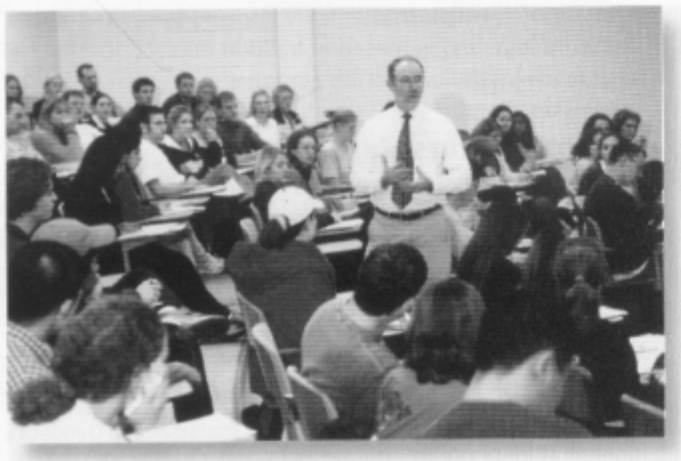
Preface

This letter, written to students and instructors in the Preface of the first edition, still encapsulates my goals as a teacher of genetics. These goals have served as the foundation for the revisions that I have undertaken in the second edition of *Genetics: A Conceptual Approach.*

When I was 14 years old, I went on a two-week canoe trip through the Quetico, a vast wilderness in southern Canada with thousands of interconnected lakes. Our guide on this trip was an experienced outdoorsman who had traveled the region many times before; he taught us how to find trails that connected one lake to the next, how to use new tools and equipment necessary for the journey, and how to survive in the wilderness. He kept us motivated by telling stories of fur trappers and traders who traveled the region in the past. Perhaps most important, this excellent teacher and motivator never carried our gear for us or paddled our canoes, recognizing that each of us had to make the journey for ourselves.

My goal as a teacher is to become a trusted guide on students' journeys through introductory genetics. I have taught genetics for more than 24 years, and one of my strengths is helping students create a mental map of genetics—one that shows where we've been, where we'll go, and how we'll get there. I provide advice and encouragement at places that are often rough spots for students, and I tell stories of the people, places, and experiments of genetics—past and present—to keep the subject interesting and alive. I help students learn the necessary details, concepts, and problem-solving skills, and I also encourage them to see the beauty of the larger landscape.



A Focus on Key Elements

Throughout this new edition of *Genetics: A Conceptual Approach,* I have maintained the original emphases on key elements that made the first edition a success: a focus on concepts and connections; a clear, accessible presentation; an emphasis on problem solving; and a superior illustration program.

• **Key Concepts and Connections** Like the original, the second edition of *Genetics: A Conceptual Approach* focuses on important concepts, giving students the big picture without overwhelming them with detail. Major concepts are driven home by brief Concepts statements, which appear immediately after a topic is discussed in the text and summarize the key points. Important concepts are reinforced again at the end of each chapter in the Concepts Summary, a list of essential points covered in the chapter. Throughout the second edition, I have provided a clear mental road map of where we've been and where we're going as we move through the topics. At the beginning of each chapter, I briefly describe the chapter organization; within chapters, Connecting Concepts boxes allow students to pause and integrate new concepts. Connecting Concepts Across Chapters at the end of each chapter highlights connections between material covered in the current chapter and topics covered in other chapters.

CONCEPTUAL APPROACH

- CONCEPTS Boxes containing key concepts appear throughout the text, succinctly summarizing important concepts and stating the take-home message.
- CONNECTING CONCEPTS These features, sprinkled throughout each chapter, consider the "big picture," synthesizing newly learned concepts and integrating them with previously covered topics.
- CONNECTING CONCEPTS ACROSS CHAPTERS Appearing at the end of each chapter, these sections reinforce major themes of the chapter and highlight connections to related material in other chapters.
- CONCEPTS SUMMARY A bulleted list of important concepts appears at the end of each chapter.

PROBLEM SOLVING

- IN-TEXT AND END-OF-CHAPTER WORKED PROBLEMS Worked Problems carefully guide students through each step in finding the solution to the types of problems for which they need the most practice solving.
- END-OF-CHAPTER QUESTIONS AND PROBLEMS Extensive class-tested questions and fresh, unique problems are presented at the end of each chapter. They are presented as Comprehension Questions, Application Questions and Problems, and Challenge Questions.

