Preface

Since its first edition in 1974, *Introduction to Genetic Analysis* has emphasized the power and incisiveness of the genetic approach in biological research and its applications. Over its many editions, the text has continuously expanded its coverage as the power of traditional genetic analysis has been extended with the introduction of recombinant DNA technology and then genomics. In the tenth edition, we incorporate the practice of modern genetics into new chapters on population genetics and the inheritance of complex traits.

John Doebley Joins the Author Team

We are delighted to welcome a new coauthor, John Doebley, to the author team. Dr. Doebley is a professor of genetics at the University of Wisconsin-Madison, where he teaches the genetics course with Sean Carroll. Dr. Doebley is an active research worker and teacher in the field of population and evolutionary genetics. His research group is trying to understand the genetic basis of the evolution of new morphological traits in plants.

Completely rewritten and updated chapters on population genetics, quantitative genetics, and evolutionary genetics

In the last several years, the field of genomics has advanced through the completion of full genomic sequences for many species and the development of a variety of genomic-scale analytical methods. These advances in genomics have revolutionized many areas of genetics, especially population and quantitative genetics. The tenth edition of *Introduction to Genetic Analysis* includes completely revised chapters on population and quantitative genetics, written by John Doebley, that integrate classical theory with cutting-edge genomic tools. These chapters examine the application of modern population and quantitative genetics to help the student understand (1) how genetic variation is patterned in human populations, (2) how human populations have adapted to different regions of the world, (3) how DNA forensics is used in criminal trials, (4) how inbreeding is managed in zoo populations, and (5) how the genes contributing to the risk of common diseases can be identified.

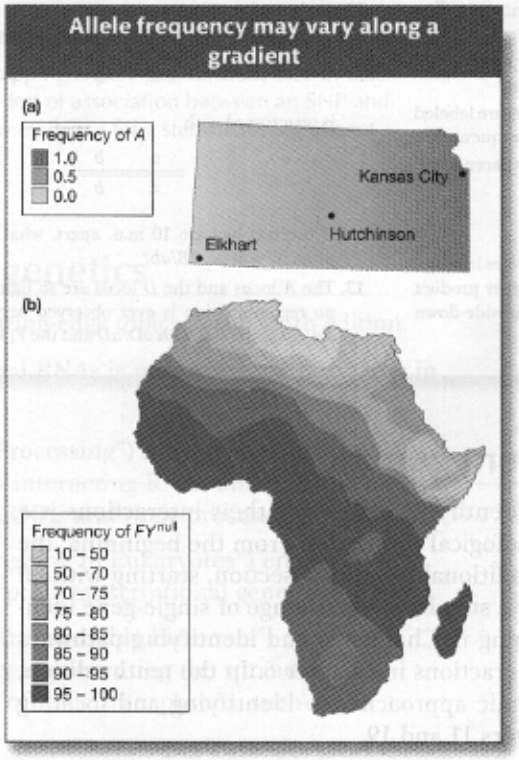

Figure 18-11 (a) Allele frequency variation across Kansas for a hypothetical species of wild sunflower. (b) Frequency variation for the FY^{null} allele of the Duffy blood group locus in Africa. [*From P. C. Sabeti et al., Science 312, 2006, 1614–1620.*]

In addition, the final chapter on the evolution of genes and traits has been heavily revised by Sean Carroll to reflect recent advances in understanding how adaptations arise. New topics include the classic story of the evolution of malarial resistance in humans, multistep evolutionary pathways, and the loss of characters through adaptive changes in regulatory sequences (illustrated by pelvic reduction in fish populations). Together, the chapter's many lucid examples provide a firm empirical foundation for the theory of evolution by natural selection.

Increased focus on visual learning and working with data

A new set of problems titled **"Working with the Figures,"** included at the back of each chapter, asks students incisive questions about figures in the chapter. We have found that students often underappreciate the wealth of information and insight provided by text figures. The new questions encourage students to spend more time thinking about the figures as a way of deepening their understanding of key concepts and analytical methods.

