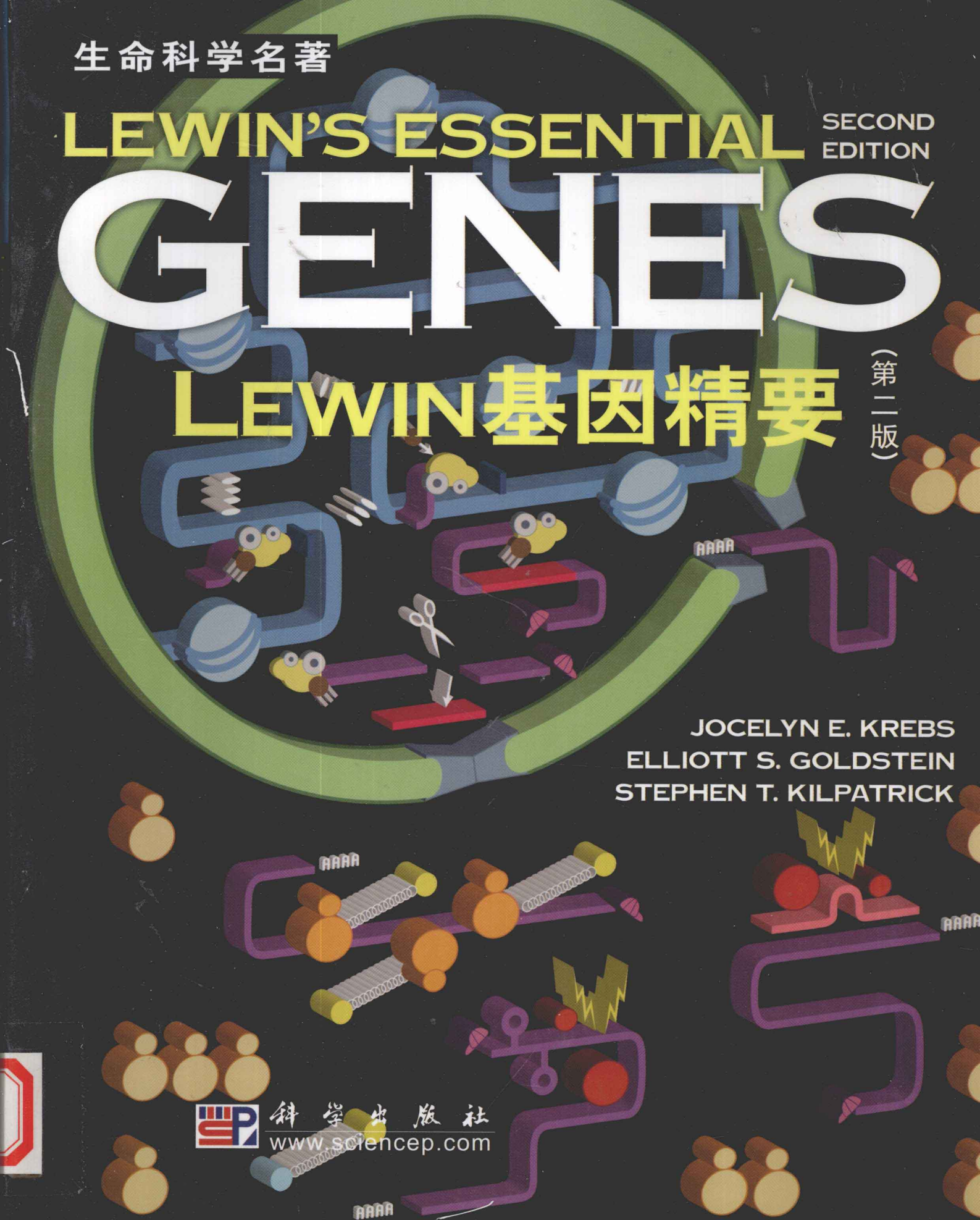
生命科学名著

# LEWIN'S ESSENTIAL GENES

SECOND EDITION

# LEWIN基因精要

（第二版）



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# Lewin's Essential GENES

*Second Edition*

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**About the cover:** In this picture, eukaryotic gene expression is depicted as a video game. mRNA (purple) is transcribed from chromosomes (blue), processed (scissors), and transported from the nucleus (green circle) where it is translated by ribosomes in the cytoplasm to polypeptides. Antisense RNAs (pink) aid in the regulation of mRNA stability.