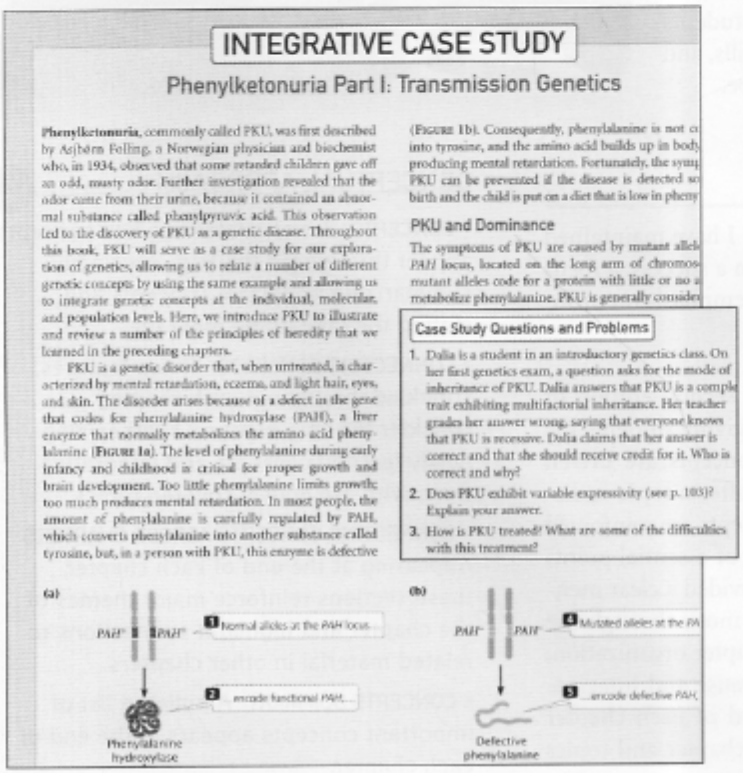
ILLUSTRATIONS

- INTEGRATED FIGURE LEGENDS Much of the explanatory information for the illustrations, which traditionally appears in figure legends, is placed in balloon text that leads students through complex processes step by step.
- CONCLUSION BOXES At the bottom of many of the illustrations is a conclusion box that emphasizes the important concept being illustrated.

• **Accessibility** The second edition, like the first, uses a lively, conversational writing style that engages and motivates the student. The popular vignettes that open each chapter and help to draw the reader into the topic are continued in the second edition, with new vignettes written for many of the chapters. Ethical questions and applications of genetics are again presented in The New Genetics essays, written by leading bioethicists. Additional information on many topics is provided through Internet sites that can be accessed through the textbook's Web site at **www. whfreeman.com/pierce2e.**

• **Emphasis on Problem Solving** Having taught introductory genetics for 24 years, I have learned that problem solving is essential to a mastery of genetics. The second edition continues to provide extensive problem sets, many drawing on original genetics research, that were developed specifically for this book and have undergone extensive class testing. The New Genetics: Mining Genomes tutorials and Classic Experiments tutorials, available on the book's Web site, provide students with additional experience in using the latest tools of bioinformatics and interpreting the most important experiments that shaped the field of genetics.

• **Clear, Simple Illustration Program** The highly acclaimed illustration program of the first edition continues to be an important feature of the second edition. Many students are visual learners, and simple, clear illustrations are essential for developing an understanding of genetics. I worked closely with the illustrators to develop every illustration in the book, integrating text and illustration and creating illustrations that are clear and instructive. Extensive integrated legends walk the student through an illustration step by step and make each one tell its own story. Many illustrations include a conclusion that emphasizes the take-home message; critical experiments are presented in special illustrations that begin by posing a question and end with the answer.


INTEGRATIVE CASE STUDY

Phenylketonuria Part I: Transmission Genetics

Phenylketonuria, commonly called PKU, was first described by Asjbörn Følling, a Norwegian physician and biochemist who, in 1934, observed that some retarded children gave off an odd, musty odor. Further investigation revealed that the odor came from their urine, because it contained an abnormal substance called phenylpyruvic acid. This observation led to the discovery of PKU as a genetic disease. Throughout this book, PKU will serve as a case study for our exploration of genetics, allowing us to relate a number of different genetic concepts by using the same example and allowing us to integrate genetic concepts at the individual, molecular, and population levels. Here, we introduce PKU to illustrate and review a number of the principles of heredity that we learned in the preceding chapters.

