Preface

A Note from the Authors

The science of genetics is less than 150 years old, but its accomplishments within that short time have been astonishing. Gregor Mendel first described genes as abstract units of inheritance in 1865; his work was ignored and then "rediscovered" in 1900. Thomas Hunt Morgan and his students provided experimental verification of the idea that genes reside within chromosomes during the years 1910-1920. By 1944, Oswald Avery and his coworkers had established that genes are made of DNA. James Watson and Francis Crick published their pathbreaking structure of DNA in 1953. Remarkably, less than 50 years later (in 2001), an international consortium of investigators deciphered the sequence of the 3 billion nucleotides in the human genome. Twentieth-century genetics made it possible to identify individual genes and to understand a great deal about their functions.

Today, scientists are able to access the enormous amounts of genetic data generated by the sequencing of many organisms' genomes. Analysis of these data will result in a deeper understanding of the complex molecular interactions within and among vast networks of genes, proteins, and other molecules that help bring organisms to life. Finding new methods and tools for analyzing these data will be a significant part of genetics in the twenty-first century.

Our third edition of *Genetics: From Genes to Genomes* emphasizes both the core concepts of genetics and the cutting-edge discoveries, modern tools, and analytic methods that will keep the science of genetics moving forward.

Our Focus—An Integrated Approach

Genetics: From Genes to Genomes represents a new approach to an undergraduate course in genetics. It reflects 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 systems biology:** the new technologies that allow a comprehensive analysis of the entire gene set and its expression in an organism.
- **Human genetics:** how genes contribute to health and disease.
- **The unity of life-forms:** the synthesis of information from many different organisms into coherent models that explain many biological systems.
- **Molecular evolution:** the molecular mechanisms by which biological systems and whole organisms have evolved and diverged.

The strength of this integrated approach is that students who complete the book will have a strong command of genetics as it is practiced today by academic and corporate researchers. These scientists are rapidly changing our understanding of living organisms, including ourselves; increasing our ability to prevent, diagnose, and treat disease and to engineer new life-forms for food and medical uses; and, ultimately, creating the ability to replace or correct detrimental genes.

The Genetic Way of Thinking

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. Chapter 1 presents the foundation of this integration. In Chapter 2, 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 6, we focus on the physical characteristics of DNA, the implications and uses of mutations, and how the double helix structure of DNA encodes, copies, and transmits biological information. Beginning in Chapter 9 we look at modern genetic techniques, including such biotechnology tools as gene cloning, hybridization, PCR, and microarrays, exploring how researchers use them to reveal the modular construction and genetic relatedness of genomes. We then show how the complete genome sequences of humans and model organisms provide insights into the architecture and evolution of genomes; how modular genomic construction has contributed to the relatively rapid evolution of life and helped generate the enormous diversity of life-forms we see around us.

Genetic portrait chapters on the website (www.mhhe.com/hartwell3) contain detailed discussions of model organisms, which clarify that their use in the study of human biology is possible only because of the genetic relatedness of all organisms. Throughout our book, 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.

Student-Friendly Features

We have taken great pains to help the student make the leap to a deeper understanding of genetics. Numerous features of this book were developed with that goal in mind.

- ***One Voice*** The role of our science writer, Ruth Veres, is to create one voice for our author team. With more than 30 years' experience in life science textbook publishing, Ms. Veres is uniquely suited to this task. By working closely with everyone on the team, she has created the friendly, engaging reading style that helps students master the concepts throughout this book. This team approach provides the student with the focus and continuity required to make the book successful in the classroom.
- ***Visualizing Genetics*** The highly specialized art program developed for this book integrates photos and line art in a manner that provides the most engaging visual presentation of genetics available. Our Feature Figure illustrations break down complex processes into step-by-step illustrations that lead to greater student understanding. All illustrations are rendered with a consistent color theme—for example, all presentations of phosphate groups are the same color, as are all presentations of mRNA.
- ***Problem Solving*** Developing strong problem-solving skills is vital for every genetics student. The authors have carefully created problem sets at the end of each chapter that allow students to improve upon their problem-solving ability.
- **Social and Ethical Issues** questions require critical thinking analysis of the scientific issues that impact our society.
- **Solved Problems** provide insight into the step-by-step process of problem solving.
- **Review Problems** offer a variety of levels of questions that develop excellent problem-solving skills.
- **Accessibility** Our intention is to bring cutting-edge content to the student level. A number of more complex illustrations are revised and segmented to help the student follow the process. Legends have been streamlined to highlight only the most important ideas, and throughout the book, topics have been revised to focus on the most critical information.

New to the Third Edition

- The **End-of-Chapter Problem Sets Have Been Extensively Revised** and include over 100 new problems. The problems are now organized by chapter section and in order of increasing difficulty within each section for ease of use by instructors and students. Each chapter contains a variety of problem types including: *Social & Ethical Issues* which prompt the student to apply problem-solving skills to real-world situations that scientific breakthroughs have forced us to face as a society; *Solved Problems* which cover topical material with complete answers to aid the student in understanding the problem solving process; and *Problems & Questions* that allow students to develop their own problem-solving skills. Answers to selected problems are in the back of the book.
- **New Chapter: Chapter 12** ***Systems Biology and Proteomics*** provides a framework for thinking about what a biological system is and describes tools for analyzing the genes and proteins of a system, as well as computational tools for integrating and modeling this information to begin to explain a system's emergent properties.
- **Content Updates** throughout make this the most current and modern book available. Every chapter reflects the updated information generated by the breakthroughs of the past few years. For example,
  - Chapter 18, *Gene Regulation in Eukaryotes,* discusses the latest on RNAi technology.
  - Chapter 22, *Evolution at the Molecular Level,* includes information on network evolution and comparative genome evolution.
- **"Tools of Genetics" boxed essays are new** to this edition. They explain various techniques geneticists use to look at DNA, genes, other aspects of the genome, and proteins, with examples of interesting applications in biology and medicine.
- An **"On Our Website" Feature,** located at the end of each chapter, directs students and teachers to additional, more detailed information on specialized topics not found in the textbook. This information is in the form of new content, references, or links to other websites.
- **Interactive Web Exercises** offer students an interactive way to analyze genetic data on the Web and complete exercises that test their understanding of the data.
- A **New Design** is more user friendly and emphasizes the pedagogical structure and features of the presentation.

A Word About the Portraits of Model Organisms

Five **Genetic Portraits** are included on the book-specific website at www.mhhe.com/hartwell3 as easy-to-download PDF files. The Genetic Portraits are also available as a printed supplement upon request. Each Genetic Portrait profiles a different model organism whose study has contributed to genetic research. The five selected were the ones chosen as the focus of the Human Genome Project. They are:

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

We anticipate that instructors will choose to cover one or two portraits 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 book. The unique genetic manipulations and properties of each of the models 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 permits 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.

Guided Tour

Students and instructors can become acquainted with the key features of this book by browsing through the Guided Tour starting on the next page. These pages constitute a visual exposition of the book's pedagogy and art program.