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In memory of Lili Pasternak (1938–2008),
an extraordinary human being
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Preface

Since the early 1970s, when recombinant DNA technology was first developed, there has been a veritable explosion of knowledge in the biological sciences. Since that time, with the advent of PCR, chemical DNA synthesis, DNA sequencing, monoclonal antibodies, directed mutagenesis, genomics, proteomics, and metabolomics, our understanding of and ability to manipulate the biological world have grown exponentially. When the first edition of Molecular Biotechnology: Principles and Applications of Recombinant DNA was published in 1994, nearly all of the transgenic organisms that were produced included only a single introduced gene. Just 15 years later, it is not uncommon for researchers to engineer organisms by modifying both the activity and the regulation of existing genes while at the same time introducing entire new pathways. In 1994, only a handful of products produced by this new technology were available in the marketplace. Today, molecular biotechnology has given us several hundred new therapeutic agents, with many more in the pipeline, as well as dozens of transgenic plants. The use of DNA has become a cornerstone of modern forensics, paternity testing, and ancestry determination. Several new recombinant vaccines have been developed, with many more on the horizon. The list goes on and on. Molecular biotechnology really has lived up to its promise, to all of the original hype. It has been estimated that worldwide there are currently several thousand biotechnology companies employing tens of thousands of scientists. When the exciting science being done at universities, government labs, and research institutes around the world is factored in, the rate of change and of discovery in the biological sciences is astounding. This fourth edition of Molecular Biotechnology, building upon the fundamentals that were established in the previous three editions, endeavors to provide readers with a window on some of the major developments in this growing field in the past several years. Of necessity, we have had to be highly selective in the material that is included in this edition. Moreover, the window that we are looking through is moving. This notwithstanding, we both expect and look forward to the commercialization of many of these discoveries as well as to the development of new approaches, insights, and discoveries.

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Molecular Biotechnology emerged as a new research field that arose as a result of the fusion in the late 1970s of recombinant DNA technology and traditional industrial microbiology. Whether one goes to the movies to see Jurassic Park with its ingenious but scientifically untenable plot of cloning dinosaurs, reads in the newspaper about the commercialization of a new “biotech” tomato that has an extended shelf life, or hears one of the critics of molecular biotechnology talking about the possibility of dire consequences from genetic engineering, there is a significant public awareness about recombinant DNA technology. In this book, we introduce and explain what molecular biotechnology actually is as a scientific discipline, how the research in the area is conducted, and how this technology may realistically impact on our lives in the future.

We have written Molecular Biotechnology: Principles and Applications of Recombinant DNA to serve as a text for courses in biotechnology, recombinant DNA technology, and genetic engineering or for any course introducing both the principles and the applications of contemporary molecular biology methods. The book is based on the biotechnology course we have offered for the past 12 years to advanced undergraduate and graduate students from the biological and engineering sciences at the University of Waterloo. We have written this text for students who have an understanding of basic ideas from biochemistry, molecular genetics, and microbiology. We are aware that it is unlikely that students will have had all of these courses before taking a course on biotechnology. Thus, we have tried to develop the topics in this text by explaining their broader biological context before delving into molecular details.

This text emphasizes how recombinant DNA technology can be used to create various useful products. We have, wherever possible, used experimental results and actual methodological strategies to illustrate basic concepts, and we have tried to capture the flavor and feel of how molecular biotechnology operates as a scientific venture. The examples that we have selected—from a vast and rapidly growing literature—were chosen as case studies that not only illustrate particular points but also provide the reader with a solid basis for understanding current research in specialized areas of molecular biotechnology. Nevertheless, we expect that some of our examples will be out of date by the time the book is published, because molecular biotechnology is such a rapidly changing discipline.
For the ease of the day-to-day practitioners, scientific disciplines often develop specialized terms and nomenclature. We have tried to minimize the use of technical jargon and, in many instances, have deliberately used a simple phrase to describe a phenomenon or process that might otherwise have been expressed more succinctly with technical jargon. In any field of study, synonymous terms that describe the same phenomenon exist. In molecular biotechnology, for example, recombinant DNA technology, gene cloning, and genetic engineering, in a broad sense, have the same meaning. When an important term or concept appears for the first time in this text, it is followed in parentheses with a synonym or equivalent expression. An extensive glossary can be found at the end of the book to help the reader with the terminology of molecular biotechnology.