PKU is a genetic disorder that, when untreated, is characterized by mental retardation, eczema, and light hair, eyes, and skin. The disorder arises because of a defect in the gene that codes for phenylalanine hydroxylase (PAH), a liver enzyme that normally metabolizes the amino acid phenylalanine (FIGURE 1a). The level of phenylalanine during early infancy and childhood is critical for proper growth and brain development. Too little phenylalanine limits growth; too much produces mental retardation. In most people, the amount of phenylalanine is carefully regulated by PAH, which converts phenylalanine into another substance called tyrosine, but, in a person with PKU, this enzyme is defective

(FIGURE 1b). Consequently, phenylalanine is not c into tyrosine, and the amino acid builds up in body producing mental retardation. Fortunately, the symp PKU can be prevented if the disease is detected s birth and the child is put on a diet that is low in phen

PKU and Dominance

The symptoms of PKU are caused by mutant allel *PAH* locus, located on the long arm of chromos mutant alleles code for a protein with little or no a metabolize phenylalanine. PKU is generally consider

Case Study Questions and Problems

1. Dalia is a student in an introductory genetics class. On her first genetics exam, a question asks for the mode of inheritance of PKU. Dalia answers that PKU is a comple trait exhibiting multifactorial inheritance. Her teacher grades her answer wrong, saying that everyone knows that PKU is recessive. Dalia claims that her answer is correct and that she should receive credit for it. Who is correct and why?
2. Does PKU exhibit variable expressivity (see p. 103)? Explain your answer.
3. How is PKU treated? What are some of the difficulties with this treatment?

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New to the Second Edition

Building on the strengths of the first edition, this edition of *Genetics: A Conceptual Approach* adds new features that strengthen, enhance, and update the book.

• **Integrative Case Study** An important emphasis of the first edition was to help students understand the connections between different topics and to see the big picture of genetics. For the second edition, this emphasis has been enhanced by the addition of an Integrated Case Study, which focuses on the genetic disease phenylketonuria (PKU). At the end of each major section of the book, a discussion of PKU illustrates—with a single recurring example—many of the principles and concepts that have been introduced in earlier chapters and integrates genetic concepts at the individual, molecular, and population levels. For instance, in PKU Part I (after Chapter 6), we consider the symptoms of PKU, its transmission as an autosomal recessive disease, and its treatment. We see that PKU is not really an autosomal recessive trait, but rather a complex, multifactorial disease. In PKU Part II (after Chapter 17), we examine the molecular organization of the phenylalanine hydroxylase (*PAH*) locus and how PKU results from mutations that may occur at any of hundreds of different sites within the this locus. In PKU

Part III (after Chapter 23), we look at PKU in relation to population genetics, how the frequencies of PKU-causing mutations vary among populations, and some possible reasons why PKU is common in particular populations. I believe that students will find this Integrated Case Study relevant, interesting, and helpful in understanding and integrating important concepts of genetics.

• **Model Organisms** In this age of genomics, model organisms are receiving increased attention as important tools for elucidating genetic concepts and processes. In the second edition of *Genetics: A Conceptual Approach*, six model organisms—*Escherichia coli* (bacterium), *Saccharomyces cerevisiae* (yeast), *Arabidopsis thaliana* (plant), *Caenorhabditis elegans* (nematode worm), *Drosophila melanogaster* (fruit fly), and *Mus musculus* (house mouse)—are given special treatment. The models are introduced in Chapter 1, along with a discussion of why models are important in genetics research. Each model organism is then discussed in a special section that follows the first major introduction of that organism. Specifically, *Drosophila melanogaster* is introduced in Chapter 4 with the discussion of X-linked inheritance of eye color in fruit flies, *Escherichia coli* is introduced in Chapter 8 with the discussion of bacterial genetics, *Caenorhabditis elegans* is introduced in Chapter 14 with the discussion of RNAi, *Arabidopsis thaliana* is introduced in Chapter 16 with the discussion of how acetylation affects chromatin structure and the expression of genes that control flowering in plants, *Mus musculus* is introduced is Chapter 18 with the discussion of knockout mice, and *Saccharomyces cerevisiae* is introduced in Chapter 20 with the discussion of mitochondrial genes. Each model organism section presents information on the advantages of the model, its life cycle and genome, and genetic methods that have been developed for use with the model. For quick reference, a full-page illustration summarizes essential information about the model.

