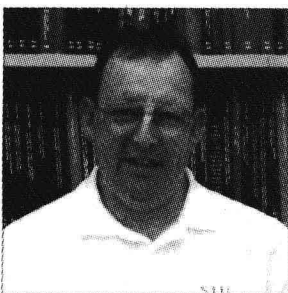
John M. Martinko dedicates this book to his mother, Lottie Martinko. Lottie has shared with me, and all of her children, the most important lessons of a successful life. Her unflagging optimism, good humor, critical insights, common sense, and especially her persistence, continue to be an inspiration and a guide. Thank you for your guiding example and gentle encouragement for over a half of a century.

Jack Parker dedicates this book to his mother, Ruth M. Parker, and to the memory of his father, Hayden John Parker.

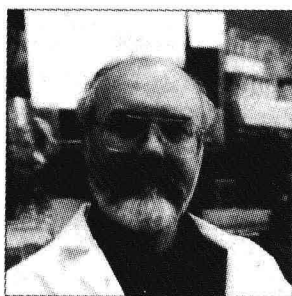
About the Authors



Michael T. Madigan received a bachelor's degree in biology and education from Wisconsin State University at Stevens Point in 1971 and M.S. and Ph.D. degrees in 1974 and 1976, respectively, from the University of Wisconsin, Madison, Department of Bacteriology. His graduate work involved study of hot spring phototrophic bacteria under the direction of Thomas D. Brock. Following three years of postdoctoral training in the Department of Microbiology, Indiana University, where he worked on phototrophic bacteria with Howard Gest, he moved to Southern Illinois University Carbondale, where he is now Professor of Microbiology. He has been a coauthor of *Biology of Microorganisms* since the fourth edition (1984) and teaches courses in introductory microbiology and bacterial diversity. In 1988 he was selected as the outstanding teacher in the College of Science, and in 1993 its outstanding researcher. In 2001 he was selected as the university's outstanding scholar. His research has dealt almost exclusively with anoxygenic phototrophic bacteria, especially those species that inhabit extreme environments. He has published 95 research papers, has coedited a major treatise on phototrophic bacteria, and is Chief Editor for North America of the journal *Archives of Microbiology*. His nonscientific interests include reading, hiking, tree planting, and caring for his dogs and horses. He lives beside a quiet lake about five miles from the SIU campus with his wife, Nancy, two dogs, Willie and Plum, and Springer and Feivel (horses).



John M. Martinko attended The Cleveland State University and majored in biology. As an undergraduate student he participated in a cooperative education program, gaining experience in several microbiology and immunology laboratories. He then worked for two years at Case Western Reserve University as a laboratory manager, conducting research on the structure, serology, and epidemiology of *Streptococcus pyogenes*. He did his graduate work at the State University of New York at Buffalo, investigating antibody specificity and antibody idiotypes for his M.A. and Ph.D. (1978) in microbiology. As a postdoctoral fellow, he worked at Albert Einstein College of Medicine in New York on the structure of major histocompatibility complex proteins. Since 1981, he has been in the Department of Microbiology at Southern Illinois University Carbondale where he is currently the Chair and Associate Professor. His research interests include the effects of growth hormone in the immune response and the development of immunodiagnostic tests for soybean brown stem rot disease. His teaching interests include undergraduate and graduate courses in immunology. He also teaches a portion of a general microbiology course, with responsibility for immunology, host defense, and infectious diseases. He lives in Carbondale with his wife, Judy, a high school science teacher, and their daughters, Martha and Helen.

