PREFACE

This textbook is intended for a first college course in genetics. In writing the book, we have faced the age-old question of organization: Which to present first, Mendelian genetics or molecular genetics? The traditional organization of a genetics text is historical—Mendelian, or transmission, genetics first, followed by molecular genetics. However, because molecular approaches to genetics have become more sophisticated and the body of knowledge about molecular genetics has grown explosively, it is easy to make a case for starting with molecular aspects. Some have followed a middle road and mingled the two topics.

Although modern genetics is a wonderfully fruitful blend of classical and molecular techniques, we think it makes sense to separate these two approaches when presenting them to students for the first time. Moreover, we have chosen to follow the traditional historical order. To us, this seems to allow for a more logical progression of ideas, moving from early, relatively simple concepts of heredity to later, more complex explanations at the molecular level. Besides that, we enjoy teaching genetics because it is like telling a story, and it doesn't seem quite right to start the story in the middle.

In spite of our own prejudices, we have tried to make this book easy to use no matter which order of topics an instructor prefers. Accordingly, we have organized this third edition of our book in the following way:

Chapter 1 is a historical introduction to genetics. It provides the bare essentials of both major branches of the discipline. After reading this chapter, students should have some appreciation for the molecular character of genes as they study the subsequent chapters on transmission genetics. If, on the other hand, an instructor chooses to start with molecular genetics, chapter 1 introduces students to the basics of heredity, providing a context for the molecules. In either case a brief review of basic concepts, such as cell cycle, mitosis, meiosis, and cell structure has been added in chapter 1 to assure that all students have at least this prerequisite knowledge.

Chapters 2 through 5 constitute a unit on transmission genetics. In chapter 2 we use Mendel's experiments to introduce the principles of segregation and independent assortment. At the same time, since it is impossible to discuss these topics without dealing with probabilities, we provide a brief introduction to statistics. In chapter 3 we show that simple Mendelian analysis does not always work, and introduce concepts such as penetrance, expressivity, and epistasis that illustrate this point. Chapter 4 deals with chromosomes: their behavior and the fact that genes reside on chromosomes. The chromosome concept leads naturally to the idea of linkage, the subject of chapter 5. Here, students learn about linkage and recombination and how to construct linkage maps with eukaryotes.

Each chapter in this first part of the book includes a discussion of the application of genetics to human problems. For example, in chapter 2 students learn to apply the concepts of segregation and independent assortment to pedigree analysis of human genetic diseases. In chapter 4 they see how human chromosomal abnormalities can have severe consequences.

The central part of the book, and its major theme, is a thirteen-chapter sequence emphasizing molecular genetics. We believe that the direction of modern genetics research demands that the heart of a modern genetics text be molecular.

Chapters 6 through 11 present the fundamentals of molecular genetics. Chapter 6 introduces the structure and properties of DNA and a minimal outline of gene function. In the first and second editions, chapter 7 consisted of a much more complete introduction to gene function, including gene replication, transcription, translation, and mutation. The following five chapters then expanded on these themes. As a result, some closely related concepts were found in separate chapters—some in chapter 7; others in chapter 11, for example. This "jumping" around to cover some topics in full caused a problem for students. To solve this problem, we have taken the material in chapter 7, "An Introduction to Gene Function," and distributed it among the appropriate subsequent chapters in this new edition. Chapter 6, "Chemistry of the Gene," is now followed by five chapters (7–11) that present the concepts of gene function. Chapter 7 describes the replication and recombination of genes. Chapters 8, 9, and 10 describe the process of gene expression. In particular, chapters 8 and 9 cover transcription in prokaryotes and eukaryotes, respectively, and chapter 10 outlines the process of translation. Finally, chapter 11 deals with another characteristic of genes, their capacity for mutation.