PROBLEMS

WORKING WITH THE FIGURES

1. In Figure 4-3, would there be any noncrossover meiotic products in the meiosis illustrated? If so, what colors would they be in the color convention used?
2. In Figure 4-6, why does the diagram not show meioses in which two crossovers occur between the same two chromatids (such as the two inner ones)?
3. In Figure 4-8, some meiotic products are labeled parental. Which parent is being referred to in this terminology?
4. In Figure 4-9, why is only locus A shown in a constant position?
5. In Figure 4-10, what is the mean frequency of crossovers per meiosis in the region A–B? The region B–C?
6. In Figure 4-11, is it true to say that from such a cross the product $v\ cv^+$ can have two different origins?
7. In Figure 4-14, in the bottom row four colors are labeled SCO. Why are they not all the same size (frequency)?
8. Using the conventions of Figure 4-15, draw parents and progeny classes from a cross

$$P\ M'''/p\ M' \times p\ M'/p\ M''''$$

9. In Figure 4-17, draw the arrangements of alleles in an octad from a similar meiosis in which the upper product of the first division segregated in an upside-down manner at the second division.
10. In Figure 4-19, what would be the RF between *A*/*a* and *B*/*b* in a cross in which purely by chance all meioses had four-strand double crossovers in that region?
11. **a.** In Figure 4-21, let GC = *A* and AT = *a*, then draw the fungal octad that would result from the final structure (5).

    b. (Challenging) Insert some closely linked flanking markers into the diagram, say *P*/*p* to the left and *Q*/*q* to the right (assume either cis or trans arrangements). Assume neither of these loci show non-Mendelian segregation. Then draw the final octad based on the structure in part 5.

BASIC PROBLEMS

12. A plant of genotype

$$\frac{A\quad B}{a\quad b}$$

is testcrossed with

$$\frac{a\quad b}{a\quad b}$$

If the two loci are 10 m.u. apart, what proportion of progeny will be *AB*/*ab*?

13. The *A* locus and the *D* locus are so tightly linked that no recombination is ever observed between them. If *Ad*/*Ad* is crossed with *aD*/*aD* and the F_1 is intercrossed,

New coverage of modern genetic analysis

One of our goals is to show how identifying genes and their interactions is a powerful tool for understanding biological properties. From the beginning, the student follows the process of a traditional genetic dissection, starting with an overview in Chapter 1, followed by a step-by-step coverage of single-gene identification in Chapter 2, gene mapping in Chapter 4, and identifying pathways and networks by studying gene interactions in Chapter 6. In the tenth edition, we add coverage of the new genomic approaches to identifying and locating genes, which are explored in Chapters 11 and 19.

- A reconceptualized Chapter 1 now provides an overview of how modern genetics works and of the kinds of powerful insights genetics provides that have revolutionized not only biology but many aspects of human society.
- Molecular markers, which are essential to gene identification, are introduced in Chapter 4, in a heavily revised section that introduces the common types of molecular markers and describes how they are detected and mapped. This early introduction of molecular markers helps students understand them as genetic elements that can be mapped just like genes.
- A new section on fine-mapping in Chapter 11 ("Gene Isolation and Manipulation") introduces the genome-based method for gene identification.
- Chapter 19 ("The Inheritance of Complex Traits") discusses using quantitative trait loci (QTL) mapping to locate QTL in the genome and fine-mapping to identify single genes.
- Whole-genome association mapping, used to scan the genome for QTL, is discussed in Chapter 19.