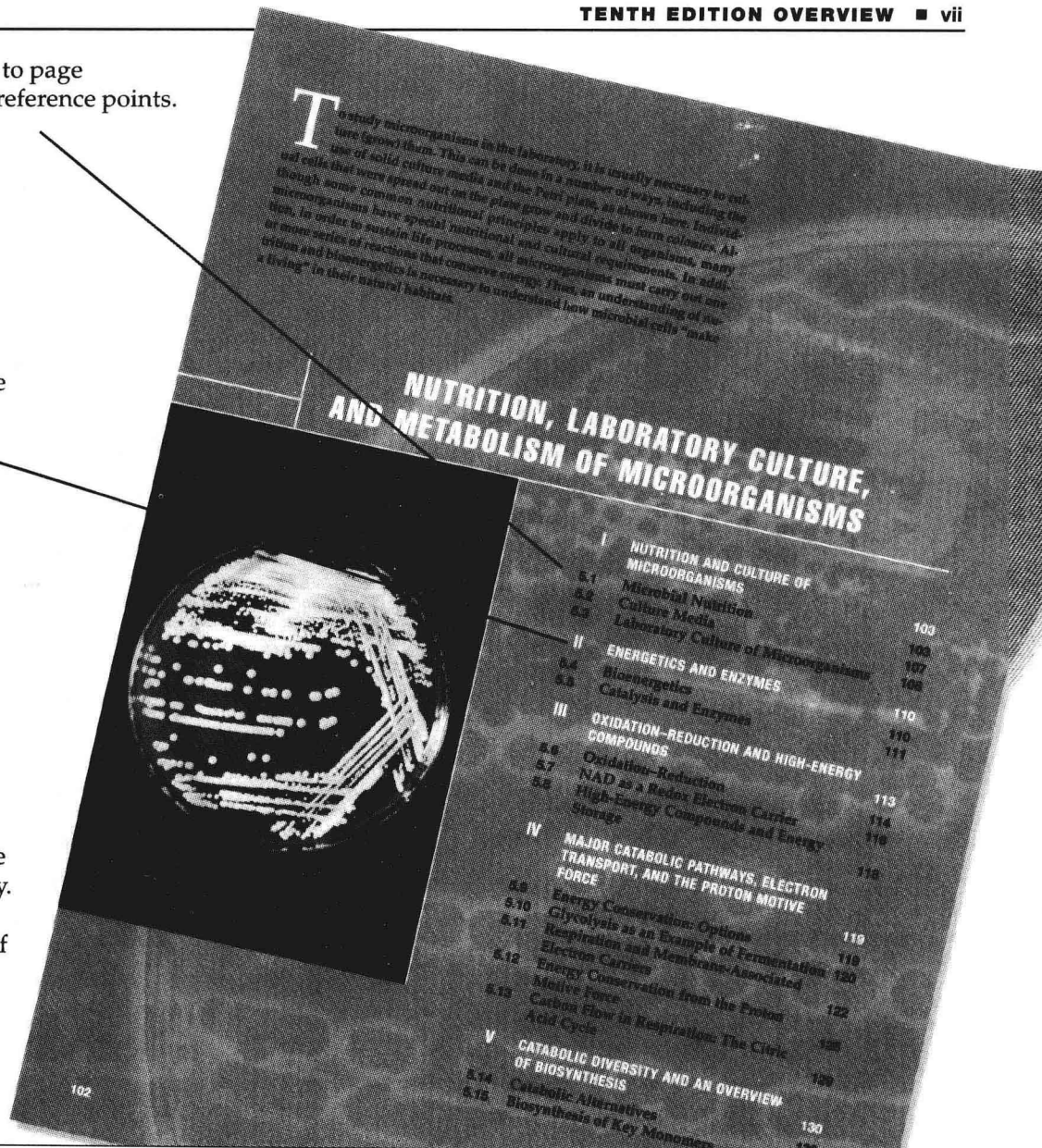


Jack Parker received his bachelor's degree in biology and also received his doctoral degree in a biology program (Ph.D., Purdue University, 1973). His research project dealt with bacterial physiology and he completed his Ph.D. research while in the microbiology department at the University of Michigan. Following this, he spent four years studying bacterial genetics at York University in Toronto, Ontario. He has taught courses in bacterial genetics, general genetics, human genetics, molecular biology, and molecular genetics, and has participated in courses in introductory microbiology, medical microbiology, and virology primarily at Southern Illinois University Carbondale, where he is now a Professor in the Department of Microbiology and Dean of the College of Science. His research has been in the broad area of molecular genetics and gene expression and has been focused most specifically on studies of how cells control the accuracy of protein synthesis. He is the author of approximately 50 research papers. His home is on the edge of the Shawnee National Forest in deep southern Illinois.

Section Numbers keyed to page numbers provides easy reference points.

New "Superheads" more effectively organize chapter contents.

The working glossary is the students' guide to the language of microbiology. Understanding these terms is key to mastery of the concepts in the chapter.



5.1 ■ MICROBIAL NUTRITION ■ 103

WORKING GLOSSARY

Activation energy the energy required to bring substrates to the reactive state

Aerobe a microorganism able to use O_2 in respiration

Anabolism the sum total of all biosynthetic reactions in the cell

Anaerobe a microorganism that either can or must grow in the absence of O_2

Aseptic technique the series of manipulations used to prevent contamination during the handling of sterile objects or microbial cultures

ATP synthase (ATPase) A multiprotein enzyme complex embedded in the membrane that catalyzes the synthesis of ATP coupled to dissipation of the proton motive force

Autotroph an organism capable of biosynthesizing all cell material from CO_2 as the

Coenzyme a small nonprotein molecule that participates in a catalytic reaction as part of an enzyme

Complex medium a culture medium composed of digests of chemically undefined substances such as yeast and meat extracts

Culture medium an aqueous solution of various nutrients suitable for the growth of microorganisms

Defined medium a culture medium whose precise chemical composition is known

Electron acceptor a substance that can accept electrons from some other substance, thereby becoming reduced in the process

Electron donor a substance that can do

Glycolysis a biochemical pathway in which glucose is fermented yielding energy (ATP) and various fermentation products. Also called the Embden-Meyerhof pathway

Oxidative phosphorylation the production of ATP at the expense of a proton motive force formed by electron transport

Photophosphorylation the production of ATP from a proton motive force formed from photosynthetic reactions

Proton motive force an energized state of the membrane resulting from the separation of charge and the elements of water (H^+ versus OH^-) across the membrane

Pure culture a culture that contains a single kind of microorganism

Reduction potential (E_0') the inherent

Completely redesigned graphs facilitate student comprehension.

