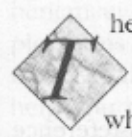


Preface

he science of genetics includes the rules of inheritance in cells, individuals, and populations and the molecular mechanisms by which genes control the growth, development, and appearance of an organism. No area of biology can be truly appreciated or understood without an understanding of genetics because genes not only control cellular processes, they also determine the course of evolution. Genetics is an exciting basic science whose concepts provide the framework for the study of modern biology.

This text provides a balanced treatment of the major areas of genetics in order to prepare you for upper-level courses and to help you share in the excitement of research. Most readers of this text will have taken a general biology course and will have had some background in cell biology and organic chemistry. However, for an understanding of the concepts in this text, the motivated student will need to have completed only an introductory biology course and have had some chemistry and algebra in high school.

Genetics is commonly divided into three areas: classical, molecular, and population. Many genetics teachers feel that a historical approach provides a sound introduction to the field and that a thorough grounding in Mendelian genetics is necessary for an understanding of molecular and population genetics—an approach this text follows. Other teachers, however, may prefer to begin with molecular genetics. For this reason, the chapters have been grouped as units and allow for flexibility in their use. A comprehensive glossary and index will help maintain continuity if the order of the chapters is changed from the original.

An understanding of genetics is crucial to advancements in medicine, agriculture, and animal breeding, and genetic controversies—such as the potential harm of recombinant DNA and the pros and cons of the Human Genome Project—have captured the interest of the general public. Throughout this text, the implications for human health and welfare of the research conducted in laboratories and universities around the world are pointed out. Digressions, in the form of boxed material, give insights into genetic techniques, controversies, and breakthroughs.

Because genetics is the first analytical biology course for many students, you may have difficulty with its quantitative aspects. There is no substitute for work with pad and pencil. This text provides a larger number of problems to help you learn and retain the material. All problems within the body of the text and a selection at the end of the chapters should be worked through as they are encountered. After you have worked out the problems, you may want to refer to the answer section in the Appendix. We provide solved problems at the end of each chapter to help.

In this text, we stress *critical thinking*, an approach that emphasizes understanding over memorization, experimental proof over the pronouncements of authorities, problem solving over passive reading, and active participation in lectures. The latter is best accomplished if you read the appropriate text chapter before coming to lecture rather than after. That way you can use the lecture to gain insight into difficult material rather than spending the lecture hectically transcribing the lecturer's comments onto the notebook page.

For those who wish to pursue particular topics, there is a reference section in the back of the text that provides chapter-by-chapter listings of review articles and articles in the original literature. Although some of these articles might be difficult for the beginner to follow, each is either a landmark paper, a comprehensive summary, or a paper with some valuable aspect to it. Some papers may contain an insightful photograph or diagram. Some magazines and journals are especially recommended for you to look at periodically, including *Scientific American*, *Science*, and *Nature*, because they contain nontechnical summaries as well as material at the cutting edge of genetics. Some articles are included to help the teacher with supplementary material or material from which concepts have been developed. Photographs of selected geneticists are also included. After all, geneticists are people who occasionally make mistakes and often disagree with each other. Perhaps the glimpse of a face from time to time will help add a human touch to this science.

New To This Edition

Since the last edition of this text, many exciting discoveries have been made in genetics. All chapters have been updated to reflect those discoveries. For example, we have added material on the historical background of genetics, genetic control of the cell cycle, the fragile-X syndrome, the Human Genome Project, the breast cancer gene, and *Drosophila* development. We have also added new boxed material on many topics, including the Lysenko affair in the former Soviet Union, why sex evolved, why the Y chromosome evolved, ancient DNA, directed mutation, mapping quantitative trait loci, and human behavior genetics.

Learning Aids for the Student

To help you learn genetics, as well as enjoy the material, we have made every effort to provide pedagogical aids for that purpose. These aids are designed to help you organize and understand the material.

Study Objectives Each chapter begins with a set of clearly defined, page-referenced objectives. These have been written with an attempt to preview the chapter and highlight the most important concepts.

Study Outline The chapter topics are provided in a list of major headings of the subject matter. These headings consist of words or phrases that clearly define what the various sections of the chapter contain.

Boldface Terms Throughout the chapter, all new terms are presented in boldface, indicating that each is defined in the glossary at the end of the book.

Boxed Material In most chapters, short topics have been set aside in boxed readings, out of the main body of the chapter. These boxes fall into eight categories that are designated by icons as follows:

Historical Accounts



Experimental Methods



Analytical Thinking



Biomedical Applications



Molecular Structure and Function



Genetic Discoveries and Hypotheses



Ethics and Genetics



Genetic Variation



These icons help you categorize and cross-reference material presented in these boxes. The material is designed to supplement the material in each chapter with entertaining, interesting, and relevant topics.

Full Color Art and Graphics Many genetics concepts are made much clearer with full-color illustrations and the latest in molecular computer models to help you visualize and interpret difficult concepts.

Summary Each chapter summary is presented with reference to the study objectives at the beginning of the chapter. Thus you can determine if you have gained an understanding of the material as presented in the study objectives and reinforced with the summary.