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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 arrived just in time for this dedication.

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; my parents, David and Sandra;
and my children, Jennifer, Andrew, and Sarah.

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 15 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. The purpose of this book is to provide a clear and concise overview of the field for the undergraduate student; it may also be appropriate for some medical school courses in the subject. Compared to the full edition, there is a redirected focus on essential topics and (in some areas) more background and introductory material.

This edition is generally updated and reorganized for a more logical flow of topics. 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 26). Two chapters on transposons and retrotransposons have been combined into one (Chapter 21). Chapter 30, "Genetic Engineering," has been expanded. Throughout the book, there is additional background material and some expanded coverage of evolutionary genetic concepts. Many new figures are included in this book, some reflecting new developments in the field.

This book is organized into five parts. **Part I (Genes)** comprises Chapters 1 through 6. 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 introduces the interrupted structures of eukaryotic genes, and Chapters 4 through 6 discuss genome structure and evolution.

**Part II (Proteins)** comprises Chapters 7 through 10. Chapters 7 to 9 provide general introductions to gene expression: transcription, translation, and the genetic code. Chapter 10 covers the transport of proteins within cells.

**Part III (Prokaryotic Gene Expression)** includes Chapters 11 through 14. Chapter 11 provides more in-depth coverage of bacterial transcription. In Chapters 12 and 13, the regulation of bacterial gene expression via operons and regulatory RNAs, including RNAi, are discussed. Chapter 14 covers the regulation of expression of genes during phage development as they infect bacterial cells.

**Part IV (DNA Replication and Recombination)** comprises Chapters 15 through 23. Chapters 15 to 18 provide detailed discussions of DNA replication in plasmids, viruses, and prokaryotic and eukaryotic cells. Chapters 19 through 22 cover recombination and its roles in DNA repair and the human immune system, with Chapter 21 focusing on different types of transposable elements. Chapter 23 discusses the structure of eukaryotic chromosomes.

**Part V (Eukaryotic Gene Expression)** includes Chapters 24 through 30. In Chapter 24, the structure of nucleosomes and chromatin is discussed; chromatin remodeling and other chromosomal alterations are covered in Chapters 26 and 27. Chapters 25 and 26 describe eukaryotic transcription and its regulation, with Chapter 28 detailing posttranscriptional RNA processing. Chapter 29 provides a discussion of ribozymes. Chapter 30 introduces basic molecular techniques for the study of genes and gene expression.

Although the chapter on genetic engineering has been placed at the end of the book, instructors may choose to use the information from this chapter at any point appropriate for their courses, such as following the introductory chapters, 1 and 2.

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 3–6
DNA Replication: Chapters 15–18
Transcription: Chapters 7, 11, 25, and 28
Translation: Chapters 8–9
Regulation of Gene Expression: Chapters 12–14, 22–23, and 26

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

## To the Instructor

This edition contains many new pedagogical components to help the instructor engage students in the topic. The text has been revised to be more accessible for students at introductory levels. Each chapter section concludes with *Concept and Reasoning Checks*: one or two questions for review, conceptual synthesis, hypothesizing, or application of learning. Each chapter includes a set of *End of Chapter Questions* with answers to half of the questions provided to the students; the other questions could be used as homework assignments or quizzes. There are additional instructional tools available on the Instructor's ToolKit CD-ROM and accompanying Web site (see below).

## To the Student

There are a number of features in the book to help you learn as you read. Each section is summarized with a bulleted list of *Key Concepts*. *Key Terms* are highlighted in boldface in the text and defined in the margin for easy reference as well as compiled into the *Glossary* at the end of the book. Each chapter includes a set of *End of Chapter Questions* intended for self-assessment. Most chapters contain at least one feature box with additional background material or more in-depth details on an issue relevant to the chapter's focus. Boxes fall into one of four categories: *Essential Ideas*, *Historical Perspectives*, *Methods and Techniques*, and *Medical Applications*. In many cases these represent areas of ongoing research in the field. Finally, each chapter concludes with suggested *Further Reading*, a brief list of current reviews and pivotal papers to supplement and reinforce the chapter content.

## Ancillaries

Jones and Bartlett Publishers offers an impressive variety 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 going to http://www.jbpub.com/biology.

