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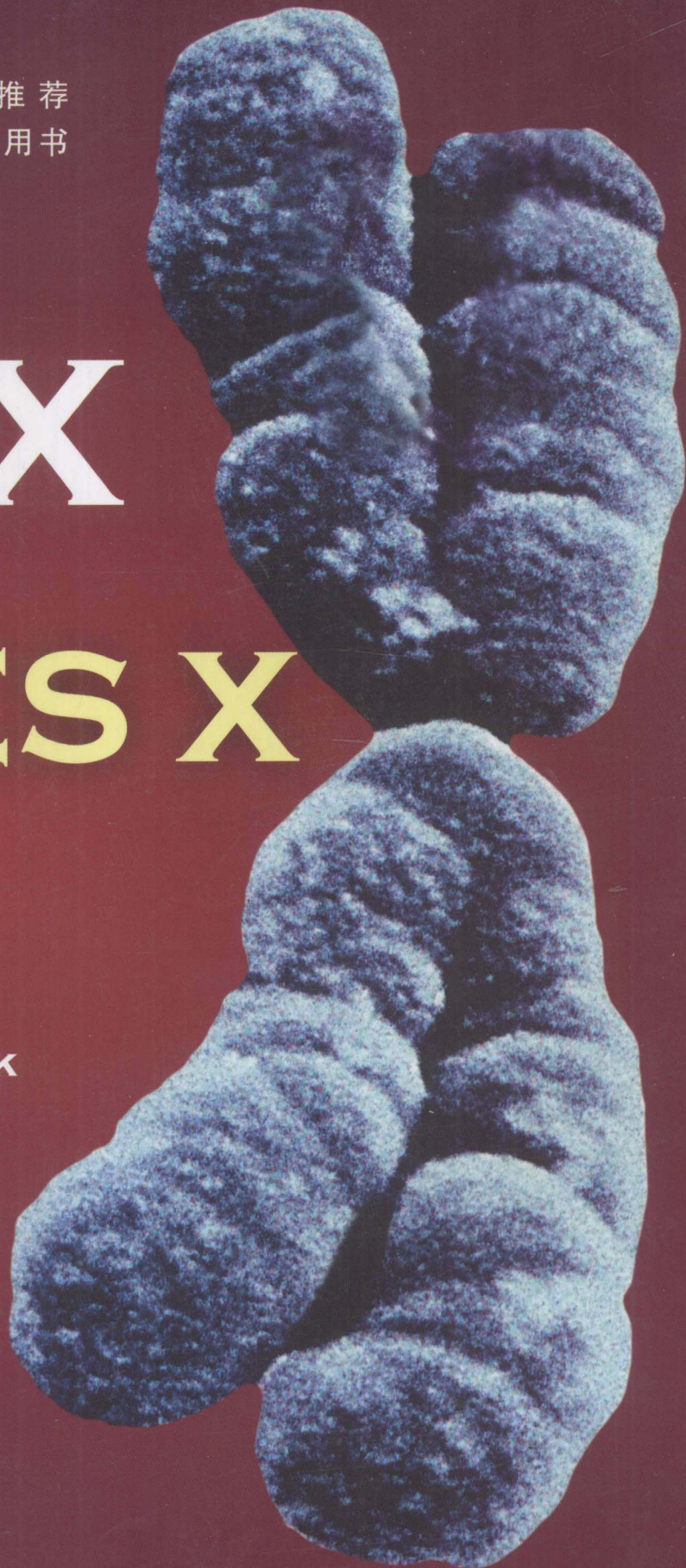
# 基因 X

## LEWIN'S GENES X

JOCELYN E. KREBS

ELLIOTT S. GOLDSTEIN

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# LEWIN'S GENES X

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# Dedication

To Benjamin Lewin, for setting the bar high.

To my mother, Ellen Baker, for raising me with a love of science; to the memory of my stepfather, Barry Kiefer, for convincing me science would stay fun; and to my partner, Susannah Morgan, for always pretending my biology jokes are funny. Finally, to my son, Rhys, who may someday read a future edition of this book.

Jocelyn Krebs

To my family: my wife, Suzanne, whose patience, understanding, and confidence in me are amazing; my children, Andy, Hyla, and Gary, who have taught me so much about using the computer; and my grandchildren, Seth and Elena, whose smiles and giggles inspire me. And to the memory of my mentor and dear friend, Lee A. Snyder, whose professionalism, guidance, and insight demonstrated the skills necessary to be a scientist and teacher. I have tried to live up to his expectations. This is for you, Doc.

Elliott Goldstein

To my wife, Lori, for our many years of love, support, and sometimes tolerance; to my daughter, Jennifer, who will actually read this book; to my son, Andrew, who continually renews my faith in humanity; and to my daughter, Sarah, who brings me joy daily.

