

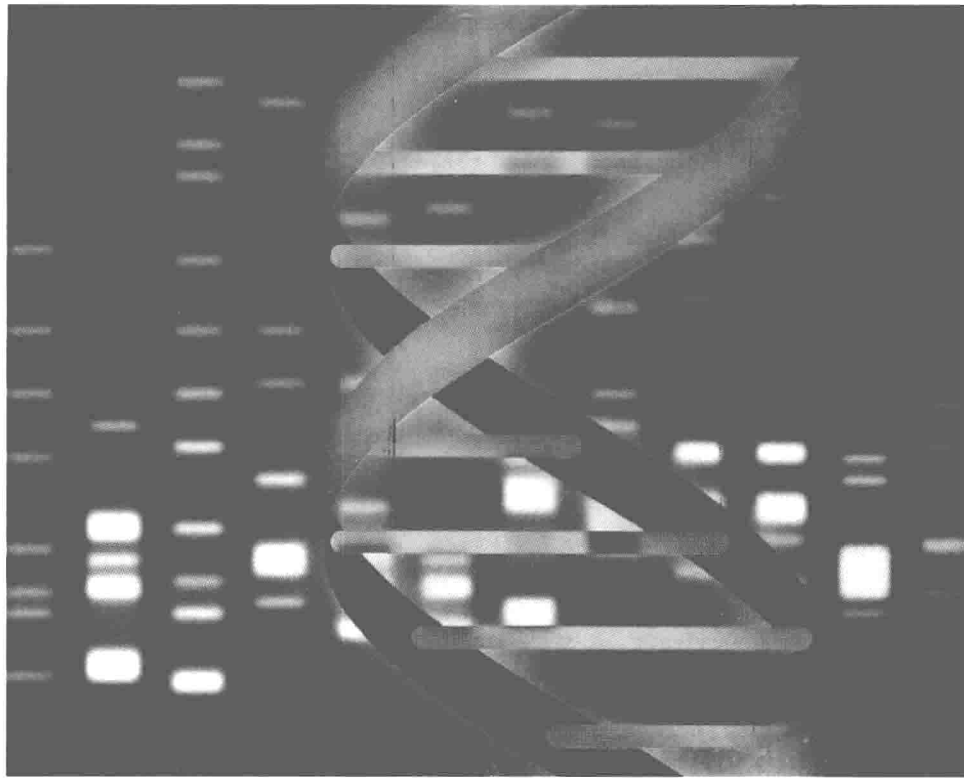


ESSENTIALS *of* GENETICS

FIFTH EDITION

WILLIAM S. KLUG
MICHAEL R. CUMMINGS

Polytene chromosomes from the salivary gland of the fruit fly *Drosophila melanogaster*, subjected to comparative immunofluorescent analysis.



ESSENTIALS OF GENETICS

William S. Krag
The College of New Jersey

Michael R. Cummings
University of Illinois at Chicago

With contributions by
Jon Herron, University of Washington
Charlotte Spencer, University of Alberta
Sara Ward, Colorado State University



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DEDICATION

*For geneticists, it is much about siblings and offspring.
Ours are the best and very special.*

To Sallie and Mike, and to Cindy, Braden, and Dori

To Mark and Kathleen, and to Brendan and Kerry

WSK

MRC

ABOUT THE AUTHORS

WILLIAM S. KLUG is currently a Professor of Biology at The College of New Jersey (formerly Trenton State College) in Ewing, New Jersey. He served as Chair of the Biology Department for 17 years, a position to which he was first elected in 1974. He received his B.A. degree in Biology from Wabash College in Crawfordsville, Indiana, and his Ph.D. from Northwestern University in Evanston, Illinois. Prior to coming to The College of New Jersey, he was on the faculty of Wabash College as an Assistant Professor, where he first taught genetics, as well as general biology and electron microscopy. His research interests have involved ultrastructural and molecular genetic studies of oogenesis in *Drosophila*. He has taught the genetics course as well as the senior capstone seminar course in human and molecular genetics to undergraduate biology majors for each of the last 35 years. He was the recent recipient of the first annual teaching award given at The College of New Jersey granted to the faculty member who most challenges students to achieve high standards.

MICHAEL R. CUMMINGS is currently an Associate Professor in the Department of Biological Sciences and in the Department of Molecular Genetics at the University of Illinois at Chicago. He has also served on the faculty at Northwestern University and Florida State University. He received his B.A. from St. Mary's College in Winona, Minnesota, and his M.S. and Ph.D. from Northwestern University in Evanston, Illinois. He has also written textbooks in human genetics and general biology for nonmajors. His research interests center on the molecular organization and physical mapping of human acrocentric chromosomes. At the undergraduate level, he teaches courses in Mendelian genetics, human genetics, and general biology for nonmajors. He has received numerous teaching awards given by the university and by student organizations.