Solved Problems From two to four problems are worked out at the end of each chapter to give you insights into the best way to solve the most basic problems presented by the material.

Solved Problems

Problem 1. In corn the single-flowered phenotype is dominant to the double flower, starchy endosperm is dominant to waxy endosperm, and serrate (toothed or toothed) leaves are dominant to entire leaves. What are the results of the testcrossing of a trihybrid?

Answer: The trihybrid has the genotype *Sst Sst Aa*, naming the alleles for the single flower (*Ss*), starchy endosperm (*Aa*), and serrate leaf (*Aa*), respectively. This parent is capable of producing eight different gamete types in equal frequencies, all combinations of one allele from each gene (*Ss Aa Aa*, *Ss Aa aa*, *Ss aa Aa*, *Ss aa aa*, *sS Aa Aa*, *sS Aa aa*, *sS aa Aa*, and *sS aa aa*). In a testcross, the other parent is a recessive homozygote with the genotype *ssst sst aa aa*, capable of producing only one type of gamete, *sst aa*. Thus zygotes of eight different genotypes (and phenotypes) can be produced in this cross, one for each of the gamete types of the trihybrid parent: *Sst Sst Aa* (single flower, starchy endosperm, serrate leaf), *Sst Sst aa* (single, starchy,

entire), *Sst sst Aa* (single, waxy, serrate), *Sst sst aa* (single, waxy, entire), *sst Sst Aa* (double, starchy, serrate), *sst Sst aa* (double, starchy, entire), *sst sst Aa* (double, waxy, serrate), and *sst sst aa* (double, waxy, entire). These should each make up one-eighth of the total number of offspring each.

Problem 2. Summer squash can be found in three shapes: disk, spherical, and elongate. In one experiment, two squash plants with disk-shaped fruits were crossed. The first 160 seeds planted from this cross produced plants with fruit shapes as follows: 89 disk, 61 spherical, and 10 elongate. What is the mode of inheritance of fruit shape in summer squash?

Answer: The numbers are very close to a ratio of 90:60:10, or 9:6:1, an epistatic variant of the 9:3:3:1, in which the two 3/16ths categories are combined. If this is the case, then the parent plants with disk-shaped fruits were dihybrids (*AaBb*). In the offspring, 9/16ths had disk-shaped fruit indicat-

Exercises and Problems At the end of the chapter are numerous problems to test your understanding of the material presented. Answers to most problems are presented in the Appendix, with a select sample of problems answered only in the Instructor's Manual so that you and your instructor can be certain that you are gaining an understanding of the material.

Technology Links The end-of-chapter exercises and problems are linked directly to several WCB technology products—Gene Game Software, Genetic Inheritance: Peas and *Drosophila* Software, and the Explorations in Genetics CD-ROM through software and CD-ROM links. These technology links are designed to help you gain a better understanding of experimental data analysis and improve your genetics problem-solving skills.

Exercises and Problems with Software Links or CD-ROM Links



Mendel's Peas: 1, 2, 13, 34, 38



Drosophila Genetics: 15, 16, 20, 28, 32, 36, 37, 40, 41, 43



Genetics CD-ROM: 6, 8, 9, 10, 11, 23, 27, 30, 44

Ancillary Materials

- An *Instructor's Manual with Test Item File*, written by William Wellnitz of Augusta College, is available upon request to adopters. It contains instructional hints and answers to selected odd-numbered end-of-chapter exercises and problems as well as a test item file of thirty-five to fifty objective questions for each chapter. (ISBN 21890-2)
- *Test Item File on MicroTest III Classroom Testing Software* is an easy-to-use computerized test generator also offered free upon request to adopters of this text. The software requires no programming experience. Using the software requires access to a personal computer (3.5-inch disk drive): DOS (ISBN 21894-5), Windows (ISBN 21896-1), or Macintosh (21898-8). Diskettes are available to instructors through a local WCB sales representative or by phoning Educational Services at (800) 228-0459. Alternatively, instructors may

use WCB's call-in/mail-in/FAX service to generate tests. To use this service, instructors should select the questions to be included in the customized test, and then simply call (800-258-2385), mail (Attn: Judi David/Wm. C. Brown Publishers/2460 Kerper Blvd./Dubuque, IA 52001), or fax (319-589-2955) their requests to WCB. Within two working days of receiving the order, WCB will send, by first-class mail or fax, a test master, a student answer sheet, and an answer key.

