PREFACE

The twentieth century witnessed the emergence of genetics as a central discipline in biology. In 1900 Gregor Mendel's laws of heredity were rediscovered; in the 1950s, James Watson and Francis Crick found that DNA, the molecule of heredity, is a double helix; and in the 1990s, the Human Genome Project progressed beyond expectations. For much of the century, the study of genetics focused on the identification of individual genes and their function. In the last decade of the century, however, another idea gained currency—the concept that no gene acts alone, instead it is through complex molecular interactions within and among vast networks of genes and proteins that organisms ultimately live and die.

Genetics: From Genes to Genomes reflects this new perspective. This book represents a new approach to an undergraduate course in genetics. It represents the way we, the authors, currently view the molecular basis of life. We integrate formal genetics—the rules by which genes are transmitted; molecular genetics—the structure of DNA and how it directs the structure of proteins; genomics and information science—the new technologies that enable gene isolation and a comprehensive analysis of the entire gene set in an organism; human genetics—how genes control health and disease; the unity of life forms—synthesis of information from many different organisms into one coherent whole; and molecular evolution—how species have evolved and diverged. The strength of this integrated approach is that students who have completed the text will have a strong command of genetics as it is practiced today by university and corporate researchers who are rapidly changing our understanding of living organisms, including ourselves; increasing our ability to prevent, treat, and diagnose disease and to engineer new life forms for food and medical uses; and, ultimately, creating the ability to replace or correct detrimental genes.

To encourage a genetic way of thinking, we begin the book with a presentation of Mendelian principles and the chromosomal basis of inheritance. From the outset, however, the integration of Mendelian genetics with fundamental molecular mechanisms is central to our approach. The Prologue presents the foundation of this integration. In Chapter 1, we tie Mendel's studies of pea-shape inheritance to the action of an enzyme that determines whether a pea is round or wrinkled. In the same chapter, we point to the relatedness of patterns of heredity in all organisms by using Mendelian principles to look at heredity in humans. Starting in Chapter 5, we focus on the physical dimensions of DNA; the implications and uses of mutations; and how the double helix of DNA encodes, copies, and transmits biological information. Beginning in Chapter 8 we also look at modern genetic techniques, including such biotechnology tools as gene cloning, hybridization, and PCR, exploring how researchers have used them to reveal the modular construction and genetic relatedness of genomes. We then show how the modular construction of genomes has contributed to the relatively rapid evolution of life and helped generate the enormous diversity of life forms we see around us. A detailed discussion of model organisms clarifies that their use in the study of human biology is possible only because of the genetic relatedness of all organisms. Throughout our text, we present the scientific reasoning of some of the ingenious researchers who have carried out genetic analysis, from Mendel to Watson and Crick to the collaborators on the Human Genome Project.

ORGANIZATION

The Prologue outlines the central themes of ***Genetics: From Genes to Genomes.*** We hope students will read this section carefully because it establishes the foundation for our integrated presentation of Mendelian and molecular genetics.

Part I (Chapters 1, 2, 3, and 4) on the ***Basic Principles: How Traits Are Transmitted*** presents a thorough discussion of Mendelian genetics; the chromosome theory of inheritance; and linkage, recombination, and mapping.

Part II (Chapters 5, 6, and 7) covers ***What Genes Are and What They Do,*** including the structure and function of DNA, the role of mutation in defining genes, and the details of gene expression.