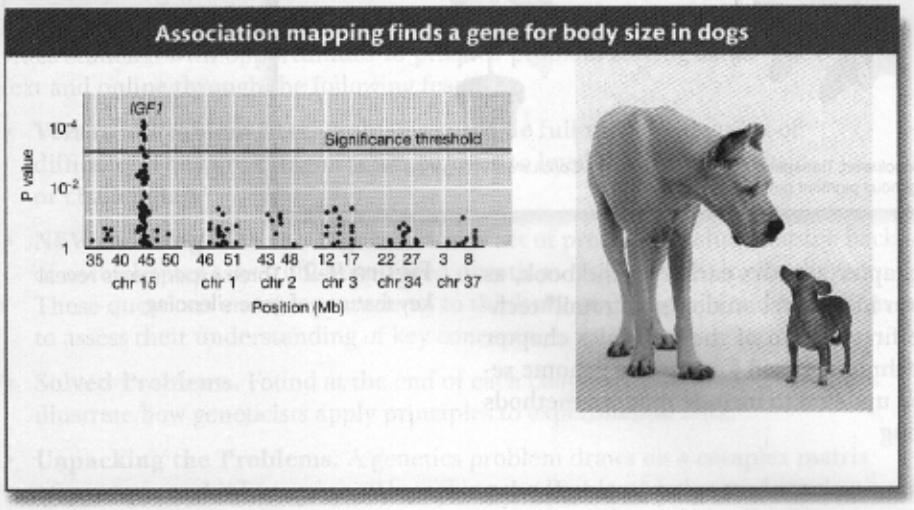

Figure 19-18 Results from an association-mapping experiment for body size in dogs. Each dot in the plot represents the P value for a test of association between an SNP and body size. Dots above the "threshold line" show evidence for a statistically significant association. [*Photo: Tetra Images/Corbis.*]

Focus on key advances in genetics

We have enhanced coverage of several cutting-edge topics in the tenth edition.

Functional RNAs: Coverage of functional RNAs is now woven into the text in multiple chapters:

- Chapter 9 ("RNA: Transcription and Processing") introduces functional RNAs, including new mention of piwi-interacting RNAs and ncRNAs and new discussion of the discovery of miRNAs and their processing in the cell.
- Chapter 13 ("Regulation of Gene Expression in Eukaryotes") ends with a new section on the role of miRNAs in post-transcriptional gene regulation.
- Chapter 16 ("The Dynamic Genome: Transposable Elements") explores the role of the RNAi silencing pathway in preventing the spread of transposable elements and the ability of some transposons, such as MITEs, to evade silencing.