The maximum growth temperature of a given organism most likely reflects the inactivation of one or more key proteins in the cell. However, the factors controlling an organism's *minimum* growth temperature are not as clear. As mentioned earlier (see Section 4.5), the cytoplasmic membrane must be in a fluid state for proper functioning. Perhaps the minimum temperature of an organism results from "freezing" of the cytoplasmic membrane so it no longer functions properly in nutrient transport or proton gradient formation. This explanation is supported by experiments in which the minimum temperature for an organism is altered to some extent by adjustments in membrane lipid composition (see Section 6.9). It is also observed that the cardinal temperatures of different microorganisms differ widely; some organisms have temperature optima as low as 4°C and some higher than 100°C. The temperature range throughout which growth occurs is even wider than this, from below freezing to greater than boiling. (The archaeon *Pyrolobus fumarii* has a temperature maximum of 113°C!) However, no single organism can grow over this whole temperature range, and the typical range for any given organism is about 30°, although some have a broader temperature range than others.

Temperature Classes of Organisms

Although there is a continuum of organisms, from those with very low temperature optima to those with high temperature optima, it is possible to broadly distinguish *four groups* of microorganisms in relation to their temperature optima: **psychrophiles**, with low temperature optima, **mesophiles**, with midrange temperature optima, **therm-**

ophiles, with high temperature optima, and **hyperthermophiles**, with very high temperature optima (Figure 6.17). Mesophiles are found in warm-blooded animals and in terrestrial and aquatic environments in temperate and tropical latitudes. Psychrophiles and thermophiles are found in unusually cold and unusually hot environments, respectively. Hyperthermophiles are found in extremely hot habitats such as hot springs, geysers, and deep-sea hydrothermal vents (see Sections 6.10 and 19.8).

In *Escherichia coli*, a typical mesophile, a detailed study of growth as a function of temperature has precisely defined its cardinal temperatures. The optimum temperature of *E. coli* in a complex medium is 39°C, the maximum is 48°C, and the minimum is 8°C. These values are subject to slight strain differences, and in general, the maximum and minimum temperatures supporting growth of an organism are higher and lower, respectively, when tested in complex rather than defined media.

✓ 6.8 Concept Check

Temperature is a major environmental factor controlling microbial growth. The cardinal temperatures describe the minimum, optimum, and maximum temperatures at which each organism grows. Microorganisms can be grouped by the temperature ranges they require.

- ✓ What are the approximate cardinal temperatures for *Escherichia coli*? To what temperature class does it belong?
- ✓ How does a *hyperthermophile* differ from a *psychrophile*?
- ✓ *Escherichia coli* can grow at a higher temperature in a complex medium than in a defined medium. Why?

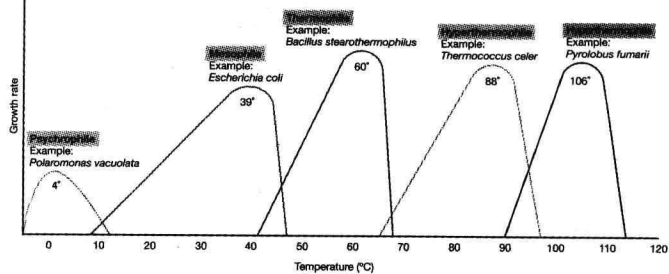


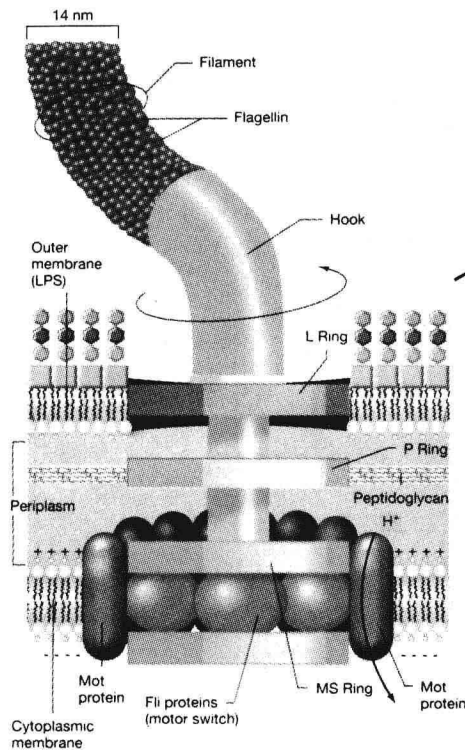
Figure 6.17 Relation of temperature to growth rates of a typical psychrophile, a typical mesophile, a typical thermophile, and two different hyperthermophiles. The temperature optima of the example organisms are shown on the graph.

Concept Checks summarize each section and provide quiz questions so students can evaluate their understanding as they progress through the chapter.