Chapters 12 through 18 further illustrate specific aspects of the functions of genes. Chapter 12 is an extension of the material in chapter 11; it details the structure and function of transposable elements in both prokaryotes and eukaryotes and shows how these mobile elements can participate in mutagenesis. Chapter 13 is a treatment of the transmission genetics of bacteria and phages. It might reasonably be placed in the first part of the book, but since so much is known about the molecular basis of prokaryotic genetics, it seems to fit better in the molecular genetics section. Also, students can better appreciate the analysis of mutations in bacterial operons after they have learned how

operons work (in chapter 8) and the chemical nature of mutations (in chapter 11). Chapter 14 explores the ways that genes govern the development of organisms. The intricate and fascinating development of the fruit fly is the major paradigm for this chapter.

Chapters 15 through 17 present practical applications of molecular genetics. Chapter 15 covers gene cloning and manipulation and shows how one branch of genetics has evolved into a kind of engineering. Chapter 16 is a new chapter, titled "Applications of Gene Cloning and Advanced Genetic Mapping," which expands upon the information presented in chapter 15. It begins with uses of cloned genes in various fields, followed by techniques used to map and sequence the human genome, which leads to discussions of cloning genes responsible for human diseases. The chapter concludes with the subject of DNA typing in the courtroom. Chapter 17 is about the molecular genetics of cancer, with special emphasis on the behavior of oncogenes. Our experience has been that students have fun with these topics, but since they need to master the basics first, these chapters come near the end of this section. Chapter 18 deals with the genetics of mitochondria and chloroplasts from both classical and molecular perspectives.

The book concludes with a two-chapter sequence on population genetics. Chapter 19 deals with introductory population genetics, including selection, genetic drift, inbreeding, mutation, and gene flow. Chapter 20 integrates these factors to discuss human diseases, molecular evolution, conservation genetics, and pesticide resistance.

The most obvious change from the second edition is in organization and updating of information. The material from the original chapter 7 has been split up and incorporated into the five chapters dealing with DNA replication, transcription, translation and mutation (chapters 7–11). A new chapter, chapter 16, has been added to this edition to reflect the explosive advancements seen in applications of gene cloning and genetic mapping. Chapter 14, "Developmental Genetics," has been heavily revised, especially in the area of *Drosophila* development, but you will also see extensive updating and new information in almost every chapter in this edition.

This edition also features a greater emphasis on problem solving. We have expanded worked-out problems within the text to give students more guidance in how to solve important types of problems, and have included a greater variety of problems at the end of each chapter. In most cases, at least one end-of-chapter problem tests the skill taught by each worked-out problem within the same chapter.

The most important underlying theme of this book is its experimental approach. Genetics, like any science, is not a collection of facts, but a way of posing and answering questions about nature. Wherever possible, we have included the experimental rationale and results that have led to our present understanding of genetics. Furthermore, many of the end-of-chapter questions require students to examine and interpret hypothetical experimental results, or to design experiments to test hypotheses. We know that genetics, especially molecular genetics, can be bewildering to college students. However, we have found that if given a clear understanding of the way geneticists practice their science, students can master the subject much more easily. That is the goal of this book.

Learning Aids for the Student

To achieve success in the study of genetics, students must understand the material presented, utilize the text as a tool for learning, and enjoy reading the text. Therefore, we have included many aids to make your study of genetics efficient and enjoyable. Each chapter contains the following:

Chapter Opening Quotation

The chapter opening quotation is designed to spark interest and provide a perspective on the chapter's contents.

Chapter Opening Learning Objectives

The chapter opening learning objectives were written to help the student preview the basic concepts in the chapter.

Boldfaced Key Terms

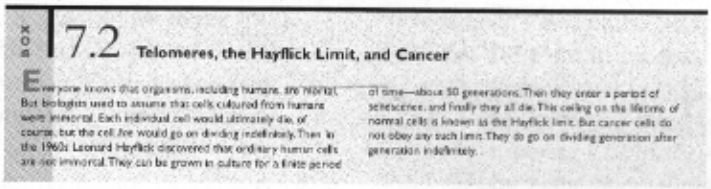
Important terms are emphasized and clearly defined when they are first presented.