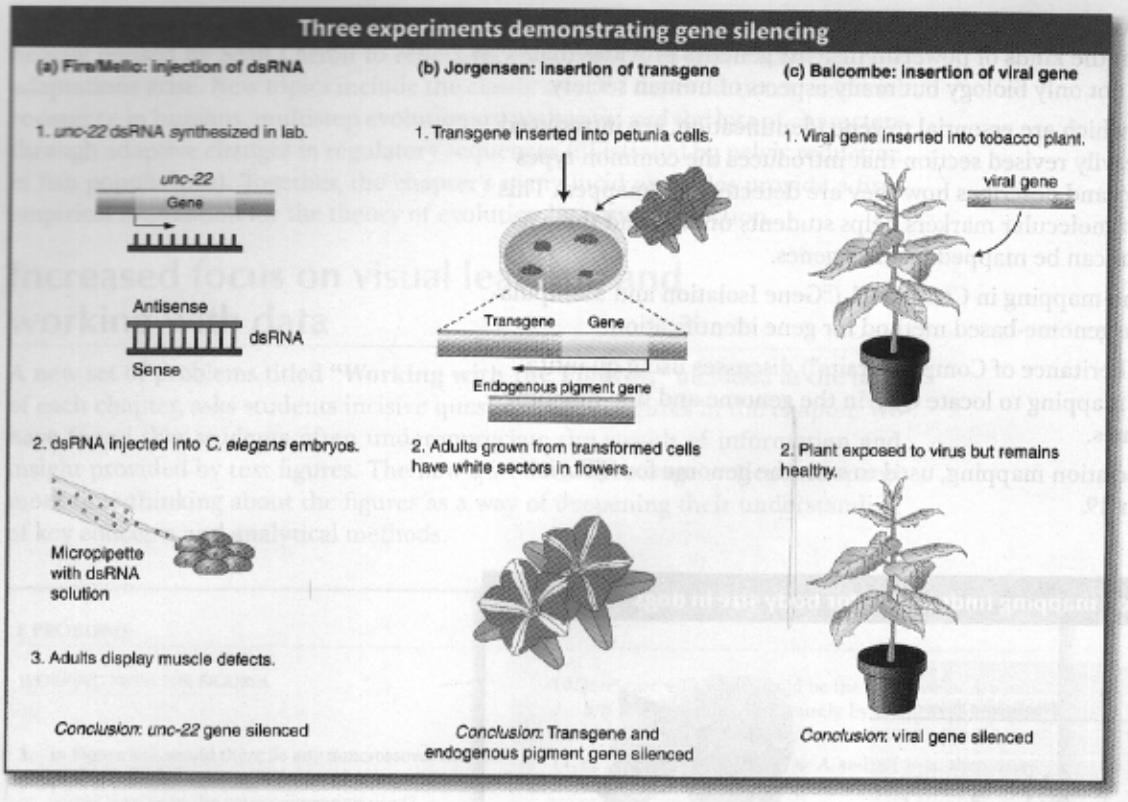

Figure 9-21 Three experiments reveal key features of gene silencing.

Modern Techniques: The techniques chapter appears earlier in the book, as Chapter 11 in the tenth edition. This chapter introduces students to "retail" techniques commonly used in labs, while the first section of the genomics chapter (Chapter 15) focuses on the "wholesale" techniques used for massive genome sequencing projects. Both chapters have been updated to include modern methods used for solving genetics problems, including

- Using PCR in the construction of recombinant DNA molecules and clones
- Finding genes through fine-mapping
- Pyrosequencing
- Next-generation whole-genome sequencing

Comparative Genomics: In revised Chapter 15 ("Genomes and Genomics"), we have enhanced coverage of how comparative genomics informs genetic analysis and reveals crucial differences between organisms.

- A new section, "Phylogenetic Inference," looks at using phylogenies to determine which genomic elements have been gained or lost during evolution.
- A new section, "Comparative Genomics of Humans," examines copy number variations and how they may be adaptive in some populations.
- A new discussion of the comparative genomics of color vision contrasts mice and humans.

Enduring Features

Coverage of Model Organisms

The tenth edition retains the enhanced coverage of model systems in formats that are practical and flexible for both students and instructors.

- Chapter 1 introduces some key genetic model organisms and highlights some of the successes achieved through their use.
- Model Organism boxes presented in context where appropriate provide additional information about the organism in nature and its use experimentally.
- A Brief Guide to Model Organisms, at the back of the book, provides quick access to essential, practical information about the uses of specific model organisms in research studies.
- An Index to Model Organisms, on the endpapers at the back of the book, provides chapter-by-chapter page references to discussions of specific organisms in the text, enabling instructors and students to easily find and assemble comparative information across organisms.

Problem Sets

No matter how clear the exposition, deep understanding requires the student to personally engage with the material. Hence our efforts to encourage student problem solving. Building on its focus on genetic analysis, the tenth edition provides students with opportunities to practice problem-solving skills—both in the text and online through the following features:

- **Versatile Problem Sets.** Problems span the full range of degrees of difficulty. They are categorized according to level of difficulty—basic or challenging.
- NEW **Working with the Figures.** A new set of problems included at the back of each chapter asks students pointed questions about figures in the chapter. These questions encourage students to think about the figures and help them to assess their understanding of key concepts.
- **Solved Problems.** Found at the end of each chapter, these worked examples illustrate how geneticists apply principles to experimental data.
- **Unpacking the Problems.** A genetics problem draws on a complex matrix of concepts and information. "Unpacking the Problem" helps students learn to approach problem solving strategically, one step at a time, concept on concept.