✓ 6.8 Concept Check

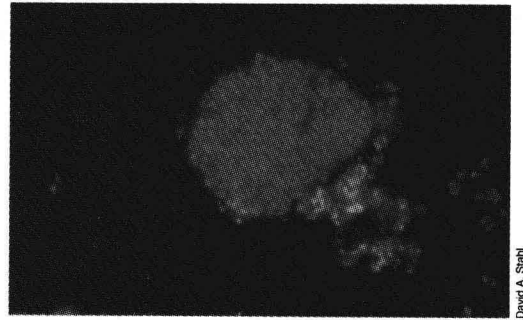
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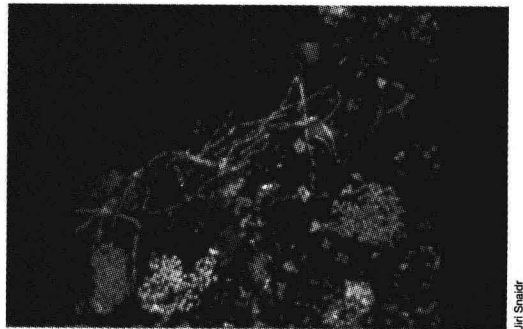


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A Focus On ... The Power of Metabolic Diversity: A Novel Nitrogenase

T nitrogenases have been characterized from a wide variety of prokaryotes, including some Archaea, and all of them show significant sequence homology at both the gene and polypeptide level. All of them, that is, until the nitrogenase from the streptomycete *Streptomyces thermoautotrophicus* was characterized.¹

S. thermoautotrophicus is a thermophilic (optimum temperature 65°C), gram-positive, filamentous prokaryote that occurs naturally in burning compost and charcoal piles (Figure 1). The organism is an aerobic

chemolithotrophic H₂ bacterium that can also use carbon monoxide (CO) as an electron donor. Although *S. thermoautotrophicus* has been known to be a nitrogen fixer for some time, some unusual properties of its nitrogen fixation system (like the fact that ammonia did not repress nitrogenase synthesis and that the enzyme did not reduce acetylene) prompted a more detailed examination of its nitrogenase. What was found represents a totally new paradigm for N₂ fixation.

The *S. thermoautotrophicus* nitrogenase contains Mo, but unlike classic Mo nitrogenase, it is completely insensitive to O₂. The dinitrogenase component of the *S. thermoautotrophicus* nitrogenase, called *Str1*, contains three different polypeptides that show some structural similarity to dinitrogenase polypeptides from other nitrogen-fixers, but the dinitrogenase reductase component, called *Str2*, shows no similarity to other dinitrogenase reductases. However, *Str2* shows very high sequence similarity to manganese-containing superoxide dismutases. In fact *Str2* is a superoxide dismutase! Recall from Chapter 6 (see Section 6.13) that superoxide dismutase function in the cell to consume superoxide (O₂⁻), forming O₂ in the process and thus preventing oxidative damage to cell components. But what does superoxide have to do with nitrogen fixation?

It has been shown that *Str2* supplies electrons to *Str1*. The source of the electrons is O₂⁻, and the O₂⁻ is formed from the

reduction of O₂ by a CO dehydrogenase (Figure 2). Thus, in analogy to the pyruvate → ferredoxin → dinitrogenase reductase → dinitrogenase sequence in classical nitrogen-fixation (see Figure 17.70), in *S. thermoautotrophicus* the sequence is CO → O₂⁻ → *Str2* → *Str1*. And, astonishingly, instead of O₂ inhibiting nitrogenase (as it does in every nitrogenase that has ever been examined), in *S. thermoautotrophicus* O₂ is actually required in the reaction mechanism of the enzyme!

Clearly, *S. thermoautotrophicus* nitrogenase is a structurally and functionally unique nitrogen-fixing system. How widespread such a system is and whether its primary function in the cell is actually to fix N₂, is as yet unknown. However, the *S. thermoautotrophicus* nitrogenase system is a good example of the power of metabolic diversity in prokaryotes: Even well-studied systems in which conformity prevails can occasionally yield big surprises and totally new concepts. Discovery of the *S. thermoautotrophicus* nitrogenase system has also renewed hope for the eventual genetic engineering of nitrogenase into agricultural crops such as corn. The fact that this nitrogenase is not oxygen labile and its energy requirements are much lower than those of classical nitrogenases (measurements show the *S. thermoautotrophicus* system to use only 25–50% of the ATP of classic Mo nitrogenases, see Figure 17.70) could make the dream of nitrogen-fixing row crops a reality someday. ■



Figure 1 Two burning charcoal piles in the Bavarian forest, Germany, containing cells of the N₂-fixing bacterium, *Streptomyces thermoautotrophicus*. The scientist shown is doing temperature measurements at various points in the piles. The piles emit the gases CO₂, CO, CH₄, and C₂H₂ and vary in temperature with depth. The surface to about 15 cm into the piles has temperatures of less than 100°C but deeper into the piles, temperatures can be over 300°C. *S. thermoautotrophicus* is active up to about 75°C, and oxidizes CO in both its energy metabolism and during N₂ fixation (see Figure 2).

