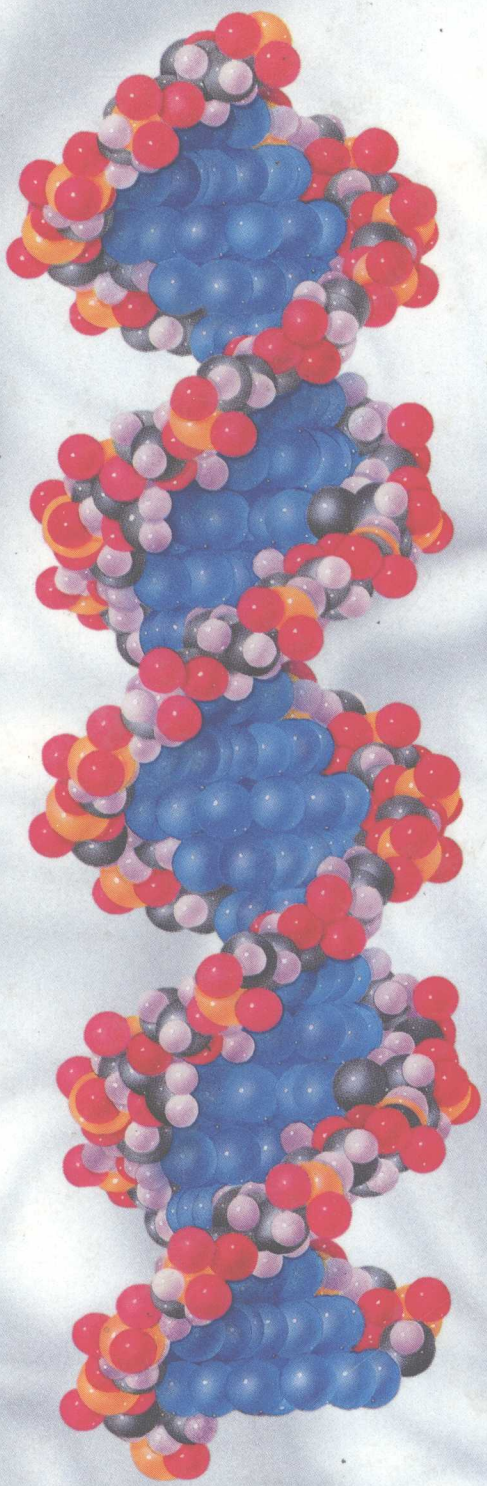
Robert F. Weaver Philip W. Hedrick



Second Edition

Genetics

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Genetics

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 second 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.

Chapters 2–5 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 6–12 present the fundamentals of molecular genetics. Chapters 6 and 7 provide an overview: chapter 6 explains the structure and properties of DNA, and chapter 7 introduces the three main functions of DNA in its role as the genetic material: (1) providing for faithful replication of genes; (2) containing the information for making the gene products, RNA and protein; and (3) accumulating mutations, which make evolution possible. This chapter also introduces the fundamentals of gene cloning. This prepares students to appreciate important experiments—many of which depend on cloned genes—that demonstrate how genes operate.

Chapters 8–12 expand on these themes. Chapter 8 treats DNA replication in detail; chapters 9, 10, and 11 deal with gene expression, the second function of a gene. In particular, chapters 9 and 10 cover transcription in prokaryotes and eukaryotes, respectively, and chapter

11 spells out the translation process. Finally, chapter 12 deals with the third attribute of a gene: its capacity for mutation.

Chapters 13–18 further illustrate specific aspects of the functions of genes. Chapter 13 is an extension of the material in chapter 12; 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 14 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 9) and the chemical nature of mutations (in chapter 12). Chapter 15 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 16 and 17 present two celebrated practical applications of molecular genetics. Chapter 16 covers gene cloning and manipulation and shows how one branch of genetics has evolved into a kind of engineering. 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 first edition is in organization. We have broken the original chapter 6 into two, more manageable chapters dealing with DNA structure and gene function, respectively. We have also moved the most elementary aspects of gene cloning to the end of chapter 7, so students will be able to understand experiments presented in subsequent chapters that use cloned genes. Finally, since extranuclear genetics does not fit neatly into any category, we have moved it to the end of the molecular genetics section. Placing this material after the gene cloning chapter has another advantage: the relatively sophisticated research on the molecular genetics of mitochondria and chloroplasts will be more easily understood.

This revised edition also features a greater emphasis on problem solving. We have included 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.

Major additions and updates include the following: We have expanded our coverage of transmission genetics with fuller discussions of tetrad analysis and other topics. We have added a discussion of Jacob and Monod's development of the operon concept to the prokaryotic transcription chapter (9). This includes the effects of all the important control mutations in the *lac* operon, and how they illustrate the phenomena of *cis*- and *trans*-acting elements. We have expanded our discussion of eukaryotic transcription factors in chapter 10. In chapter 15, we have emphasized the role of transcription factors and enhancers in governing gene expression and therefore cell differentiation. In chapter 16 we have included a discussion of DNA fingerprinting, with a box on the legal implications of its use in identifying criminals. This box also introduces the polymerase chain reaction (PCR), often used in conjunction with forensic DNA fingerprinting to amplify the DNA in small tissue samples. We have also introduced transgenic animals and plants as vehicles for expressing foreign genes. In chapter 17, we have expanded the list of oncogenes, stressing their roles in cell growth regulation.

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.

Robert F. Weaver
Philip W. Hedrick

Ancillaries

Available upon request to all adopters is an **instructor's manual/solutions manual** written by Holly Ahern of SUNY Albany. It contains worked-out solutions to all the end-of-chapter questions as well as a **test item file** of thirty-five to fifty objective questions for each chapter. Instructors may also request a set of fifty overhead **transparencies** or **slides** that will be useful in explaining difficult concepts.

Also available upon request, adopters of *Principles of Genetics* may request **wcb testpak,** a free computerized testing service that includes two options:

—A software package in IBM® 3.5 and 5.25, Apple®, and MAC programs that will enable you to print test masters, allow students to take exams on the computer, and use the program to grade/store exam results.

—Use the test item file found in the back of the instructor's manual to create exams via our call-in/mail-in service. Choose the questions you want printed, and within two working days of your request, we will put a test master, a student answer sheet, and an answer key in the mail to you. Call-in hours are 8:30–5:00 CST, Monday through Friday.

Finally, Wm. C. Brown is offering GenPak: A Computer-Assisted Guide to Genetics by Tully Turney of Hampden–Sydney College. This MAC-Hypercard program features numerous, interactive/tutorial (problem-solving) exercises in Mendelian, molecular, and population genetics (0–697–13760–0).

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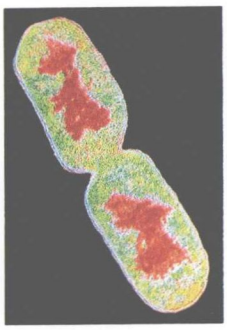

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