How Genetics Is Practiced Today

A feature called "What Geneticists Are Doing Today" suggests how genetic techniques are being used today to answer specific biological questions such as, "What is the link between telomere shortening and aging?" or, "How can we find missing components in a specific biological pathway?"

Increased Coverage of Modern Experiments

Building on the text's traditional focus on classical experiments, the molecular chapters present the evidence and reasoning that led to some of the more recent advances. These include the discovery of RNAi and advances in our understanding of eukaryotic gene regulation.

Media and Supplements

TEACHING RESOURCES FOR INSTRUCTORS

Electronic teaching resources are available from two sources: the Instructor's Resource DVD and the Instructor's Resource Web site.

Instructor's Resource DVD
(ISBN: 1-4292-7000-4)
The IRDVD contains all text images in PowerPoint and JPEG formats, 45 FLASH Animations, Clicker Questions, Layered PowerPoints, and Assessment Bank.

Password-Protected Instructor's Resource Web Site at www.whfreeman.com/iga10e
Includes all of the electronic resources for teachers listed below. Contact your W. H. Freeman sales representative to learn how to log on as an instructor.

Electronic Resources

Clicker Questions
Jump-start discussions, illuminate important points, and promote better conceptual understanding during lectures.

Layered PowerPoints
Illuminate challenging topics for students by deconstructing intricate genetic concepts, sequences, and processes step-by-step in a visual format.

All Images from the Text
More than 500 illustrations can be downloaded as JPEGs and PowerPoints. Use high-resolution images with enlarged labels to project clearly for lecture hall presentations. Additionally, these JPEG and PowerPoint files are available without labels for easy customization in PowerPoint.

45 Step-Through and Continuous Play FLASH Animations
These animations were authored by Anthony Griffiths in conjunction with BioStudio Visual Communications. The complete list of animations appears on page xix.

Assessment Bank
This resource brings together a wide selection of genetics problems for use in testing, homework assignments, or in-class activities. Searchable by topic and provided in MS Word format, the assessment bank offers a high level of flexibility.

Print Resources

Overhead Transparency Set (ISBN: 1-4292-7566-9)
The full-color overhead transparency set contains 150 key illustrations from the text with enlarged labels that project more clearly for lecture hall presentation.

RESOURCES FOR STUDENTS

Book Companion Site at http://www.whfreeman.com/iga10e
The free book companion site offers the 45 FLASH animations listed above and the ***Practice Tests***. Students can test their understanding and receive immediate feedback by answering online questions in **Practice Tests** that cover the core concepts in each chapter.

Other genomic and bioinformatic resources for students:
Text Appendix A, *Genetic Nomenclature,* lists model organisms and their nomenclature.
Text Appendix B, *Bioinformatic Resources for Genetics and Genomics,* builds on the theme of introducing students to the latest genetic research tools by providing students with some valuable starting points for exploring the rapidly expanding universe of online resources for genetics and genomics.

Animations

Forty-five animations developed by Anthony Griffiths are fully integrated with the content and figures in the text chapters. These animations are available on the Book Companion site.

CHAPTER 1
Three-Dimensional Structure of Nuclear Chromosomes (Figure 1-10)
RFLP Analysis and Gene Mapping

CHAPTER 2
Mitosis (Chapter Appendix 2-1)
Meiosis (Chapter Appendix 2-2)

CHAPTER 3
Meiotic Recombination Between Unlinked Genes by Independent Assortment (Figures 3-8 and 3-13)

CHAPTER 4
Meiotic Recombination Between Linked Genes by Crossing Over (Figure 4-7)
A Mechanism of Crossing Over: A Heteroduplex Model (Figure 4-21)
A Mechanism of Crossing Over: Genetic Consequences of the Heteroduplex Model