¹Robb, M., D. Gaskari, and O. Meyer, 1997. *J. Biol. Chem.* 272: 29527–29533.

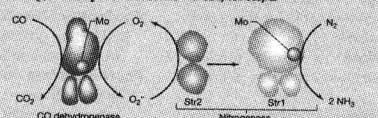
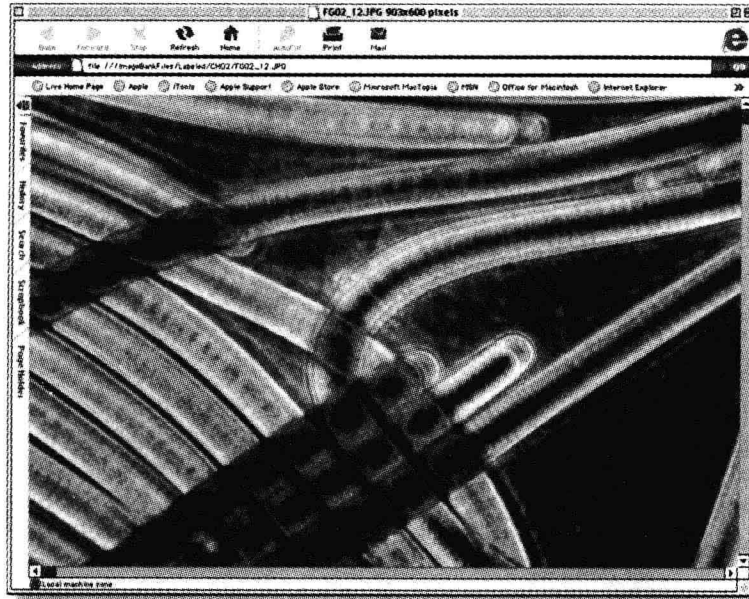


Figure 2 Reactions of nitrogen fixation in *S. thermoautotrophicus*. Although quite different proteins than dinitrogenase reductase and dinitrogenase, *Str2* and *Str1* are functionally equivalent, respectively, to these proteins.

Interesting scientific asides in boxed inserts—Techniques and Application boxes describe methods in microbiology and their application in the real world; Learning from the Past boxes describe historical developments in microbiology and their implications today; A Focus On boxes address text topics in greater detail.

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7.2 ■ DNA STRUCTURE: THE DOUBLE HELIX ■ 171

called exons, and the intervening noncoding regions, introns. Both intron and exon regions are transcribed into the primary transcript, or pre-mRNA, and the functional mRNA is subsequently formed by removal of noncoding regions. A summary contrasting genetic phenomena in prokaryotes and eukaryotes is given in Figure 7.2.

✓ 7.1 Concept Check

The three key processes of macromolecular synthesis are DNA replication; transcription, the synthesis of RNA from a DNA template; and translation, the synthesis of proteins using messenger RNA as template. Although the basic processes are the same in both prokaryotes and eukaryotes, the organization of genetic information is more complex in eukaryotes. Many eukaryotic genes have both coding regions (exons) and noncoding regions (introns).

- ✓ What three informational macromolecules are involved in genetic information flow?
- ✓ In all cells there are three processes involved in genetic information flow. What are they?

II DNA STRUCTURE

We dealt with the general structure of nucleic acids in Chapter 3. In the next few sections of this chapter we shall discuss the details of DNA structure necessary for an understanding of molecular genetics and the types of genetic elements containing DNA that are found in cells. With this information as a basis, we can then discuss how DNA is replicated, transcribed into RNA, and translated into protein.

7.2 DNA Structure: The Double Helix

The genetic information for all cellular processes is stored in DNA in the sequence of bases along the polynucleotide chain. As we have noted, only four different nucleic acid bases are found in DNA: adenine (A), guanine (G), cytosine (C), and thymine (T). As already shown in Figure 3.11, the backbone of the DNA chain consists of alternating units of phosphate and the sugar deoxyribose; connected to each sugar is one of the nucleic acid bases. Recall especially the numbering system for the positions of sugar and base; the phosphate connecting two sugars spans from the 3'-carbon of one sugar to the 5'-carbon of the adjacent sugar (see Figure 7.14). At one end of the DNA molecule the sugar has a phosphate on the 5'-hydroxyl, whereas at the other end the sugar has a free hydroxyl at the 3'-position.

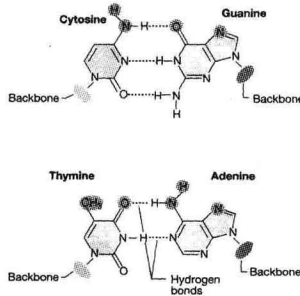


Figure 7.3 Specific pairing between adenine (A) and thymine (T) and between guanine (G) and cytosine (C) via hydrogen bonds. These two base pairs are the base pairs typically found in double-stranded DNA. Atoms that are found in the major groove of the double helix and that interact with proteins are highlighted in red. The deoxyribose phosphate backbones of the two strands of DNA are also indicated.