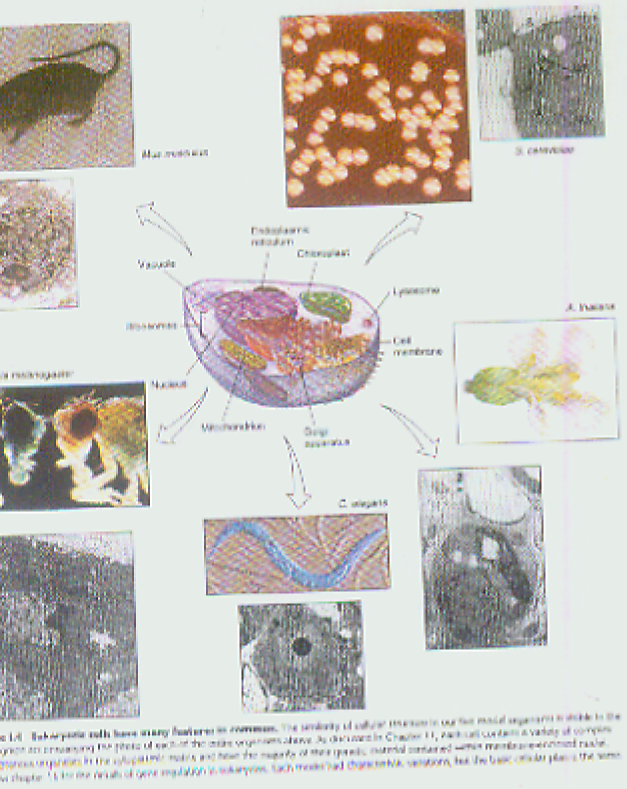
Part III (Chapters 8, 9, and 10) describes the ***Use of Genetic Engineering to Unravel the Information in Genomes*** and includes topics on mapping and analysis of genomes, detection of genotype, and the use of cloning, PCR, and hybridization in genetic analysis.

Part IV (Chapters 11, 12, 13, and 14) on ***How Genes Travel*** presents the molecular mechanisms underlying the chromosomal transmission of genetic information in eukaryotes and prokaryotes.

Part V (Chapters 15, 16, and 17) on ***How Genes Are Regulated*** discusses prokarytotic and eukaryotic gene regulation as well as the regulation of the cell cycle.

Part VI (Chapters 18–22) presents ***Gene Regulation and Development: Portraits of Model Eukaryotic Organisms.*** This **Genetic Portraits** unit contains five chapters, each one profiling a different model organism whose study has greatly contributed to genetic research. Included are

Saccharomyces cerevisiae: Genetic Portrait of Yeast
Arabidopsis thaliana: Genetic Portrait of a Model Plant
Caenorhabditis elegans: Genetic Portrait of a Simple Metazoan
Drosophila melanogaster: Genetic Portrait of a Fruit Fly
Mus musculus: Genetic Portrait of a House Mouse.



We anticipate that instructors will choose to cover one or two portrait chapters during the semester. Students may then use the specifics of the selected model organism to build an understanding of the principles and applications discussed in the text. The unique genetic manipulations and properties of each model make them important for addressing different biological questions using genetic analysis. In the portraits, we explain how biologists learned that the evolutionary relatedness of all organisms enables the extrapolation from a model to the analysis of other living forms. The portraits should thus help students understand how insights from one model organism can suggest general principles applicable to other organisms, including humans.

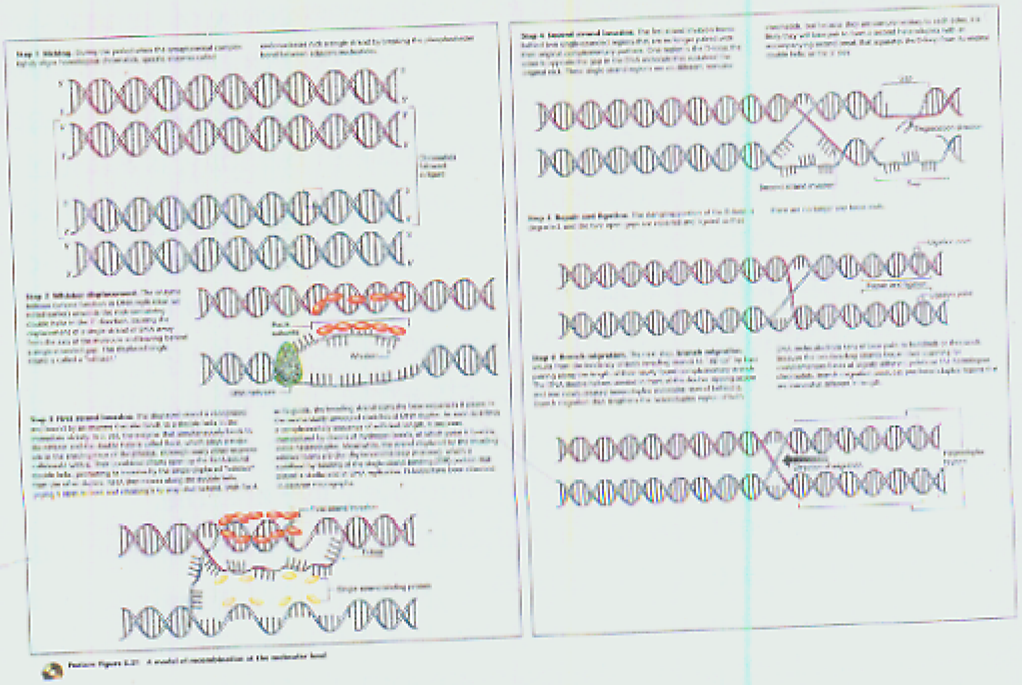
Part VII (Chapters 23 and 24) on ***How Genes Change*** explains the evolution of genes and genomes in populations and at the molecular level.