CHAPTER 5
Bacterial Conjugation and Mapping by Recombination (Figures 5-11 and 5-17)

CHAPTER 6
Interactions Between Alleles at the Molecular Level, *RR:* Wild-Type
Interactions Between Alleles at the Molecular Level, *rr:* Homozygous Recessive, Null Mutation
Interactions Between Alleles at the Molecular Level, *r′r′*: Homozygous Recessive, Leaky Mutation
Interactions Between Alleles at the Molecular Level, *Rr:* Heterozygous, Complete Dominance

CHAPTER 7
Autotetraploid Meiosis (Figure 7-6)
Meiotic Nondisjunction at Meiosis I (Figure 7-12)
Meiotic Nondisjunction at Meiosis II (Figure 7-12)
Chromosome Rearrangements: Paracentric Inversion, Formation of Paracentric Inversions (Figure 7-27)
Chromosome Rearrangements: Paracentric Inversion, Meiotic Behavior of Paracentric Inversions (Figure 7-28)
Chromosome Rearrangements: Reciprocal Translocation, Formation of Reciprocal Translocations (Figure 7-30)
Chromosome Rearrangements: Reciprocal Translocation, Meiotic Behavior of Reciprocal Translocations (Figure 7-30)
Chromosome Rearrangements: Reciprocal Translocation, Pseudolinkage of Genes by Reciprocal Translocations (Figure 7-32)

CHAPTER 8
DNA Replication: The Nucleotide Polymerization Process (Figure 8-15)
DNA Replication: Coordination of Leading and Lagging Strand Synthesis (Figure 8-20)
DNA Replication: Replication of a Chromosome (Figure 8-24)

CHAPTER 9
Transcription (Figure 9-4)

CHAPTER 10
Translation: Peptide-Bond Formation (Figure 10-2)
Translation: The Three Steps of Translation (Figure 10-16)
Nonsense Suppression at the Molecular Level: The *rod*^{ns} Nonsense Mutation (Figure 10-18)

Nonsense Suppression at the Molecular Level: The tRNA Nonsense Suppressor (Figure 10-18)
Nonsense Suppression at the Molecular Level: Nonsense Suppression of the *rod*^{ns} Allele (Figure 10-18)

CHAPTER 11
Polymerase Chain Reaction (Figure 11-3)
Finding Specific Cloned Genes by Functional Complementation: Functional Complementation of the Gal$^-$ Yeast Strain and Recovery of the Wild-Type *GAL* Gene
Finding Specific Cloned Genes by Functional Complementation: Making a Library of Wild-Type Yeast DNA
Finding Specific Cloned Genes by Functional Complementation: Using the Cloned *GAL* Gene as a Probe for *GAL* mRNA
Screening and Selecting for Mutations
RFLP Analysis and Gene Mapping

CHAPTER 12
Regulation of the Lactose System in *E. coli:* Assaying Lactose Presence/Absence Through the Lac Repressor (Figure 12-6)
Regulation of the Lactose System in *E. coli:* O^C *lac* Operator Mutations (Figure 12-8)
Regulation of the Lactose System in *E. coli:* I^- Lac Repressor Mutations (Figure 12-9)
Regulation of the Lactose System in *E. coli:* I^S Lac Superrepressor Mutations (Figure 12-10)

CHAPTER 14
Gene Interactions in *Drosophila* Embryogenesis: Cell Signaling in Dorsal–Ventral Axis Formation

CHAPTER 15
DNA Microarrays: Using an Oligonucleotide Array to Analyze Patterns of Gene Expression (Figure 15-19)
DNA Microarrays: Synthesizing an Oligonucleotide Array

CHAPTER 16
Replicative Transposition (Figure 16-9)

CHAPTER 17
Molecular Mechanism of Mutation (Figure 17-8)
UV-Induced Photodimers and Excision Repair (Figure 17-19)

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