

A vibrant, close-up photograph of a large number of butterflies, primarily in shades of green and yellow, with some black and white patterns. They are clustered together on lush green foliage, creating a textured and colorful background. A small white rectangular label is visible in the top left corner.

GENETICS

D. Peter Snustad • Michael J. Simmons

Sixth Edition

International Student Version

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SIXTH EDITION

International Student Version

D. Peter Snustad

University of Minnesota

Michael J. Simmons

University of Minnesota



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Dedications

To Judy, my wife and best friend.
D.P.S.

To my family, especially to Benjamin.
M.J.S.

About the Authors

D. Peter Snustad is a Professor Emeritus at the University of Minnesota, Twin Cities. He received his B.S. degree from the University of Minnesota and his M.S. and Ph.D. degrees from the University of California, Davis. He began his faculty career in the Department of Agronomy and Plant Genetics at Minnesota in 1965, became a charter member of the new Department of Genetics in 1966, and moved to the Department of Plant Biology in 2000. During his 43 years at Minnesota, he taught courses ranging from general biology to biochemical genetics. His initial research focused on the interactions between bacteriophage T4 and its host, *E. coli*. In the 1980s, his research switched to the cytoskeleton of *Arabidopsis* and the glutamine synthetase genes of corn. His honors include the Morse-Amoco and Dagley Memorial teaching awards and election to Fellow of the American Association for the Advancement of Science. A lifelong love of the Canadian wilderness has kept him in nearby Minnesota.

Michael J. Simmons is a Professor in the Department of Genetics, Cell Biology and Development at the University of Minnesota, Twin Cities. He received his B.A. degree in biology from St. Vincent College in Latrobe, Pennsylvania, and his M.S. and Ph.D. degrees in genetics from the University of Wisconsin, Madison. Dr. Simmons has taught a variety of courses, including genetics and population genetics. He has also mentored many students on research projects in his laboratory. Early in his career he received the Morse-Amoco teaching award from the University of Minnesota in recognition of his contributions to undergraduate education. Dr. Simmons's research focuses on the genetic significance of transposable elements in the genome of *Drosophila melanogaster*. He has served on advisory committees at the National Institutes of Health and was a member of the Editorial Board of the journal *Genetics* for 21 years. One of his favorite activities, figure skating, is especially compatible with the Minnesota climate.

Preface

The science of genetics has been evolving rapidly. The DNA of genomes, even large ones, can now be analyzed in great detail; the functions of individual genes can be studied with an impressive array of techniques; and organisms can be changed genetically by introducing alien or altered genes into their genomes. The ways of teaching and learning genetics have also been changing. Electronic devices to access and transmit information are ubiquitous; engaging new media are being developed; and in many colleges and universities, classrooms are being redesigned to incorporate “active learning” strategies. This edition of *Genetics* has been created to recognize these scientific and educational advances.

Goals

Genetics balances new information with foundational material. In preparing this edition, we have been guided by four main goals:

- **To focus on the basic principles of genetics** by presenting the important concepts of classical, molecular, and population genetics carefully and thoroughly. We believe that an understanding of current advances in genetics and an appreciation for their practical significance must be based on a strong foundation. Furthermore, we believe that the breadth and depth of coverage in the different areas of genetics—classical, molecular, and population—must be balanced, and that the ever-growing mass of information in genetics must be organized by a sturdy—but flexible—framework of key concepts.
- **To focus on the scientific process** by showing how scientific concepts develop from observation and experimentation. Our book provides numerous examples to show how genetic principles have emerged from the work of different scientists. We emphasize that science is an ongoing process of observation, experimentation, and discovery.
- **To focus on human genetics** by incorporating human examples and showing the relevance of genetics to societal issues. Experience has shown us that students are keenly interested in the genetics of their own species. Because of this interest, they find it easier to comprehend complex concepts when these concepts are illustrated with human examples. Consequently, we have used human examples to illustrate genetic principles wherever possible. We have also included discussions of the Human Genome Project, human gene mapping, genetic disorders, gene therapy, and genetic counseling throughout the text. Issues such as genetic screening, DNA profiling, genetic engineering, cloning, stem cell research, and gene therapy have sparked vigorous debates about the social, legal, and ethical ramifications of genetics. We believe that it is important to involve students in discussions about these issues, and we hope that this textbook will provide students with the background to engage in such discussions thoughtfully.
- **To focus on developing critical thinking skills** by emphasizing the analysis of experimental data and problems. Genetics has always been a bit different from other disciplines in biology because of its heavy emphasis on problem solving. In this text, we have fleshed out the analytical nature of genetics in many ways—in the development of principles in classical genetics, in the discussion of experiments in molecular genetics, and in the presentation of calculations in population genetics. Throughout the book we have emphasized the integration of observational and experimental evidence with logical analysis in the development of key concepts. Each chapter has two sets of worked-out problems—the *Basic Exercises*