- Instructors may also request a set of 125 *full-color transparencies*, which are useful in explaining difficult concepts in lecture.
- *Genetic Inheritance: Peas and Drosophila Software*, linked directly to this text, is an affordable Macintosh software program, developed at Purdue University, that can be packaged with this text. The software allows students to simulate hundreds of genetic crosses right at their computers to gain valuable practice in the quantitative aspects of genetics. The pea experiments investigate Mendel's theories of dominance, segregation, independent assortment, and how numbers of offspring affect test results. Once students master the concepts illustrated with the basic pea crosses, they can challenge themselves with the *Drosophila* experiments, which also explore the concepts of monohybrid, dihybrid, and trihybrid crosses, as well as the determination of linkage, map distances, and gene order on chromosomes. This software can also be packaged with the text. (ISBN 28861-7)
- *Gene Game Software*, linked directly to this text, is an easy-to-use, interactive Macintosh software game, developed by Bill Sofer of the State University of New Jersey-Rutgers. It requires students to use their critical thinking skills and apply the scientific method in cloning a fictitious fountain of youth gene. Gene Game software can also be packaged with this text. (ISBN 24893-3)
- *Explorations in Genetics CD-ROM*, linked directly to this text, is an interactive multimedia program developed by George B. Johnson, Washington University-St. Louis, and WCB. It calls on users to manipulate genetic variables and examine how they impact the results as they explore such modules as Constructing a Genetic Map, DNA Fingerprinting: You Be the Judge, and Gene Regulation. The CD-ROM is compatible with both Windows and Macintosh systems. (ISBN 28862-5)
- *Student Study Guide in Genetics*, by Ken Zwicker, also accompanies this text. It features key concepts and terms and study questions and answers. (ISBN 21891-0)

- The new fourth edition of *Laboratory Manual of Genetics*, by A. M. Winchester and P. J. Wejksnora, University of Wisconsin-Milwaukee, is an up-to-date, practical manual. It features classical and molecular biology exercises that give students the opportunity to apply the scientific method to "real"—not simulated—lab investigations. (ISBN 12287-5)
- *How Scientists Think*, by George B. Johnson, is a concise, illustrated book that presents discussions of twenty-one classic genetics and molecular biology experiments. It is an intriguing way to foster critical thinking and reinforce the scientific method in a genetics course. (ISBN 27875-1)
- *Genetics Problem-Solving Guide*, by William Wellnitz, is a companion guide that systematically walks students through the logical steps involved in solving genetics problems. (ISBN 13739-2)
- *Compendium of Problems in Genetics*, by John Kuspira and Ramesh Bhambhani, University of Alberta, includes logical, illustrated exercises—including many based on actual experimental data from classic papers—for students at basic and advanced levels. (ISBN 16734-8)
- *Case Workbook in Human Genetics*, by Ricki Lewis, SUNY-Albany, includes thought-provoking case studies in human genetics, with many examples gleaned from the author's experiences as a practicing genetics counselor. (ISBN 22287-X)
- *GenPak: Computer-Assisted Academic Programs in Genetics*, by Tully Turney, Hampden-Sydney College, is a Macintosh hypercard program featuring interactive, problem-solving exercises in Mendelian, molecular, and population genetics. (ISBN 17370-4)

Acknowledgments

I would like to thank many people for their encouragement and assistance in the production of this fifth edition. I especially thank Robin Steffek, my Developmental Editor, for continuous support, enthusiasm, and help in improving the usability of the text. In addition, Liz Sievers, my Project Editor, provided much help in moving this revision along. It was also a pleasure to work with many other dedicated and creative people during the production of this book, especially Sue Dillon, Laura Beaudoin, and Charlotte Goldman. Several colleagues of mine at Boston University were especially

generous with their information and comments, notably Ed Loechler, Tom Gilmore, Gail Patt, Gary Jacobson, Dean Tolan, and John Celenza. I also wish to thank Mike Gaines of the University of Miami for many helpful comments. Many reviewers greatly helped improve the quality of this edition. I specifically wish to thank the following:

Reviewers of the Fifth Edition

W. Keith Hartberg
Baylor University
William A. Thomas
Colby-Sawyer College
William R. Wellnitz
Augusta College
W. Ralph Andersen
Brigham Young University
Todd Stanislav
Xavier University of Louisiana
Jeffrey J. Byrd
St. Mary's College of Maryland
Ronald L. Frank
University of Missouri-Rolla
David G. Futch
San Diego State University
Michael A. Goldman, Ph.D.
San Francisco State University
Paul Goldstein
University of Texas at El Paso
Lawrence Hale
University of Prince Edward Island
Dr. Deborah Rochefort
Shepherd College
Gail R. Patt
Boston University
Ken Zwicker
Banner & Allegretti, Ltd.

Reviewers of the Fourth Edition

Charles H. Green
Rowan College of New Jersey
LaJoyce H. Debro
Jacksonville State University
Larry R. Eckroat
Penn State Erie-The Behrend College
Wade N. Hazel
DePauw University

Carol Ann Rush
La Roche College
John W. Schiefelbein
University of Michigan
David E. Sheppard
University of Delaware
William R. Wellnitz
Augusta College
W. Keith Hartberg
Baylor University
Austin L. Hughes
Penn State-University
R. L. Bernstein
San Francisco State University

Susan Lovett
Brandeis University
Ammini S. Moorthy
Wagner College

Special recognition is also due to Dr. Michael Goldman of SFSU for his suggestions in revising chapter 15.

Lastly, thanks are due to the many students, particularly those in my Introductory Genetics, Population Biology, and Graduate Seminar courses, who have helped clarify points, find errors, and discover new and interesting ways of looking at the many topics collectively called genetics.

Robert H. Tamarin
Boston