The **Epilogue** discusses ***Human Genetics and the Future of Biology.*** The focus of this closing essay is on the changing role of genetics research as a way to decipher biological networks and systems. Biology is now a science based on three levels of molecular information: information encoded in DNA, and information in proteins, and information encompassed in interactions among cells and tissues. The potential impact on the field of preventive medicine intensifies the need to confront many social and ethical issues.

CHAPTER FEATURES

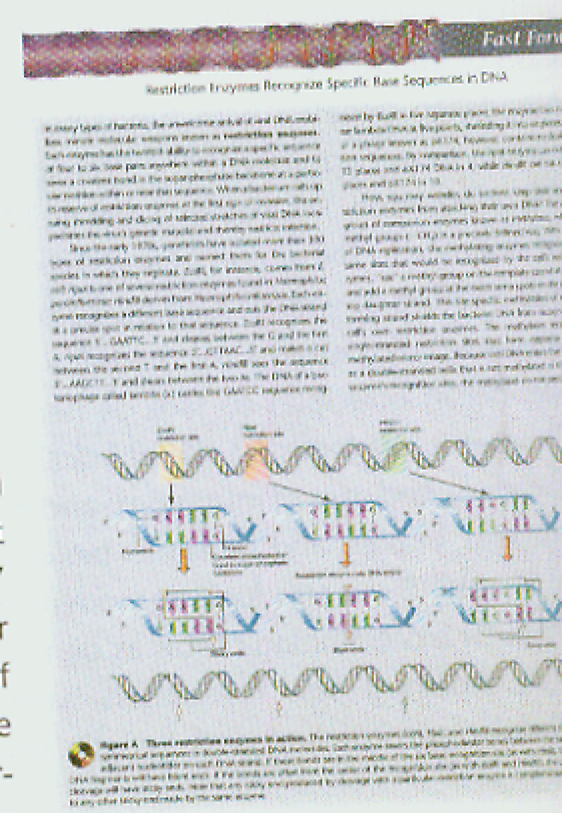
Introduction Each chapter begins with an engaging story related to the key ideas and principles of the chapter. This opening story is followed by a description of one or more overarching themes that unify the discussion, and then, in turn, by an advance organizer—a short, bulleted list of the chapter's topics in the order in which they appear in the text. The intent of the introduction is to create a narrative and conceptual framework that will help students organize and remember the vast amount of vocabulary and experimental data they encounter.

Feature Figures These special two-page spreads integrate line art and text to summarize important genetic processes in detail. For example, in Chapter 5 on *DNA: How the Molecule of Heredity Carries, Replicates, and Recombines Information*, the Feature Figure details a "Model of Recombination at the Molecular Level," walking students through the basic steps of the process. In Chapter 17, *Cell-Cycle Regulation and the Genetics of Cancer*, the Feature Figure details "Phenotypic Changes That Distinguish Tumor Cells from Normal Cells" outlines changes that produce uncontrolled cell growth, genomic and karyotypic instability, a potential for cellular immortality, and disruptions of local tissues that enable a tumor to invade distant tissues.