section, which contains simple problems that illustrate basic genetic analysis, and the *Testing Your Knowledge* section, which contains more complex problems that integrate different concepts and techniques. A set of *Questions and Problems* follows the worked-out problems so that students can enhance their understanding of the concepts in the chapter and develop their analytical skills. Each chapter also has a *Problem-Solving Skills* feature, which poses a problem, lists the pertinent facts and concepts, and then analyzes the problem and presents a solution.

Content and Organization of the Sixth Edition

The organization of this edition of *Genetics* is similar to that of the previous edition. However, the content has been sifted and winnowed to allow thoughtful updating. In selecting material to be included in this edition of *Genetics*, we have tried to be comprehensive but not encyclopedic.

The text comprises 24 chapters—one less than the previous edition. Chapters 1–2 introduce the science of genetics, basic features of cellular reproduction, and some of the model genetic organisms; Chapters 3–8 present the concepts of classical genetics and the basic procedures for the genetic analysis of microorganisms; Chapters 9–13 present the topics of molecular genetics, including DNA replication, transcription, translation, and mutation; Chapters 14–17 cover more advanced topics in molecular genetics and genomics; Chapters 18–21 deal with the regulation of gene expression and the genetic basis of development, immunity, and cancer; Chapters 22–24 present the concepts of quantitative, population, and evolutionary genetics.

As in previous editions, we have tried to create a text that can be adapted to different course formats. Many instructors prefer to present the topics in much the same way as we have, starting with classical genetics, progressing into molecular genetics, and finishing with quantitative, population, and evolutionary genetics. However this text is constructed so that teachers can present topics in different orders. They may, for example, begin with basic molecular genetics (Chapters 9–13), then present classical genetics (Chapters 3–8), progress to more advanced topics in molecular genetics (Chapters 14–21), and finish the course with quantitative, population, and evolutionary genetics (Chapters 22–24). Alternatively, they may wish to insert quantitative and population genetics between classical and molecular genetics.

Pedagogy of the Sixth Edition

The text includes special features designed to emphasize the relevance of the topics discussed, to facilitate the comprehension of important concepts, and to assist students in evaluating their grasp of these concepts.

- **Chapter-Opening Vignette.** Each chapter opens with a brief story that highlights the significance of the topics discussed in the chapter.
- **Chapter Outline.** The main sections of each chapter are conveniently listed on the chapter's first page.
- **Section Summary.** The content of each major section of text is briefly summarized at the beginning of that section. These opening summaries focus attention on the main ideas developed in a chapter.
- **Key Points.** These learning aids appear at the end of each major section in a chapter. They are designed to help students review for exams and to recapitulate the main ideas of the chapter.
- **Focus On Boxes.** Throughout the text, special topics are presented in separate *Focus On* boxes. The material in these boxes supports or develops concepts, techniques, or skills that have been introduced in the text of the chapter.