Each chapter opens with an outline of topics and concludes with a detailed summary and list of review questions to sharpen students’ critical thinking skills. All of the key ideas in the book are carefully illustrated by the more than 200 full-color diagrams in the pedagogical belief that a picture is indeed worth a thousand words. After introducing molecular biotechnology as a scientific and economic venture in Chapter 1, the next five chapters (2 to 6) deal with the methodologies of molecular biotechnology. The chapters of Part I act as a stepping-stone for the remainder of the book. Chapters 7 to 12 in Part II present examples of microbial molecular biotechnology covering such topics as the production of metabolites, vaccines, therapeutics, diagnostics, bioremediation, biomass utilization, bacterial fertilizers, and microbial pesticides. Chapter 13 describes some of the key components of large-scale fermentation processes using genetically engineered (recombinant) microorganisms. In Part III, we deal with the molecular biotechnology of plants and animals (Chapters 14 and 15). The isolation of human disease-causing genes by using recombinant DNA technology and how, although it is in its early stages, genetic manipulation is being currently contemplated for the treatment of human diseases are presented in Chapters 16 and 17. The book concludes with coverage of the regulation of molecular biotechnology and patents in Part IV.

A brief mention should be made about the reference sections that follow each chapter. Within many of the chapters we have relied upon the published work of various researchers. In all cases, although not cited directly in the body of a chapter, the original published articles are noted in the reference section of the appropriate chapter. In some cases, we have taken “pedagogic license” and either extracted or reformulated data from the original publications. Clearly, we are responsible for any distortions or misrepresentations from these simplifications, although we hope that none has occurred. The reference sections also contain other sources that we used in a general way, which might, if consulted, bring the readers closer to a particular subject.

Acknowledgments

We express our appreciation to the following people who reviewed various parts of the manuscript as it was being developed. The comments of these expert scientists and teachers helped us immeasurably: Arthur I. Aronson, Purdue University; Ronald M. Atlas, University of Louisville; Fred Ausubel, Massachusetts General Hospital; David R. Benson, University of Connecticut; Jean E. Brenchley, Pennsylvania State University; A. M. Chakrabarty, University of Illinois at Chicago; Stan Gelvin, Purdue
University; Janet H. Glaser, University of Illinois at Urbana-Champaign; David Gwynne, Cambridge NeuroScience; George D. Hegeman, Indiana University; James B. Kaper, University of Maryland at Baltimore; Donald R. Lightfoot, Eastern Washington University at Cheney and Spokane; Cynthia Moore, Washington University; William E. Newton, Virginia Polytechnic University; Danton H. O’Day, University of Toronto in Mississauga; Richard D. Palmiter, University of Washington; David H. Persing, Mayo Clinic; William S. Reznikoff, University of Wisconsin; Campbell W. Robinson, University of Waterloo; Marc Siegel, University of Waterloo; Aaron J. Shatkin, Center for Advanced Biotechnology and Medicine at Rutgers University; Jim Schwartz, Genentech; Daniel C. Stein, University of Maryland at College Park; Dean A. Stetler, University of Kansas; and Robert T. Vinopal, University of Connecticut.

The following professionals at ASM Press worked on the book and deserve our thanks: Susan Birch, senior production editor; Ruth Siegal, developmental editor; Jodi Simpson, copy editor; Susan Schmidler, designer and art director; Peg Markow at Ruttle, Shaw & Wetherill, Inc., senior project manager; and Network Graphics, illustrators. Finally we are indebted to Patrick Fitzgerald, Director of ASM Press, who, in all possible ways, helped transform our original efforts into an acceptable final form. His encouragement as a persistent and friendly “torturer” was deeply appreciated.

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