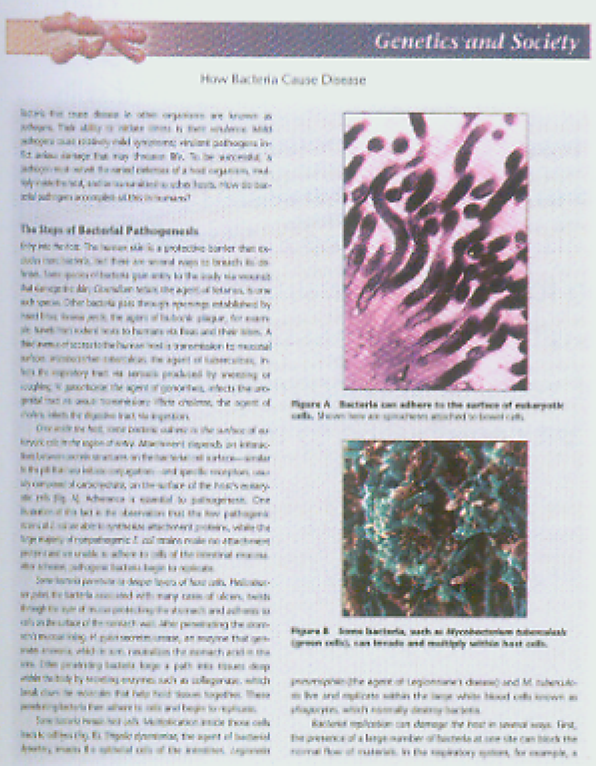
Comprehensive Examples These sections of the text are extensive case histories or research synopses that summarize the main points in the preceding section or chapter and show how they relate to each other. Very often these developed examples expand on the chapter's introductory story. In Chapter 6, *Anatomy and Function of a Gene: Dissection through Mutation*, for example, the opening story locates the rhodopsin gene on human chromosome 3 and explains that different mutations in the gene lead to night blindness or total blindness. The Comprehensive Example at the end of the chapter describes in detail "How Gene Mutations Affect Light-Receiving Proteins and Vision," covering such topics as the cellular and molecular basis of vision; the evolution of the rhodopsin gene family; and many of the mutations, amino-acid substitutions, and unequal crossing over events that affect both black and white and color vision.

Fast Forward Essays This feature prefigures detailed discussions of concepts and principles in later chapters, serving as a tool to integrate Mendelian and molecular genetics. Chapter 1, *Mendel's Breakthrough: Patterns, Particles, and Principles of Heredity*, contains two Fast Forward essays, one on the fact that "Genes Encode Proteins," the other on techniques for "The Direct Analysis of Human Genotype." These essays help students understand that Mendel's laws



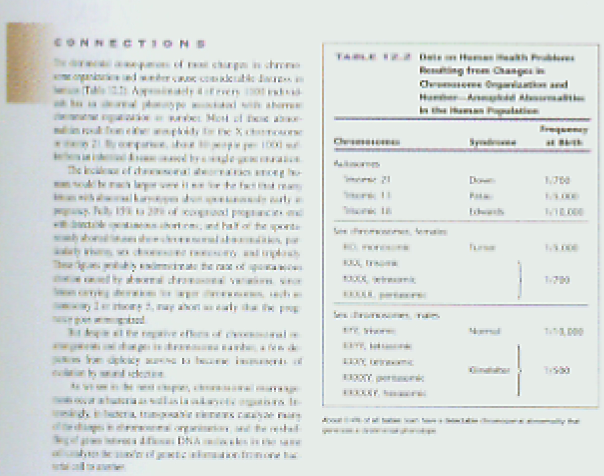
have a molecular basis. In Chapter 5, *DNA: How the Molecule of Heredity Carries, Replicates, and Recombines Information*, where we present in detail the structure of the DNA molecule, the Fast Forward essay explains how "Restriction Enzymes Recognize Specific Base Sequences in DNA." This simple introduction of restriction enzymes foreshadows a discussion in Chapter 8, *DNA at High Resolution: The Use of DNA Cloning, PCR, and Hybridization as Tools of Genetic Analysis*, about the use of restriction enzymes in DNA cloning. It thus relates the basic concept of DNA structure to the tools of biotechnology that depend on a knowledge of that structure.