DNA as a Double Helix

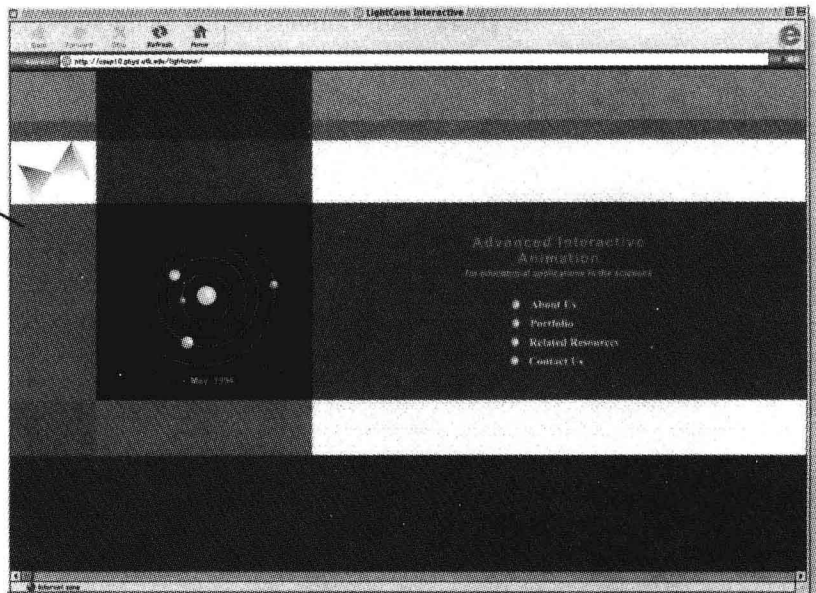
As we will discuss in Chapter 9, the chromosomes of some viruses are single-stranded. In all cellular organism chromosomes, however, DNA exists as two polynucleotide strands whose base sequences are complementary. The complementarity of DNA arises because of the specific pairing of the purine and pyrimidine bases: Adenine always pairs with thymine, and guanine always pairs with cytosine (Figure 7.3). The two strands in the resulting double-stranded molecule are arranged in an antiparallel fashion (see Figure 7.4). This means the two strands are in a "head-to-toe" arrangement. In Figure 7.4 the strand on the left is arranged 5' to 3' top to bottom, whereas the other strand is 5' to 3' bottom to top. The two strands are wrapped around each other forming a double helix (Figure 7.5). In this double helix, DNA forms two distinct grooves, the major groove and the minor groove. Of the many proteins that interact specifically with DNA (as we shall see in Chapter 8), most engage predominantly with the major groove, where there is a considerable amount of space. Because of the regularity of the double helix, some atoms of the bases are always exposed in the major groove (and some in the minor groove). Atoms in the major groove that are known to be important in interactions with proteins are shown in Figure 7.3.

The size of a DNA molecule can be expressed in terms of its molecular weight, but because a single nucleotide has a molecular weight of about 330, and because DNA molecules are many nucleotides long, the molecular weight mounts up rapidly. (The nucleic acid in

MEDIA TUTORIAL: DNA Structure

Media Tutorials available on the Companion Web Site are indicated by icons next to key figures.

Media Tutorials consist of animations, interactive exercises, review quizzes, links to important web sites, and much more.



Microbiology is a biological science that has effectively wedded the old and the new. Some of the basic techniques of microbiology discovered over 100 years ago—the isolation of pure cultures, for example—are still practiced with regularity in the laboratory today. But today's microbiologists are also armed with sophisticated tools that facilitate detailed molecular analyses of microbial cells. These tools have fueled new discoveries that are thrusting microbiology into the limelight of disciplines as diverse as medicine, agriculture, and ecology. It is within this exciting period in microbiology that we present the tenth edition of *Brock Biology of Microorganisms (BBOM)*, a textbook of microbiology that blends fundamental principles (the old) with state-of-the-art science (the new) in a format that will appeal to both students and instructors.

What's New? Organization

This edition of *BBOM* contains many new organizational features that will help students better master the material and help instructors prepare stimulating presentations for the classroom. First, the book has been extensively reorganized into six major units: (1) Principles of Microbiology; (2) Evolutionary Microbiology and Microbial Diversity; (3) Metabolic Diversity and Microbial Ecology; (4) Immunology, Pathogenicity, and Host Responses; (5) Microbial Diseases; and (6) Microorganisms as Tools for Industry and Research. Each unit consists of several chapters whose content define the themes. Unit 1, The Principles, forms the heart of the general microbiology course as currently envisioned by the Education Division of the American Society for Microbiology (ASM); in other words, Unit 1 is the "core" material that every student should know. Included for the first time in this unit is an overview chapter (Chapter 2) on microbial diversity that introduces the major groups of microorganisms and their evolutionary relationships. This chapter will allow instructors who emphasize the medical or molecular aspects of microbiology the opportunity to give their students a taste of microbial diversity without the details. This chapter also covers some of the basic aspects of cell structure/function and is written in such a way that only a minimal background in chemistry and biology is necessary to follow the story.

