Preface

Genetics has long been one of the key areas in biology, and in the twenty-five years since the first unravelings of the DNA mysteries, we have seen an unparalleled explosion of knowledge and understanding about genetics and its related disciplines. Not only is knowledge of genetics accumulating rapidly, but its many applications are affecting our daily lives and bringing benefit to humanity. In writing *Genetics,* my goal is to provide today's students with a necessary new synthesis of this vital field.

It is most gratifying when a project that has demanded a great deal of time and effort is successful. The first edition of *Genetics* has achieved such a positive response from its users that the publisher and I have invested our time and effort to improve that book so that we have a superior new edition. The second edition retains the overall approach, logical progression of ideas, organization, and pedagogical features (such as "Analytical Approaches for Solving Genetics Problems," "Keynotes") that made the first edition readily accessible to students. It retains too a format that allows you to use the chapters out of sequence to accommodate your own teaching strategies. Some significant changes, however, appear in this second edition:

1. All the molecular aspects of genetics are updated, so that the book continues to reflect our current understanding of genes at the molecular level.
2. Molecular approaches applied to the traditional, classical areas of genetics (such as diagnosis of human disease) have been developed in more detail.
3. Because recombinant DNA technology has revolutionized many areas of biology, a chapter is added, concentrating on recombinant DNA technology and the manipulation of DNA. This addition is significant in that it shows how, by manipulating DNA, many applications have become available for use in biological research, commercial ventures, and medical diagnoses. The first edition had some coverage of this topic, but I have expanded and updated it to reflect the most recent uses of this technology.

4. A new chapter on genetic recombination shows models for generating genetic change by crossover events.
5. The chapter on gene regulation in eukaryotes is significantly rewritten and expanded.
6. The chapters on genetics of populations and quantitative genetics are expanded and significantly strengthened by additional examples and by more comprehensive treatment of all topics.
7. The art program is completely revised. Many figures have been added, and all the original illustrations have been redrawn for greater clarity. The innovative new art program emphasizes key genetic processes, making genetics more accessible to students and pedagogically sound for instructors.
8. Many questions and problems are added to the chapters. All answers have been checked for accuracy by independent reviewers.
9. Many references have been added to the "Suggested Readings" that accompany each chapter.
10. Many of the first-edition "boxed" special topics have been integrated into the text so that these topics receive as much attention as all the other topics.

Organization and Coverage

The second edition's twenty-four chapters contrast to the first edition's eighteen. This change reflects added chapters as well as reorganized material. Dividing some of the chapters in two allows for greater clarity and depth of coverage.

The first seven chapters deal with transmission of the genetic material. In Chapter 1 we review the structure of viruses and of prokaryotic and eukaryotic cells, and asexual and sexual reproduction. Mitosis and meiosis are discussed in the context of both animal and plant life cycles. Chapter 2 is focused on the contributions Mendel made to our understanding of the principles of heredity, and Chapters 2 and 3 both present the basic principles of genetics in relation to Mendel's laws. Chapter 3 covers experimental evidence for the relationship between genes and chromosomes, methods of sex determination, and Mendelian genetics in human beings.

The exceptions to and extensions of Mendelian analysis (such as the existence of multiple alleles, lethal alleles, and modifications of dominance relationships) are described in Chapter 4. In Chapter 5, we describe how the order of and distance between the genes on eukaryotic chromosomes are determined in genetic experiments designed to quantify the crossovers that occur during meiosis. In the next two chapters, we consider advanced mapping analysis in eukaryotes, and genetic mapping in prokaryotes. (This material had been combined in one chapter in the first edition.) Chapter 6 is focused on tetrad analysis, primarily in fungal systems, on using mitotic analysis in mapping eukaryotic genes, and on procedures for mapping genes to human chromosomes by means of somatic cell hybrids. In Chapter 7, we discuss the ways of mapping genes in bacteriophages and in bacteria (transformation, conjugation, and transduction).