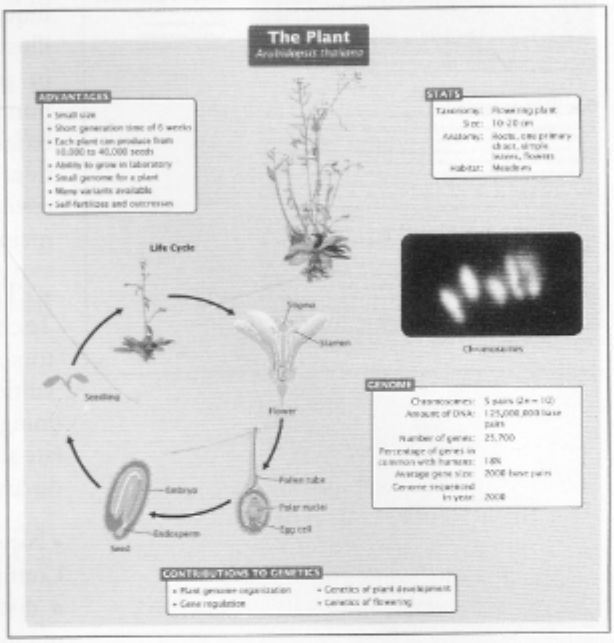
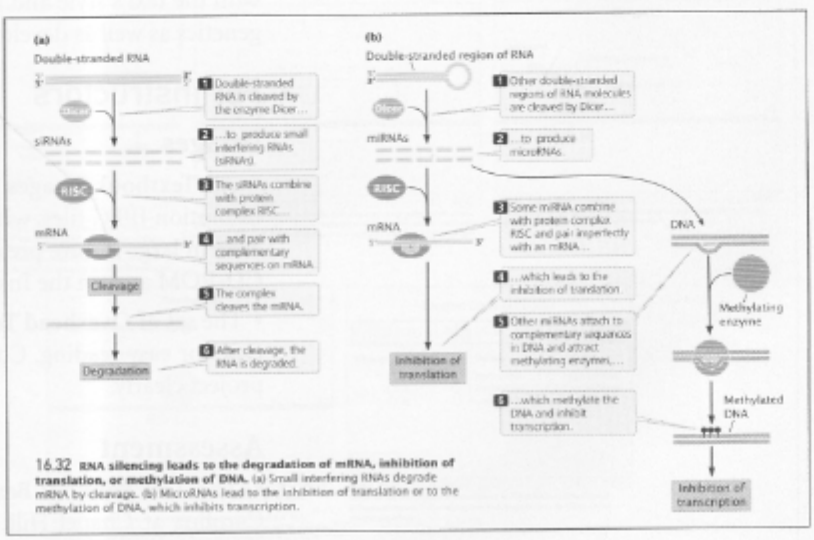


Figure 16.33, page 465

• **Updated Coverage** All topics have been updated with the latest findings of research. A number of topics have been expanded and updated, including:

- cell-cycle checkpoints (Chapter 2)
- chromosome movement and segregation (Chapter 2)
- artificial chromosomes (Chapter 11)
- chromatin structure and function (Chapter 11)
- error-prone DNA polymerases (Chapter 12)
- small interfering RNAs, microRNAs, and RNA interference (Chapter 14)
- RNA splicing (Chapter 14)
- ribosome structure (Chapter 15)
- riboswitches and RNA-mediated gene expression (Chapter 16)
- adaptive mutation (Chapter 17)
- DNA fingerprinting (Chapter 18)
- reporter gene sequences (Chapter 19)
- comparative genomics (Chapter 19)
- human haplotypes (Chapter 19)
- cancer genetics and DNA repair genes (Chapter 21)
- the control of flowering in *Arabidopsis* (Chapter 21)
- DNA sequence variation (Chapter 23)
- molecular phylogenies (Chapter 23)
- genome evolution (Chapter 23)



16.32 **RNA silencing leads to the degradation of mRNA, inhibition of translation, or methylation of DNA.** (a) Small interfering RNAs degrade mRNA by cleavage. (b) MicroRNAs lead to the inhibition of translation or to the methylation of DNA, which inhibits transcription.

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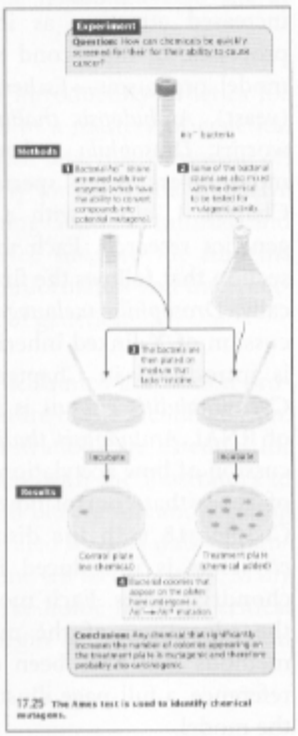
4

SEX DETERMINATION AND SEX-LINKED CHARACTERISTICS

Sex Wars in Isopods

• **New Introductory Stories** Students and instructors alike have said how much they enjoyed the vignettes that begin each chapter, providing context for the topic and helping to draw the reader into the subject. Ten chapters begin with new vignettes written specifically for this edition, including stories with intriguing titles such as "The Blind Men's Riddle," "Sex Wars in Isopods," "Preventing Train Wrecks in Replication," and "The Donkey: A Wild Ass or a Half Ass?"