- ***On the Cutting Edge Boxes.*** The content of these boxes highlights exciting new developments in genetics—often the subject of ongoing research.
- ***Problem-Solving Skills Boxes.*** Each chapter contains a box that guides the student through the analysis and solution of a representative problem. We have chosen a problem that involves important material in the chapter. The box lists the facts and concepts that are relevant to the problem, and then explains how to obtain the solution. Ramifications of the problem and its analysis are discussed in the Student Companion site.
- ***Basic Exercises.*** At the end of each chapter we present several worked-out problems to reinforce each of the fundamental concepts developed in the chapter. These simple, one-step exercises are designed to illustrate basic genetic analysis or to emphasize important information.
- ***Testing Your Knowledge.*** Each chapter also has more complicated worked-out problems to help students hone their analytical and problem-solving skills. The problems in this section are designed to integrate different concepts and techniques. In the analysis of each problem, we walk the students through the solution step by step.
- ***Questions and Problems.*** Each chapter ends with a set of questions and problems of varying difficulty organized according to the sequence of topics in the chapter. The more difficult questions and problems have been designated with colored numbers. These sets of questions and problems provide students with the opportunity to enhance their understanding of the concepts covered in the chapter and to develop their analytical skills.
- ***Appendices.*** Each Appendix presents technical material that is useful in genetic analysis.
- ***Glossary.*** This section of the book defines important terms. Students find it useful in clarifying topics and in preparing for exams.
- ***Answers.*** Answers to the odd-numbered Questions and Problems are given at the end of the text.

ONLINE RESOURCES

BOOK COMPANION WEB SITE

www.wiley.com/go/global/snustad

This text-specific Web site provides students with additional resources and extends the chapters of the text to the resources of the World Wide Web. Resources include:

TEST BANK

The test bank is available on the Instructor Companion site and contains approximately 50 test questions per chapter. It is available online as MS Word files and as a computerized test bank. This easy-to-use test-generation program fully supports graphics, print tests, student answer sheets, and answer keys. The software's advanced features allow you to produce an exam to your exact specifications.

LECTURE POWERPOINT PRESENTATIONS

Highly visual lecture PowerPoint presentations are available for each chapter and help convey key concepts illustrated by imbedded text art. The presentations may be accessed on the Instructor Companion site.

PRE AND POST LECTURE ASSESSMENT

This assessment tool allows instructors to assign a quiz prior to lecture to assess student understanding and encourage reading, and following lecture to gauge improvement and weak areas. Two quizzes are provided for every chapter.

PRACTICE QUIZZES

Available on the Student Companion site, these quizzes contain 20 questions per chapter for students to quiz themselves and receive instant feedback.

ANSWERS TO QUESTIONS AND PROBLEMS

Answers to odd-numbered Questions and Problems are located at the end of the text for easy access for students. Answers to all Questions and Problems in the text are available only to instructors on the Instructor Companion site.

ILLUSTRATIONS AND PHOTOS

All line illustrations and photos from *Genetics, 6th Edition*, are available on the Instructor Companion site in both jpeg files and PowerPoint format. Line illustrations are enhanced to provide the best presentation experience.

Acknowledgments

As with previous editions, this edition of *Genetics* has been influenced by the genetics courses we teach. We thank our students for their constructive feedback on both content and pedagogy, and we thank our colleagues at the University of Minnesota for sharing their knowledge and expertise. Genetics professors at other institutions also provided many helpful suggestions. In particular, we acknowledge the help of the following reviewers:

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Jennifer Dearden and Lauren Morris helped with many of the logistical details in preparing this edition, and Lisa Passmore researched and obtained many new photographs. Jennifer MacMillan, Senior Photo Editor, skillfully coordinated the entire photo program. We are grateful for all their contributions. We thank Maureen Eide, Senior Designer, for creating a fresh text layout, and we thank Precision Graphics and Aptara for executing the illustrations. Elizabeth Swain, Senior Production Editor, superbly coordinated the production of this edition, Betty Pessagno faithfully copyedited the manuscript, Lilian Brady did the final proofreading, and Stephen Ingle prepared the index. We deeply appreciate the excellent work of all these people. We also thank Clay Stone, Executive Marketing Manager, for helping to get this edition into the hands of prospective users. With an eye toward the next edition, we encourage students, teaching assistants, instructors, and other readers to send us comments on this edition in care of Jennifer Dearden at John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ, 07030.

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