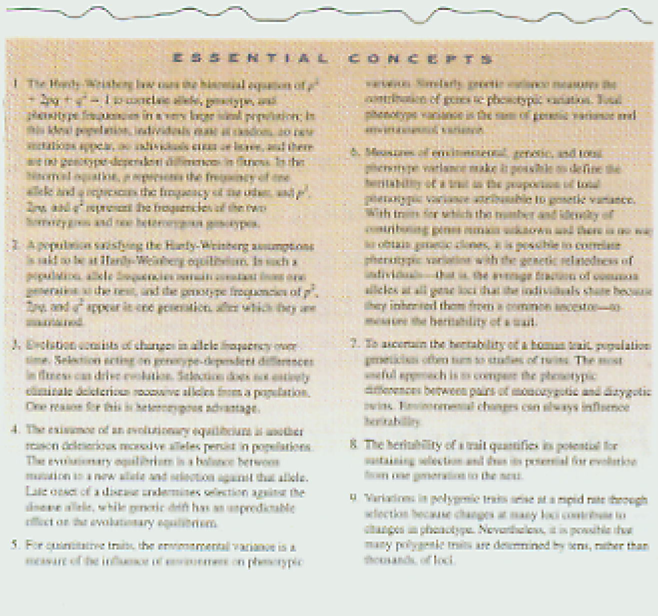
Genetics and Society Essays These essays explore the social and ethical issues created by the multiple applications of modern genetic research. They cover a wide variety of topics from the right to privacy to the question of who has the right to make reproductive decisions. In Chapter 9, the Genetics and Society essay asks "Does DNA Fingerprinting Serve the Interests of Justice?" In Chapter 10, the essay examines "The Patentability of DNA." In Chapter 13, it looks at "How Bacteria Can Cause Disease," presenting the mechanisms of bacterial pathogenesis step by step and describing the defense mechanisms that fight infection.


Genetics and Society

How Bacteria Cause Disease

Connections and Essential Concepts Each chapter closes with a **Connections** section that serves as a bridge between the topics in the just-completed chapter and those in the up-coming chapter or chapters. The Connections section is followed by an **Essential Concepts** section that helps students focus on the most critical information—the chapter's "take-home" messages. The end-of-chapter exercises include solved problems, **Social and Ethical Issues** discussion questions, and a diverse set of problems and questions for the student to solve.


CONNECTIONS


ESSENTIAL CONCEPTS

Outstanding Art Work The quality of the art is critical to the success of this text, and you will find that the photos, electron micrographs, and line art have been carefully selected and rendered to give students the best presentation possible. Color consistency has been used in rendering the line art to aid student comprehension. The following key is a guide to the use of color in our illustrations.

"old" DNA	protein 1
"new" DNA	protein 2
"new new" DNA	protein 3
mRNA (messenger)	phosphate group
tRNA (transfer)	ribosomes
rRNA (ribosomal)	membrane
mRNA (mitochrondrial)	nucleus
sugar (for ribose)	chromatin
	mitochrondria

REFERENCE SECTION

In the back of the text, we provide a **Genetic Nomenclature Appendix.** Since the study of genetics is a relatively new science, a completely consistent nomenclature, similar to those found in more established sciences, does not exist. Instead, the details of gene notation differ from model organism to model organism. To assist students in understanding the use of gene symbols throughout the book, and particularly in the section on model organisms, this concise appendix details the minor differences in notation by organism.

Mastering the vocabulary of genetics is critical to understanding the science. To aid in that mastery, we provide a detailed **Glossary.**

The **Answer Appendix** contains answers to selected end-of-chapter problems. Students can build their problem-solving skills by working through the solved problems within each chapter and then, for the unsolved problems, checking the solutions they arrive at on their own against the answers in the Answer Appendix.

ACKNOWLEDGMENTS

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