Software Correlations

Selected sections of text are cross-referenced to WCB software/multimedia products, including the *Explorations in Cell Biology and Genetics* CD-ROM by George Johnson. Icons appear by section headings to signal a software application. In addition, an Appendix provides a description of each *Explorations* module that is cited, along with "Questions to Explore."

Genetic Inheritance: Peas and Drosophila Software (Mac).

Explorations in Cell Biology and Genetics CD-ROM.



BOX 7.2 Telomeres, the Hayflick Limit, and Cancer

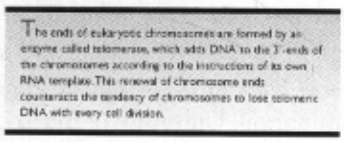
Everyone knows that organisms, including humans, are mortal. But biologists used to assume that cells cultured from humans were immortal. Each individual cell would ultimately die, of course, but the cell *line* would go on dividing indefinitely. Then in the 1960s Leonard Hayflick discovered that ordinary human cells are not immortal. They can be grown in culture for a finite period of time—about 50 generations. Then they enter a period of senescence, and finally they all die. This ceiling on the lifetime of normal cells is known as the Hayflick limit. But cancer cells do not obey any such limit. They do go on dividing generation after generation indefinitely.

Boxed Readings

Most chapters contain a boxed reading. These readings cover a variety of interesting topics, including some of the ethical issues involved with recent developments in molecular biology and gene therapy. A portion of box 7.2, is shown above.

Section Summaries

These summaries help the student review and understand the section's basic concepts before continuing on to the next section of the chapter. For example:



The ends of eukaryotic chromosomes are formed by an enzyme called telomerase, which adds DNA to the 3′ ends of the chromosomes according to the instructions of its own RNA template. This renewal of chromosome ends counteracts the tendency of chromosomes to lose telomeric DNA with every cell division.

End-of-Chapter Worked-Out Problems

To help students develop their analytical, quantitative, and problem-solving skills, example problems and detailed solutions are provided. Look for this heading at the end of the chapter:

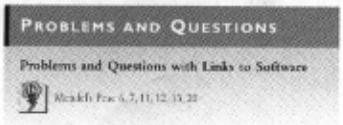
WORKED-OUT PROBLEMS

End-of-Chapter Summary

This narrative section summarizes the important basic concepts of the chapter.

End-of-Chapter Problems and Questions

The problems and questions are written to aid students in their understanding of basic genetic concepts and processes. They also help students test and develop their analytical problem-solving skills. Selected End-of-Chapter questions are cross-referenced to genetic software published by Wm. C. Brown Publishers. Product information is available under "Supplementary Materials." This section is identified by the following heading:



PROBLEMS AND QUESTIONS

Problems and Questions with Links to Software

Answers to End-of-Chapter Problems and Questions (Appendix A)

The answers to all of the end-of-chapter problems and questions are provided to help students immediately evaluate their problem-solving skills.

Selected Readings for Each Chapter (Appendix B)

References for each chapter are provided to help students investigate and study important topics.

Glossary

Definitions of boldfaced terms are assembled in a glossary at the end of this textbook.

Index

An easy-to-use, comprehensive index is provided to help students locate information on topics they need to review.

New Student Supplement

A text-specific *Student Study Guide,* titled "A Synopsis of Genetics," is available with the third edition of *Genetics.* The study guide is written by Roger Denome of Stonehill College and supports the student in understanding the key concepts presented in the text. More than just an outline or set of questions, it brings a distinctive approach, complete with its own illustrations, and designed to zero in on and clarify major concepts. (ISBN 29086–7)

Supplementary Materials

1. An *Instructor's Manual with Test Item File (IM/TIF)* is available free to all adopters of Weaver/Hedrick, *Genetics,* third edition. This IM/TIF consists of two sections. The first section is a list of transparencies that accompany the text and thought questions and problems for each text chapter. The second section (TIF) contains objective questions pertinent to the material found in each text chapter. These include multiple choice, true/false, fill-in-the-blank, and short-answer questions.