• **New Experimental Illustrations** A popular feature of the first edition was the focus on scientific inquiry and experimental methods. The experimental illustrations outline key experiments and techniques in genetics. The second edition includes a greater number of experimental illustrations; they have been redesigned so that each now consistently poses a question, describes the experimental process, shows the results, and draws a conclusion that ties back to the main concept being discussed.



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• **The New Genetics: Ethics, Science, and Technology** In response to suggestions by instructors and students, this popular feature of the first edition has been enhanced by updating and streamlining. Discussion questions have been added to stimulate student thinking and provide a basis for classroom discussion.

• **New End-of-Chapter Questions and Problems** Continuing the emphasis on problem solving that was a distinctive feature of the first edition, many new questions and problems have been added at the end of each chapter.

Media and Supplements

Our complete package of media resources and supplements is designed to provide instructors with the proper tools to help their students become adept at solving problems and thinking like geneticists. All the available resources are fully integrated with the text's style and goals, allowing students to continue connecting concepts in genetics as well as develop their problem-solving skills.

For Instructors

Images

• All **Textbook Images** are available already placed in PowerPoint® and as high-resolution JPEG files, with large type and a vibrant color palette that projects clearly even in large lecture presentations. Images are available on the Instructor's Resource CD-ROM and on the Instructor's Resource Web Site.

• The set of **Overhead Transparencies** includes 130 images from the text, with large type for easy reading. Complicated illustrations are broken down into parts so they project clearly.

Assessment

• The **Test Bank** by Ben Pierce, Gregory Copenhaver of the University of North Carolina at Chapel Hill, Susan Elrod of California Polytechnic State University at San Luis Obispo, and Rodney Mauricio of the University of Georgia is carefully

designed to match the pedagogical intent of the textbook. It contains 50 questions per chapter, including multiple-choice, true-or-false, and short-answer questions. The on-line test bank consists of chapter-by-chapter Microsoft Word files that are easy to download, edit, and print from the Instructor's Resource CD-ROM or the Instructor's Resource Web Site.

• We are pleased to now offer our Test Bank and End of Chapter questions in Blackboard and WebCT cartridges. For your ease of use, the End of Chapter questions have been converted into multiple choice and fill-in-the-blank questions. Now you can choose which online course management system to use for electronic access to hundreds of homework and quiz questions.

Access

• The **Instructor's Resource CD-ROM** contains all text images in PowerPoint® and as high-resolution JPEG files, all animations, and the Solutions Manual and Test Bank in chapter-by-chapter Microsoft Word files that are easy to download, edit, and print.

• The Password-Protected **Instructor's Resource Web Site** includes all the resources listed here (**www.whfreeman.com/pierce2e**). Contact your W. H. Freeman sales representative to learn how to log on as an instructor.

For Students

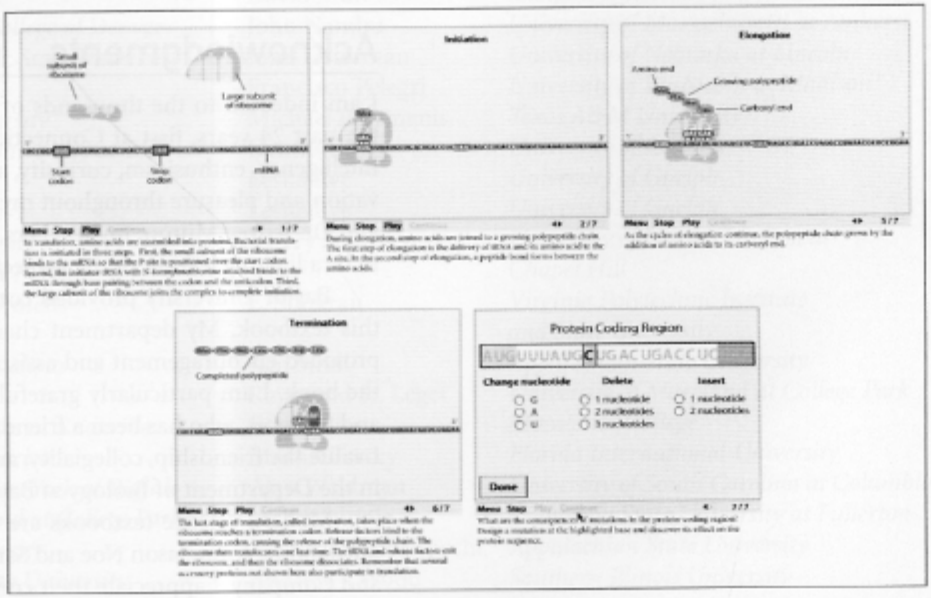
Printed Solutions and Problem-Solving MegaManual