Other chapters that have been revamped in Unit 1 include Chapters 9 and 10. Compared with previous editions of *BBOM*, Chapter 9 (Essentials of Virology) has been restructured and downsized to place emphasis on the *essential concepts* of virology, instead of viral diversity. The latter material still exists, however, in the

new Chapter 16 (Bacterial, Plant and Animal Viruses), for those instructors who wish to explore viral diversity in more detail. Another substantially reorganized chapter is Chapter 10, Bacterial Genetics. This chapter has been rewritten from two major standpoints, microbial genetics as it occurs in the intact organism (*in vivo*) and microbial genetics as it is practiced *in vitro*. To accomplish the latter, some material from the biotechnology chapter has been reworked and moved to this new chapter on genetics. Thus, Chapter 10 better reflects bacterial genetics as it is actually practiced today—a blend of *in vivo* and *in vitro* science.

As has been a tradition with *BBOM*, the material in each chapter is broken into several *numbered heads* to assist instructors in assigning reading material. But in addition, in parallel to the unit concept that pervades organization at the level of the entire book, the numbered heads within a chapter are themselves grouped into major themes. The latter are signaled by red headings set in all caps, and were introduced in this edition to better group related material within a chapter into logical pieces.

In summary then, the tenth edition of *BBOM* is organized to capture and distill the basics while deploying the full story of the science at those points where it will have maximum impact. The authors and publishers are confident that this new format will make *BBOM 10/e* an even stronger resource for students and instructors alike.

Content

Every three years the authors of this book face one major question: how do we add new material and still keep the book within bounds? Longtime users of *BBOM* will immediately recognize that the tenth edition is essentially no longer than the ninth. This feat was accomplished by balancing the needs of the new material with a careful reevaluation of the old. Nothing essential to a fundamental understanding of microbiology has been deleted from *BBOM*; the tenth edition is still a book built on basic principles and strong science. But streamlining of some chapters along with a first-class art program has given the authors the space necessary to paint an up-to-the-minute picture of the science of microbiology in a volume that does not require weight training to lift off the table.

Several *totally new* chapters will be found in *BBOM 10/e*. The new overview of microbial diversity chapter (Chapter 2) and the viral diversity chapter (Chapter 16) have already been mentioned in this regard. Also new to this edition are Chapter 15

(Microbial Genomics); Chapter 18 (Methods in Microbial Ecology); Chapter 22 (Essentials of Immunology); Chapter 23 (Molecular Immunology); Chapter 27 (Animal-Transmitted, Arthropod-Transmitted, and Soilborne Microbial Diseases); Chapter 28 (Wastewater Treatment, Water Purification, and Waterborne Microbial Diseases); and Chapter 29 (Food Preservation and Foodborne Microbial Diseases). All of these areas are “hot topics” in microbiology today and needed increased visibility and expanded coverage. These new chapters should accomplish just that.

The genomic revolution has transformed microbiology into a new science almost overnight. For the first time, scientists can inspect, almost in a routine fashion now, the entire genetic blueprint of a microorganism, and then compare the blueprint with those of other organisms, from viruses to humans. Genomics has revealed the great genetic unity and diversity of living organisms and has opened the door to new advancements in every discipline of biology. And combined with proteomic analyses, scientists can now ask sophisticated questions about *gene expression* in ways never before possible. Chapter 15 in *BBOM 10/e* tells the genomic story, but goes well beyond just listing organisms whose genomes have been sequenced. The chapter explains what genomics is, how the reams of DNA sequence data that are being generated can be used, and what the genomic revolution has revealed thus far in terms of both the genomic and proteomic capacities of key microorganisms.

The new chapters in immunology were written to provide both the basics and the details of this important science. Chapter 22 (Essentials of Immunology) presents the basic principles of immunology without delving into too much detail. This chapter should therefore be a very student-friendly and readily teachable overview of immunology. We reserve the molecular details of immunology for the rather short Chapter 23. This chapter places the essentials material (Chapter 22) within a molecular context for those students and instructors whose background and interests support the study of immunology at this level. In Chapter 24 (Clinical Microbiology and Immunology) we have expanded our coverage of immunoassays to include more information about the basic mechanisms behind precipitation, agglutination, and antibody production. For those instructors who teach immunology only as a diagnostic or investigative tool, we have also included a very short summary of immune principles here. Thus, with the material on immunology organized as it is, the science of immunology can be integrated into introductory microbiology classes at all levels.


The new chapters in medical microbiology are expansions of this material originally covered in only two

chapters in previous editions. This has given the authors the opportunity to develop this important material in a more thorough way. And in this day and age where foodborne and waterborne illnesses are major public health problems (even in developed countries), and new threats to health and security, such as bioterrorism, are a fact of life, the unit on medical microbiology and immunology will be both a source of basic principles and a reference for keeping up with events in the news.