In Chapters 8 through 15, the "molecular core" of the book, we present the current state of knowledge on the molecular aspects of genetics. In Chapter 8, we cover the structure of DNA, and present the classical experiments revealing that DNA and RNA are genetic material, and the double helix model for the structure of DNA. In this edition, the details of DNA structure and the organization of DNA in chromosomes in prokaryotes are exposed in Chapter 9. We cover DNA replication in prokaryotes and eukaryotes in Chapter 10.

After thoroughly explaining the nature of the gene and its relationship to chromosome structure, we discuss the first step in the expression of a gene transcription. In this edition, we describe the general process of transcription in Chapter 11 and we present the currently understood details of the structure, transcription, and processing of messenger RNA, transfer RNA, and ribosomal RNA molecules for both prokaryotes and eukaryotes in Chapter 12. In Chapter 13, we describe the structure of proteins, the evidence

for the nature of the genetic code, and a detailed expression of our current knowledge on translation in both prokaryotes and eukaryotes. In Chapter 14, we examine genetic fine structure and some aspects of gene function, such as genetic control of protein and enzyme structure and function, and involvement of particular sets of genes in directing and controlling biochemical pathways. In the new Chapter 15, on recombinant DNA technology, we discuss in detail the modern tools used in molecular genetics. Recombinant DNA technology for cloning and characterizing genes and manipulating DNA, are described followed by the commercial applications of recombinant DNA technology.

In the next four chapters, we describe the ways in which genetic material can change or be changed or both. The processes of gene mutation and the procedures which screen for potential mutagens and carcinogens (Ames test) and which select for particular classes of mutants from a heterogeneous population are discussed in Chapter 16. Chromosome aberrations—that is, changes in normal chromosome structure or chromosome number—are described in Chapter 17, and the structures and movement of transposable genetic elements in prokaryotes and eukaryotes are presented in Chapter 18. Models for generating genetic change by genetic recombination events are discussed in still another addition, Chapter 19.

The next two chapters are focused on regulation of gene expression in prokaryotes (Chapter 20) and eukaryotes (Chapter 21). In Chapter 20, we discuss the operon as a unit of gene regulation, the current molecular details in the regulation of gene expression in bacterial operons, and regulation of genes in bacteriophages. In Chapter 21, we explain how gene expression is regulated in eukaryotes by focusing on the molecular changes that accompany gene regulation, short-term gene regulation in lower and higher eukaryotes, gene regulation in development and differentiation, genetic defects in human development, and oncogenes and their relationship to cancer.

In Chapter 22, we address the organization and genetics of extranuclear genomes of mitochondria and chloroplasts. We cover the classical genetic experiments, which established that a gene is extranuclear. In this chapter we also discuss current molecular information about the organization of genes within the extranuclear genomes.

In Chapters 23 and 24, we describe quantitative genetics and the genetics of populations, respectively. In Chapter 23, we develop the concept that some heritable traits, the quantitative traits, show continuous variation over a range of phenotypes. In Chapter 23 we also discuss heritability: the relative extent to which a characteristic is determined by genes or by the environment. In Chapter 24, we present the basic principles in the genetics of populations and extend our treatment of the gene from the individual organism to a population of organisms.

Pedagogical Features

Because the study of genetics is so complex and difficult, I have incorporated a number of special pedagogical features to help students and enhance their understanding and appreciation of genetic principles:

1. Most chapters have a section on "Analytical Approaches for Solving Genetics Problems." The principles of genetics have always been best taught with a problem-solving approach. Often, however, beginning students do not acquire experience with the basic concepts that would enable them to methodically attack assigned problems. In the "Analytical Approaches" sections, typical genetic problems are "talked through" in step-by-step detail to help students understand how to tackle a genetics problem by applying fundamental principles.
2. More than 400 questions and problems in the problem sets closing each chapter give students further practice in solving genetics problems. For each chapter, the problems are chosen to represent a range of difficulty and topics. The answers to selected questions (indicated by *) are included at the back of the