Stephen Kilpatrick



# Preface

Of the diverse ways to study the living world, molecular biology has been most remarkable in the speed and breadth of its expansion. New data are acquired daily, and new insights into well-studied processes come on a scale measured in weeks or months rather than years. It's difficult to believe that the first complete organismal genome sequence was obtained less than fifteen years ago. The structure and function of genes and genomes and their associated cellular processes are sometimes elegantly and deceptively simple but frequently amazingly complex, and no single book can do justice to the realities and diversities of natural genetic systems.

This book is aimed at advanced students in molecular genetics and molecular biology. In order to provide the most current understanding of the rapidly-changing subjects in molecular biology, we have enlisted twenty-one scientists to provide revisions and content updates in their individual fields of expertise. Their expert knowledge has been incorporated throughout the text. Much of the revision and reorganization of this edition follows that of the second edition of *Lewin's Essential GENES*, but there are many updates and features that are new to this book. Most notably, there are two new chapters: Chapter 3 ("Methods in Molecular Biology and Genetic Engineering") provides an introduction to the concepts and practice of laboratory techniques in molecular biology early on in the book, and Chapter 8 ("Genome Evolution") combines, expands, and updates material that had been scattered among various chapters in previous editions, as well as introducing a number of topics new to this book. This edition is generally updated and reorganized for a more logical flow of topics, and many chapters have been renamed to better indicate their contents. In particular, discussion of chromatin organization and nucleosome structure now precedes the discussion of eukaryotic transcription, because chromosome organization is critical to all DNA transactions in the cell, and current research in the field

of transcriptional regulation is heavily biased toward the study of the role of chromatin in this process. The discussion of transcriptional activation and chromatin remodeling has accordingly been combined into one chapter (Chapter 28). Two chapters on transposons and retrotransposons have been combined into one (Chapter 17). In addition, some chapters have been revised to contain extensive new material. The original introductory chapter on messenger RNA has been entirely rewritten to cover more advanced topics (Chapter 22, "mRNA Stability and Localization"), and the regulatory RNA chapter has been dramatically expanded to include material on RNAi pathways (Chapter 30, "Regulatory RNA"). Many new figures are included in this book, some reflecting new developments in the field, particularly in the topics of chromatin structure and function, epigenetics, and regulation by noncoding and microRNAs in eukaryotes.

This book is organized into four parts. **Part 1 (Genes and Chromosomes)** comprises Chapters 1 through 10. Chapters 1 and 2 serve as an introduction to the structure and function of DNA and contain basic coverage of DNA replication and gene expression. Chapter 3 provides information on molecular laboratory techniques. Chapter 4 introduces the interrupted structures of eukaryotic genes, and Chapters 5 through 8 discuss genome structure and evolution. Chapters 9 and 10 discuss the structure of eukaryotic chromosomes.

**Part 2 (DNA Replication and Recombination)** comprises Chapters 11 through 18. Chapters 11 to 14 provide detailed discussions of DNA replication in plasmids, viruses, and prokaryotic and eukaryotic cells. Chapters 15 through 18 cover recombination and its roles in DNA repair and the human immune system, with Chapter 16 discussing DNA repair pathways in detail and Chapter 17 focusing on different types of transposable elements.

**Part 3 (Transcription and Posttranscriptional Mechanisms)** includes Chapters 19 through 25.



Chapters 19 and 20 provide more in-depth coverage of bacterial and eukaryotic transcription. Chapters 21 through 23 are concerned with RNA, discussing messenger RNA, RNA stability and localization, RNA processing, and the catalytic roles of RNA. Chapters 24 and 25 discuss translation and the genetic code.

**Part 4 (Gene Regulation)** comprises Chapters 26 through 30. In Chapter 26, the regulation of bacterial gene expression via operons is discussed. Chapter 27 covers the regulation of expression of genes during phage development as they infect bacterial cells. Chapters 28 and 29 cover eukaryotic gene regulation, including epigenetic modifications. Finally, Chapter 30 covers RNA-based control of gene expression in prokaryotes and eukaryotes.

For instructors who prefer to order topics with the essentials of DNA replication and gene expression followed by more advanced topics, the following chapter sequence is suggested:

Introduction: Chapters 1–2

Gene and Genome Structure: Chapters 5–7

DNA Replication: Chapters 11–14

Transcription: Chapters 19–22

Translation: Chapters 24–25

Regulation of Gene Expression: Chapters 9–10 and 26–30

Other chapters can be covered at the instructor's discretion.