In summary, long-time users of *BBOM* will find the tenth edition to be the reliable friend they’ve always known. New users will find it to be the most current, accurate, and complete coverage of microbiology available in a textbook today. Coupled with an excellent set of teaching aids (see below) *BBOM 10/e* should set the standard in the field for years to come.

Pedagogical Aids

Art and photos are the mainstay of any textbook in the biological sciences. And frankly speaking, we think *BBOM 10/e* has the best in the business in both regards. The art program has once again been delivered by Imagineering of Toronto, Canada. Virtually every piece of art has seen some modification in order to maximize its impact and clarity. Some stylistic improvements have also been introduced into the art program, including a beautiful new rendering of all graphs in the book. High quality photos and photomicrographs have been a mainstay in *Biology of Microorganisms* since the first edition appeared in 1970, and *BBOM 10/e* proudly carries on this tradition with the inclusion of nearly 50 new B&W and color photos. And, as usual, these photos have been supplied by top researchers in the field.

BBOM 10/e once again employs a variety of student study aids to weave together the concepts and strengthen the learning experience. Instead of placing summary and quiz material only at the *end* of a chapter (as many textbooks like to do), *BBOM 10/e* contains two review tools—concept checks and concept links—*built right into* each chapter. Each **Concept Check** consists of a short summary of the material in the previous numbered head along with a short series of questions that together, reviews the major points in that section. **Concept Links** (signaled by the blue link icon, ) are the ties between the current text and related material found elsewhere in the book. In addition, readers will find the popular **Working Glossary**—a dictionary of essential terms—at the opening of each chapter. The Working Glossary is the student’s lifeline to the *language* of microbiology, an understanding of which is a key to mastering the concepts. Finally, and as in previous editions, the end of each chapter contains a number of review and application questions, many new to

this edition; the questions are designed to probe a student's retention of important concepts and ability to solve problems.

Supplements

A number of supplements accompany this book. Totally new to the tenth edition of *BBOM* are a series of online media tutorials that are found in the *Companion Website* (www.prenhall.com/brock). These cover a number of conceptually challenging topics in microbiology, including basic processes in molecular biology, genetics, medical microbiology and immunology, and microbial metabolism. These unique instructional resources include animations, interactive exercises, and self-quizzes, and will be a major supporting feature for the material in Unit I of *BBOM 10/e*, the heart of the introductory course in microbiology.

These tutorials are designed to guide students' understanding of various fundamental concepts through animations, interactive exercises, and self-assessment. Each concept that is the subject of an Online Media Tutorial is identified by an icon similar to the one in the margin next to this paragraph, placed alongside the relevant figure in the text. Also on the website are additional materials for each chapter along with the popular *Virtual Exam*, first introduced with *BBOM 9/e*. The Virtual Exam is a large pool of questions (written in an objective format, multiple choice, true-false, matching, and the like) keyed to individual chapters that students can use as a resource to help prepare for their real exams in the classroom. Virtual Exam questions have been assembled from actual examinations given in introductory microbiology courses in the United States that assign *BBOM* as a textbook. With the Virtual Exam, students can take an exam online and receive instant feedback on their readiness for exam day.

A variety of supplements are available for instructors. First, a set of over **350 Full Color Transparencies**, far more than is available with any other textbook of microbiology, accompany every adoption of *BBOM 10/e*. Although computer lectures are becoming the norm in many classrooms, the transparency is still the visual aid workhorse for many instructors. To help instructors in this regard, all of the most teachable figures in the book are covered in the transparency set. Second, a first-rate *Instructor's Resource CD-ROM* is available that contains virtually all of the art and photos from *BBOM 10/e* in Microsoft PowerPoint® to assist instructors in tailoring computer presentations to the goals and objectives of their particular course. In addition, all of the animations and exercises that appear on the student website will be on the Instructor's Resource CD-ROM. Whether one uses transparencies or CD-ROMs, the *BBOM 10/e* instructor package offers all of the necessary tools for de-

veloping clear, compelling, and stimulating presentations for the classroom.

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Although the authors have put a strong effort into assembling this classic tenth edition of *BBOM*, the book would never have come together in the way it did without the help of many other individuals. These include all the people at Prentice Hall/Pearson, including in particular our editor, Gary Carlson and his editorial assistant, Susan Zeigler, and our production editor, Debra Wechsler. Gary offered key editorial input into this project, including the commissioning of several very useful reviews. Susan kept the project moving along in the critical reviewing stages, and was extremely helpful in dealing with author requests. Debra, in her usual thorough and professional way, is largely responsible for the beautiful appearance of the final product. Through everyone's gallant efforts in the publishing side of this book, the authors had more freedom than usual to contemplate issues such as organization, content, and pedagogy.

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Any errors in this book, either those of commission or omission, are, of course, solely the responsibility of the authors. In this regard, we list author contact information and would greatly appreciate receiving comments, suggestions, and corrections from users. The entire author team has been with the book through a number of editions now and have through the years developed rather “thick skins” to criticism. Thus, we would sincerely enjoy receiving the frank input of users concerning how the book could be made even better in the future.

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