Preface

Today's college students come to a course in genetics full of enthusiasm stimulated by social and ethical controversies related to genetics reported in the popular press. The challenges for the instructor are to sustain this enthusiasm, to kindle a desire to understand the principles of genetics, and to help students integrate genetic knowledge into a wider social and ethical context. We have written *Essential Genetics* to help instructors meet these challenges. It is designed for the shorter, less comprehensive introductory course in genetics. The brevity of the text fits the pace of what can be covered in a typical one-semester or one-quarter course. The topics have been carefully chosen to help students achieve the following learning objectives:

- Understand the basic processes of gene transmission, mutation, expression, and regulation
- Learn to formulate genetic hypotheses, work out their consequences, and test the results against observed data
- Develop basic skills in problem solving, including single-concept exercises, those requiring the application of several concepts in logical order, and numerical problems requiring some arithmetic for solution
- Gain some sense of the social and historical context in which genetics has developed as well as an appreciation of current trends
- Become aware of some of the genetics resources and information that are available through the World Wide Web

Many special features are included to make the book "user friendly." These are discussed individually below. Based on our own experiences in teaching genetics, they have been implemented and found to be effective in the classroom.

CHAPTER ORGANIZATION

The text is written in a clear, direct, lively, and concise manner. To help the student keep track of the main concepts without being distracted by details, each chapter begins with a list of **Key Concepts** written in simple declarative sentences, highlighting the most important concepts presented in the chapter. There is also an **Outline** showing the principal subjects to be discussed. The body of each chapter provides more detailed information and experimental evidence. An opening paragraph gives an overview of the chapter, illustrates the subject with some specific examples, and shows how the material is connected to genetics as a whole. The section and subsection **Headings** are in the form of complete sentences that encapsulate the main message. The text makes liberal use of **Numbered Lists** and **Bullets** to aid students in organizing their learning, as well as **Summary Statements** set apart from the main text in order to emphasize important principles. Each chapter also includes **The Human Connection.** This is a special feature highlighting a research paper in human genetics that reports a key experiment or raises important social, ethical, or legal issues. Each Human Connection has a brief introduction of its own, explaining the importance of the experiment and the context in which it was carried out. At the end of each chapter is a complete **Summary, Key Terms, geNETics on the web** exercises that guide students in the use of Internet resources in genetics, and several different types and levels of **Problems.** At the back of the book are **Answers** to some of the problems and a complete **Glossary.**

CONTENTS

The organization of the chapters is that favored by the majority of instructors who teach genetics. It is the organization we use in our own courses. An important feature is the presence of an introductory chapter providing a broad overview of the gene: what it is, what it does, how it changes, how it evolves. Today, most students learn about DNA in grade school or high school. In our teaching, we have found it rather artificial to pretend that DNA does not exist until the middle of the term. The introductory chapter therefore serves to connect the more advanced concepts that students are about to learn with what they already know. It also serves to provide each student with a solid framework for integrating the material that comes later.

Throughout each chapter, there is a balance between challenge and motivation, between observation and theory, and between principle and concrete example. Molecular, classical, and evolutionary genetics are integrated throughout. A number of points related to organization and coverage should be noted:

Chapter 1 is an overview of genetics designed to bring students with disparate backgrounds to a common level of understanding. This chapter enables classical, molecular, and evolutionary genetics to be integrated throughout the rest of the book. Included in Chapter 1 are the basic concepts of genetics: genes as DNA that function through transcription and translation, that change by mutation, and that affect organisms through inborn errors of metabolism. Chapter 1 also includes a discussion of the classical experiments demonstrating that DNA is the genetic material.

Chapters 2 through 5 are the core of Mendelian genetics, including segregation and independent assortment, the chromosome theory of heredity, mitosis and meiosis, linkage and chromosome mapping, tetrad analysis in fungi, and chromosome mechanics. An important principle of genetics, too often ignored or given inadequate treatment, is that of the complementation test and how complementation differs from segregation or other genetic principles. The complementation test is the experimental definition of a gene. Chapter 2 includes a clear and concise description of complementation, with examples, showing how complementation is used in genetic analysis to group mutations into categories (complementation groups), each corresponding to a different gene. Chapter 4 introduces the use of molecular markers in genetics, because these are the principal types of genetic markers in use today.

Chapters 6 and 7 deal with DNA, including the details of DNA structure and replication in Chapter 6 and mechanisms of mutation and DNA repair in Chapter 7, including chemical mutagens and new information on the genetic effects of the Chornobyl nuclear accident. A novel feature in Chapter 6 is a description of how basic research that revealed the molecular mechanisms of DNA replication ultimately led to such important practical applications as DNA hybridization analysis, DNA sequencing, and the polymerase chain reaction. These examples illustrate the value of basic research in leading, often quite unpredictably, to practical applications.

Chapter 8 deals with the principles of genetics in prokaryotes, with special emphasis on *E. coli* and temperate and virulent bacteriophages. There is an extensive discussion of mechanisms of genetic recombination in microbes, including transformation, conjugation, transduction, and the horizontal transfer of genes present in plasmids, such as F′ plasmids.

Chapters 9 through 12 focus on molecular genetics in the strict sense. Chapter 9 examines the details of gene expression, including transcription, RNA processing, and translation.

Chapter 10 deals with recombinant DNA and genome analysis. Included are the use of restriction enzymes and vectors in recombinant DNA, cloning strategies, transgenic animals and plants, and applications of genetic engineering. Also discussed are methods used in the analysis of complex genomes, such as the human genome, in which a gene that has been localized by genetic mapping to a region of tens of millions of base pairs must be isolated in cloned form and identified.

Chapter 11 is an integrative chapter dealing with genetic mechanisms of regulation. The first half of the chapter focuses on gene regulation in prokaryotes, the second half on that in eukaryotes.

Chapter 12 examines the genetic control of development. In addition to a discussion of developmental mechanisms in animals, there is a section on the genetic analysis of floral development in *Arabidopsis thaliana*. The material on pattern formation in *Drosophila* development is illustrated with spectacular color photographs by James Langeland, Stephen Paddock, and Sean Carroll, showing the discrete, overlapping patterns of gene expression as the embryo becomes segmented. The section on the development of flowers in plants is beautifully illustrated with photographs by Elliot Meyerowitz and John Bowman.

Chapters 13 and 14 deal with population and evolutionary genetics. The discussion of population genetics includes DNA typing in criminal investigations and paternity testing. The material on quantitative genetics includes a discussion of methods by which particular genes influencing quantitative traits (QTLs, or quanti-