### Pedagogical Features

This edition contains several features to help students learn as they read. Each chapter begins with a *Chapter Outline*, and each section is summarized with a bulleted list of *Key Concepts*. *Key Terms* are highlighted in bold type in the text and compiled in the *Glossary* at the end of the book. Finally, each chapter concludes with an expanded and updated list of *References*, which provides both primary literature and current reviews to supplement and reinforce the chapter content. Additional instructional tools are available online and on the Instructor's media CD-ROM.

### Ancillaries

Jones and Bartlett Publishers offers an impressive array of traditional and interactive multimedia supplements to assist instructors and aid students in mastering molecular biology. Additional information and review copies of any of the following items are available through your Jones and Bartlett sales representative or by visiting <http://www.jbpub.com/biology>.

### For the Student

#### *Interactive Student Study Guide*

Jones and Bartlett Publishers and Brent Nielsen of Brigham Young University have developed an interactive, electronic study guide dedicated exclusively to this title. Students will find a variety of study aids and resources at <http://biology.jbpub.com/lewin/genesx>, all designed to explore the concepts of molecular biology in more depth and to help students master the material in the book. A variety of activities are available to help students review class material, such as chapter summaries, Web-based learning exercises, study quizzes, a searchable glossary, and links to animations, videos, and podcasts, all to help students master important terms and concepts.

### For Instructors

#### *Instructor's ToolKit CD-ROM*

The *Instructor's Media CD-ROM* provides the instructor with the following resources:

- The **PowerPoint® Image Bank** provides all of the illustrations, photographs, and tables (to which Jones and Bartlett Publishers holds the copyright or has permission to reprint digitally) inserted into PowerPoint slides. With the Microsoft® PowerPoint program, you can quickly and easily copy individual image slides into your existing lecture slides.
- A set of **PowerPoint Lecture Outline Slides**, created by author Stephen Kilpatrick, of the University of Pittsburgh at Johnstown, provides outline summaries and relevant images for each chapter of *Lewin's GENES X*. A PowerPoint viewer is provided on the CD, and instructors with the Microsoft PowerPoint software can customize the outlines, figures, and order of presentation.

#### *Online Instructor Resources*

The **Test Bank**, updated and expanded by author Stephen Kilpatrick, is provided as a text file with 750 questions in a variety of formats. The Test Bank is easily compatible with most course management software.

### Acknowledgments

The authors would like to thank the following individuals for their assistance in the preparation of this book: The editorial, production, marketing, and sales teams at Jones and Bartlett have been exemplary in all aspects of this project. Cathy Sether, Caroline Perry, Megan Turner, Kimberly Potvin, Leah Corrigan, and Lou Bruno deserve special mention. Cathy brought us



together on this project and in doing so launched an efficient and amiable partnership. She has provided able leadership and has been an excellent resource as we ventured into new territories. Caroline, Lou and Leah have handled the daily responsibilities of the writing and production phases with friendly professionalism and helpful guidance. Megan and Kimberly have made the process of choosing and revising figures very smooth.

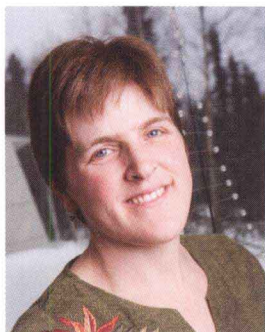
We thank the editors of individual chapters, whose expertise, enthusiasm, and careful judgment

brought the manuscript up to date in many critical areas. We also thank Brent Nielsen of Brigham Young University for an early version of Section 8.3, and David Rand of Brown University for suggestions for improvement to Chapter 8.

Jocelyn E. Krebs  
Elliott S. Goldstein  
Stephen T. Kilpatrick

# About the Authors

**Benjamin Lewin** founded the journal *Cell* in 1974 and was Editor until 1999. He founded the Cell Press journals *Neuron*, *Immunity*, and *Molecular Cell*. In 2000, he founded Virtual Text, which was acquired by Jones and Bartlett Publishers in 2005. He is also the author of *Essential GENES* and *CELLS*.



**Jocelyn E. Krebs** received a B.A. in Biology from Bard College, Annandale-on-Hudson, NY, and a Ph.D. in Molecular and Cell Biology from the University of California, Berkeley. For her Ph.D. thesis, she studied the roles of DNA topology and insulator elements in transcriptional regulation.

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**Stephen T. Kilpatrick** received a B.S. in Biology from Eastern College (now Eastern University) in St. Davids, PA, and a Ph.D. from the Program in Ecology and Evolutionary Biology at Brown University. His thesis research was an investigation of the population genet-



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**Hank W. Bass** is an Associate Professor of Biological Science at Florida State University. His laboratory works on the structure and function of meiotic chromosomes and telomeres in maize using molecular cytology and genetics.

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