*Online 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/essentialgenes, 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 an interactive summary, 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.

*Instructor's ToolKit CD-ROM*

The *Instructor's ToolKit CD-ROM* contains a suite of files to help professors teach their courses. The materials are cross-platform for Windows and Macintosh systems. All the files on the CD are ready for online courses using the **WebCT** or **Blackboard** formats.

- The **PowerPoint® Image Bank** provides 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.
- The **PowerPoint Lecture Outline Slides** presentation package provides images and lecture notes, created by Hao Nguyen, of California State University, Sacramento, for each chapter of *Lewin's Essential Genes, Second Edition*. A PowerPoint viewer is provided on the CD. Instructors with the Microsoft PowerPoint software can customize the outlines, figures, and order of presentation.
- The **Test Bank**, also created by Hao Nguyen, is provided as a text file with over 700 questions in a variety of formats.

## Acknowledgments

The authors would like to thank the following individuals for their assistance in the preparation of this book:

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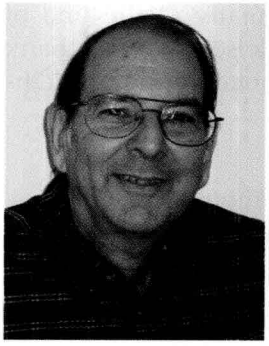
# About the Authors

**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 & Bartlett Publishers in 2005. He is also the author of *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. She performed her postdoctoral training as an American Cancer Society Fellow at the University of Massachusetts Medical School in the laboratory of Dr. Craig Peterson, where she focused on the roles of histone acetylation and chromatin remodeling in transcription. In 2000, Dr. Krebs joined the faculty in the Department of Biological Sciences at the University of Alaska, Anchorage, where she is now an Associate Professor. She directs a research group studying chromatin structure and function in transcription and DNA repair in the yeast *Saccharomyces cerevisiae* and the role of chromatin remodeling in embryonic development in the frog *Xenopus*. She teaches courses in molecular biology for undergraduates, graduate students, and first-year medical students. She also teaches a Molecular Biology of Cancer course and has taught Genetics and Introductory Biology. She lives in Eagle River, AK, with her partner and a house full of dogs and cats. Her non-work passions include hiking, camping, and snowshoeing.



**Elliott S. Goldstein** earned his B.S. in Biology from the University of Hartford (Connecticut) and his Ph.D. in Genetics from the University of Minnesota, Department of Genetics and Cell Biology. Following this, he was awarded an N.I.H. Postdoctoral Fellowship to work with Dr. Sheldon Penman at the Massachusetts Institute of Technology. After leaving Boston, he joined the faculty at Arizona State University in Tempe, where he is an Associate Professor in the Cellular, Molecular, and Biosciences program in the School of Life Sciences and in the Honors Disciplinary Program. His research interests are in the area of molecular and developmental genetics of early embryogenesis in *Drosophila melanogaster*. In recent years, he has focused on the *Drosophila* counterparts of the human proto-oncogenes *jun* and *fos*. His primary teaching responsibilities are in the undergraduate General Genetics course as well as the graduate level Molecular Genetics course. Dr. Goldstein lives in Tempe with his wife, his high school sweetheart. They have three children and two grandchildren. He is a bookworm who loves reading as well as underwater photography. His pictures can be found at http://www.public.asu.edu/~elliotg/.

**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 genetics of

interactions between the mitochondrial and nuclear genomes of *Drosophila melanogaster*. Since 1995, Dr. Kilpatrick has taught at the University of Pittsburgh at Johnstown (UPJ) in Johnstown, PA. His regular teaching duties include undergraduate courses in nonmajors biology, introductory majors biology, and advanced undergraduate courses in genetics, evolution, molecular genetics, and biostatistics. He has also supervised a number of undergraduate research projects in evolutionary genetics. Dr. Kilpatrick's major professional focus has been in biology education. He has participated in the development and authoring of ancillary materials for several introductory biology, genetics, and molecular genetics texts as well as writing articles for educational reference publications. For his classes at UPJ, Dr. Kilpatrick has developed many active learning exercises in introductory biology, genetics, and evolution. Dr. Kilpatrick resides in Johnstown, PA, with his wife and three children. Outside of scientific interests, he enjoys music, literature, and theater and occasionally performs in local community theater groups.

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