2. *Computerized Testing and Classroom Management Software* is offered free upon request to adopters of this textbook. The TIF from the *Instructor's Manual* is included in the database of this computerized testing software. The software also provides a grade-recording program. The software requires no programming experience and is available in IBM and Macintosh formats. Diskettes are available through your local WCB sales representative.
3. A set of *100 full-color acetate transparencies,* based on illustrations taken from the textbook, may be used to supplement classroom lectures and is available free to adopters.
4. *Gene Game Software,* by Bill Sofer of Rutgers University, linked to this text, is a Macintosh software game that gives students the opportunity to test their logic and critical thinking skills while attempting to clone a fictitious "Fountain of Youth" gene. Contact your local WCB sales representative for more information on this fun, interactive software game. (ISBN 24893)
5. *Genetic Inheritance: Peas and Drosophila Software,* linked directly to this text, is an affordable software program, developed at Purdue University, that can be packaged with this text. The software allows students to simulate hundreds of genetic crosses right at their computers to gain valuable practice in the quantitative aspects of genetics. The pea experiments investigate Mendel's theories of dominance, segregation, independent assortment, and how numbers of offspring affect test results. Once students master the concepts illustrated with the basic pea crosses, they can challenge themselves with the *Drosophila* experiments, which also explore the concepts of monohybrid, dihybrid, and trihybrid crosses, as well as the determination of linkage, map distances, and gene order on chromosomes. This software can also be packaged with the text. (Mac ISBN 28861–7), (Windows ISBN 35225-0)
6. *Explorations in Genetics CD-ROM,* linked directly to this text, is an interactive multimedia program developed by George B. Johnson, Washington University–St. Louis, and WCB. It calls on users to manipulate genetic variables and examine how they impact the results as they explore such modules as Constructing a Genetic Map, DNA Fingerprinting: You Be the Judge, and Gene Regulation. The CD-ROM is compatible with both Windows and Macintosh systems. (ISBN 28862–5)
7. *GenPak: Computer-Assisted Academic Programs in Genetics,* by Tully Turney, Hampden-Sydney College, is a Macintosh hypercard program featuring interactive, problem-solving exercises in Mendelian, molecular, and population genetics. (ISBN 17370–4)
8. The new fourth edition of *Laboratory Manual of Genetics,* by A. M. Winchester and P. J. Wejksnora, University of Wisconsin–Milwaukee, is an up-to-date, practical manual. It features classical and molecular biology exercises that give students the opportunity to apply the scientific method to "real"—not simulated—lab investigations. (ISBN 12287–5)
9. *How Scientists Think,* by George B. Johnson, is a concise, illustrated book that presents discussions of twenty-one classic genetics and molecular biology experiments. It is an intriguing way to foster critical thinking and reinforce the scientific method in a genetics course. (ISBN 27875–1)
10. *Case Workbook in Human Genetics,* by Ricki Lewis, SUNY–Albany, includes thought-provoking case studies in human genetics, with many examples gleaned from the author's experiences as a practicing genetics counselor. (ISBN 22287–X)
11. *Genetics Problem-Solving Guide,* by William Wellnitz, is a companion guide that systematically walks students through the logical steps involved in solving genetics problems. (ISBN 13739–2)
12. *Compendium of Problems in Genetics,* by John Kuspira and Ramesh Bhambhani, University of Alberta, includes logical, illustrated exercises—including many based on actual experimental data from classic papers—for students at basic and advanced levels. (ISBN 16734–8)

Reviewers

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Brescia College

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Muhlenberg College

James Courtright
Marquette University

S. Cecilia Agnes Mulrennan
Regis College

Harry Wistrand
Agnes Scott College

Lance Urven
University of Wisconsin–Whitewater

John Rinehart
Eastern Oregon State College