• **Solutions Manual** by Jung H. Choi of the Georgia Institute of Technology and Mark McCallum of Pfeiffer University. This manual contains complete answers and worked-out solutions to all questions and problems that appear in the textbook. It has been reviewed extensively by instructors throughout the United States.

• **Interactive Genetics CD-ROM** by Lianna Johnson and John Merriam of UCLA. This program leads students through many typical genetics problems one step at a time, with specific feedback to provide guidance along the way. Common mistakes and misunderstandings are addressed, and useful problem-solving strategies are suggested.

• **The New Genetics: Mining Genomes** by Mark S. Wilson of Humboldt State University. This printed text for the interactive bioinformatics Web tutorials described under the "Interactive Media" heading below enables students to review in a print format the information that they've learned while doing the on-line exercises.

• **Optional Free-of-Charge Text Solutions and "The Time Saver Series: Genetics in Motion" Animations CD-ROM** All solutions to the problems in the textbook are available in CD-ROM format, as are all of "The Time Saver Series: Genetic in Motion" animations. Free of charge when ordered with the textbook with ISBN 0-7167-6836-4.



Interactive Media

All the following material is found at the *Genetics* On-Line Web Site at
www.whfreeman.com/pierce2e

• **The Time-Saver Series: Genetics in Motion** features animated tutorials designed to review and synthesize the main topics of a chapter. They aid students in making the connections

between the key concepts and the details of important processes such as transcription, translation, meiosis, mitosis, and replication. In addition, the animations enhance student learning through their accessible step-by-step style which draws students into the topic and asks them to evaluate the process critically. For example, after reviewing the steps of bacterial translation (initiation, elongation and termination), students are asked, "*What are the consequences of mutations in the protein-coding region?*" Options allow students to design a mutation and discover its effect on the subsequent protein produced. This interactivity will enable your students to master both the concepts and their applications quickly. The major animated concepts are:

Stages of the Cell Cycle
Mitosis
Meiosis
Nondisjunction
Independent Assortment and Crossing Over (in meiosis)
Crosses with Multiple Loci
Dominance and Incomplete Dominance
Replication
Prokaryotic Transcription
Eukaryotic Transcription
RNA Processing
Translation
Gene Expression: Regulation (*lac* operon)
Gene Expression: Attenuation (*trp* operon)
Techniques: Plasmid Cloning
Techniques: Dideoxy Sequencing
Technique: PCR
Population Genetics: Hardy-Weinberg, H-W Assumptions, Genotypic and Allelic Frequencies, Overdominance,
Directional Selection and Inbreeding
Segregation: X-linked inheritance
Homologous Recombination
Techniques: Plasmid Cloning
Mapping a Three-Point Cross
DNA Supercoiling
DNA Mutation
Bacterial Conjugation
RNAi

• **The New Genetics: Mining Genomes** comprises ten interactive tutorials that guide students through live analyses and searches of on-line databases, giving them experience in using the latest tools of bioinformatics. Each step simply and clearly explains what is taking place on the screen and directs students to the next step.

• **Classic Experiments in Genetics** are tutorials that help students master the essential concepts of genetics by leading them through classic experiments that have shaped the field of genetics.

• **Web Links,** called out in the textbook, provide relevant, recent updates for each chapter.

Acknowledgments

I am indebted to the thousands of genetics students who have filled my classes in the past 24 years, first at Connecticut College and later at Baylor University. Their intelligence, enthusiasm, curiosity, and humor have been a constant source of motivation and pleasure throughout my professional life. I thank Dr. Raymond Canham and Dr. Jeffrey Mitton, my teachers, for introducing me to genetics and teaching me to be a lifelong learner of the subject.

Baylor University provided continual support throughout the development of this textbook. My department chairs, W. Keith Hartberg and Robert Doyle, have provided encouragement and assistance throughout the writing of both editions of the book. I am particularly grateful to Wallace Daniel, Dean of the College of Arts and Sciences, who has been a friend, supporter, and role model for the past 10 years. I value the friendship, collegiality, and technical expertise provided by my colleagues in the Department of Biology at Baylor.

Modern science textbooks are a team effort, and I have been blessed with an outstanding team. Jason Noe and Sara Tenney managed this project at W. H. Freeman and Company. I appreciate their commitment to this second edition and their many

creative contributions to the project. Randi Rossignol skillfully applied her vast knowledge of genetics to the development and writing of this second edition. Her good humor, encouragement, and expertise made working on this revision a pleasure. I thank the illustrators at J/B Woolsey Associates and Dragonfly for the book's outstanding illustration program. I am indebted to Elaine Palucki and Deena Goldman for organizing and managing the Internet and other supplements, to Bradley Umbaugh at W. H. Freeman and to Cathy Townsend and Becky Dodson at Seven Worldwide Publishing Solutions for managing the book's production, to Patricia Zimmerman for outstanding editing and many editorial suggestions, to Diana Blume for the book's design, to Ted Szczepanski and Vikii Wong for photo research, and to Sarah Martin for directing the marketing of the book.

Brigitte Raumann, Tanya Awabdy, and Tracy Washburn's creative skills and exceptional technical expertise produced the wonderful animations that accompany the book. Gregory Copenhaver, Susan Elrod, and Rodney Mauricio created the Test Bank, Jung Choi and Mark McCallum wrote the Solutions Manual, Lianna Johnson and John Merriam created the interactive problem-solving tutorials, and Mark Wilson wrote The New Genetics: Mining Genomes tutorials and exercises. Ronald Green, Art Caplan, and Kelly Carroll wrote The New Genetics essays.

A large number of colleagues served as reviewers and class testers of the textbook, kindly lending me their technical expertise and teaching experience. Their assistance is gratefully acknowledged; any remaining errors are entirely my own responsibility.

In the final stages of writing this edition, with tight deadlines looming near, my wife was in a serious automobile accident and spent three weeks in the hospital. The concern, understanding, and generosity of the people at Baylor, W. H. Freeman, and Seven Worldwide during this time meant more than I can express. Throughout both editions of the book, my family—Marlene, Sarah, and Michael—have been a continous source of inspiration, encouragement, and support.

My gratitude goes to the reviewers of the second edition:

Lucy Andrews	*University of Alabama at Birmingham*
John Belote	*Syracuse University*
Susan Bergeson	*University of Texas at Austin*
Andrew Bohanak	*San Diego State University*
Nancy Brooker	*Pittsburg State University*
Mary Bryk	*Texas A&M University*
Mary Colavito	*Santa Monica College*
Georgina Cornwall	*Metropolitan State College of Denver*
Susan Elrod	*California Polytechnic State University at San Luis Obispo*
Les Erickson	*Salisbury State University*
Robert Farrell	*Pennsylvania State University at York*
Julia Frugoli	*Clemson University*
Paul Gauss	*Western State College*
Elliot Goldstein	*Arizona State University*
Paul Goldstein	*University of Texas at El Paso*
Peter Hart	*University of Massachusetts at Dartmouth*
Kaius Helenurm	*University of South Dakota*
J.L. Henriksen	*Bellevue University*
Leslie Hickok	*University of Tennessee at Knoxville*
Bruce Hofkin	*University of New Mexico*
Margaret Hollingsworth	*State University of New York at Buffalo*
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Mitrick Johns	*Northern Illinois State University*
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John Nambu	*University of Massachusetts at Amherst*
John Osterman	*University of Nebraska at Lincoln*
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Michael Polymenis	*Texas A&M University*
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Leslie Rye	*University of Guelph*
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Jeffery Sekelsky	*University of North Carolina at Chapel Hill*
E. Shokraii	*Virginia Polytechnic Institute and State University*
Ken Shull	*Appalachian State University*
Raymond St. Leger	*University of Maryland at College Park*
Jim Straka	*Macalester College*
Martin Tracey	*Florida International University*
Alan Waldman	*University of South Carolina at Columbia*
Fred Whipple	*California State University at Fullerton*
Michael Windelspecht	*Appalachian State University*
Andrew J. Wood	*Southern Illinois University*

I wish to thank the reviewers and class testers of the first edition:

Joan Abramowitz, *University of Houston, Downtown;* James Allan, *Edinburgh University;* James O. Allen, *Florida International University;* Fred Allendorf, *University of Montana;* Ross Anderson, *Master's College;* Pablo Arenaz, *University of Texas at El Paso;* Alan Atherly, *Iowa State University;* Charles Atkins, *Ohio University;* Vance Baird, *Clemson University;* Stephanie Baker, *Erskpine College;* Phillip T. Barnes, *Connecticut College;* George Bates, *Florida State University;* Amy Bejsovec, *Duke University;* John Belote, *Syracuse University;* David Benner, *East Tennessee State University;* Spencer Benson, *University of Maryland at College Park;* Dan Bergey, *Montana State University;* Andrew Bohonak, *San Diego State University;* J. Hoyt Bowers, *Wayland Baptist University;* Jane Bradley, *Des Moines Area Community College;* Elizabeth Bryda, *Marshall University;* Michael Buratovich, *Spring Arbor University;* Peter Burgers, *Washington University in St. Louis;* Jeffrey Byrd, *St. Mary's College of Maryland;* Patrick Calie, *Eastern Kentucky University at Richmond;* Arthur Champlin, *Colby College;* Lee Anne Chaney, *Whitworth College;* Bruce Chase, *University of Nebraska at Omaha;* Christian Chavret, *Indiana University at Kokomo;* Carol Chihara, *University of San Francisco;* Joseph Chinnici, *Virginia Commonwealth University;* Jung H. Choi, *Georgia Institute of Technology;* Craig Coates, *Texas A&M University;* John Condie, *Fort Lewis College;* Patricia Conklin, *State University of New York College at Cortland;* Victor Corces, *Johns Hopkins University;* Victor Cox, *Parkland College;* Drew Cressman, *Sarah Lawrence College;* David Crowley, *Mercer Community College;* Laszlo Csonka, *Purdue University;* Michael R. Culbertson, *University of Wisconsin at Madison;* Mike Dalbey, *University of California at Santa Cruz;* Alix Darden, *The Citadel;* Terry Davin, *Penn Valley Community College;* Sandra Davis, *University of Louisiana at Monroe;* Thomas Davis, *University of New Hampshire;* Ann Marie Davison, *Kwantlen University College;* Steven Denison, *Eckerd College;* Carter Denniston, *University of Wisconsin at Madison;* Myra Derbyshire, *Mount Saint Mary's College;* Andrew A. Dewees, *Sam Houston State University;* AnnMarie DiLorenzo, *Montclair State University;* Judith A. Dilts, *William Jewell College;* Stephen DiNardo, *University of Pennsylvania;* Linda Dixon, *University of Colorado at Denver;* Frank Doe, *University of Dallas;* Diana Downs, *University of Wisconsin at Madison;* Richard Duhrkopf, *Baylor University;* Maureen Dunbar, *Pennsylvania State University, Berks College;* Lynn Ebersole, *Northern Kentucky University;* Larry Eckroat, *Pennsylvania State University, Erie;* Johnny El-Rady, *University of South Florida;* Ted English, *North Carolina State University;* Scott Erdman, *Syracuse University;* Asim Esen, *Virginia Polytechnic Institute and State University;* Paul Evans, *Brigham Young University;* Elsa Q. Falls, *Randolph-Macon College;* Robert Farrell, *Pennsylvania State University, York;* Kathleen M. Fisher, *San Diego State University;* Valerie Flechtner, *John Carroll University;* Mary Flynn, *MCP Hahnemann University;* Thomas Fogle, *Saint Mary's College;* Rosemary Ford, *Washington College;* Laurie Freeman, *Fulton-Montgomery Community College;* Julia Frugoli, *Clemson University;* Maria Galb-Meagher, *University of Florida;* Arupa Ganguly, *University of Pennsylvania;* Dan Garza, Novartis Pharmaceutical Company; Ivan Gepner, *Monmouth University;* Elliot S. Goldstein, *Arizona State University;* Paul Goldstein, *University of Texas at El Paso;* Javier Gonzalez, *University of Texas at Brownsville;* Deborah Good, *University of Massachusetts;* Harvey F. Good, *University of Le Verne;* Myron Goodman, *University of Southern California;* Richard L. Gourse, *University of Wisconsin at Madison;* Michael W. Gray, *Dalhousie University;* Michael Grotewiel, *Michigan State University;* James Haber, *Brandeis University;* Randall Harris, *William Carey College;* Stan Hattman, *University of Rochester;* Martha Haviland, *Rutgers University;* John Hays, *Oregon State University;* James L. Hayward, *Andrews University;* Donna Hazelwood, *Dakota State University;* Kaius Helenurm, *University of South Dakota;* Curtis Henderson, *MacMurray College;* Jerald Hendrix, *Kennesaw State University;* Richard P. 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