Essentials of Genetics is written for courses requiring a text that is shorter and more basic than its more comprehensive companion, *Concepts of Genetics*. While coverage is thorough, current, and of high quality, *Essentials* is written to be more accessible to biology majors early in their undergraduate careers, as well as to students majoring in agriculture, chemistry, engineering, forestry, psychology, or wildlife management. Because the text is shorter than many other books, *Essentials of Genetics* will also be more manageable in one-quarter and one-semester courses.

Goals

Although *Essentials of Genetics* is almost 300 pages shorter than its companion volume, our goals during revision are the same for both books. Specifically, we seek to

- Emphasize concepts rather than excessive detail.
- Write clearly and directly to students in order to provide understandable explanations of complex analytical topics.
- Establish careful organization within and between chapters.
- Maintain constant emphasis on scientific analysis as the means to illustrate the nature of scientific discovery.
- Propagate the rich history of genetics that so beautifully illustrates how information is acquired and extended within the discipline as it develops and grows.
- Emphasize problem solving, thereby guiding students to think analytically and to apply and extend their knowledge of genetics.

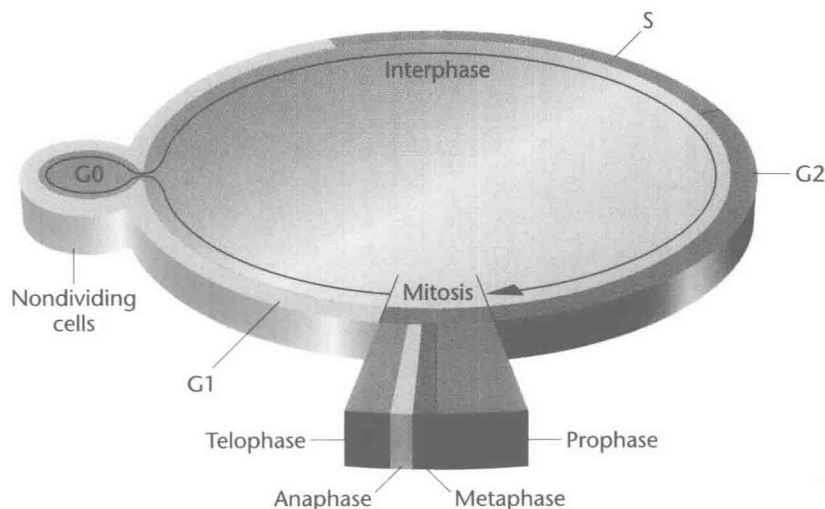
- Provide the most modern and up-to-date coverage of this exciting field.
- Include whole chapters that provide comprehensive coverage of topics at the cutting edge of genetics.
- Create inviting, engaging, and pedagogically useful full-color figures enhanced by equally helpful photographs to support concept development.
- Provide outstanding On-line Media Tutorials where students are guided in their understanding of important concepts by working through the best animations, tutorial exercises, and self-assessment tools available.

These goals serve as the cornerstones of *Essentials of Genetics*. This pedagogic foundation allows the book to accommodate courses with many different approaches and lecture formats. Chapters are written to be as independent of one another as possible, allowing instructors to utilize them in various sequences. We believe that the varied approaches embodied in these goals work together to provide students with optimal support for their study of genetics.

Features New to the Fifth Edition

This edition has several new features that continue to make *Essentials of Genetics* the most distinctive and pedagogically useful textbook available to students of genetics, including:

- **How Do We Know What We Know?** This is a new feature found at the end of the introduction in each chapter. Based on a modern approach to teaching biology referred to as “Science as a way of Knowing,” this section asks



the student to be aware of the most important issues that have framed our thinking and to constantly ask themselves how we discovered this information. We believe that this approach, which has always been pursued in the text of each chapter but is now formalized, will enhance students' understanding of the topics covered in each chapter. The ideas behind this approach are explained in Chapter 1, and the execution begins in Chapter 2.

- **New Problems** Over 300 new problems, many based on research data derived from the literature of genetics, have been added to chapters throughout the text. Students will find in excess of 30 Problems and Discussion Questions at the end of almost all of the chapters. As in past editions, solutions appear in the *Student Handbook and Solutions Manual*.
- **Extranuclear Inheritance** Formal coverage, absent from recent editions, has been returned to this edition. This topic is covered in Chapter 4, "Modification of Mendelian Ratios", and Chapter 12, "Chromosome Structure and DNA Sequence Organization."
- **New Genetics, Technology, and Society Essays** Six new topics have been added to this edition.

A Question of Gender: Sex Selection in Humans (Chapter 5) looks at the future of this controversial topic.

Why Is There No Effective HIV Vaccine? (Chapter 16) explores the immunological aspects of AIDS.

Footprints of a Killer (Chapter 18) examines our attempts to genetically identify anthrax strains.

Gene Therapy—Two Steps Forward or Two Steps Back (Chapter 19) examines why this approach has yet to reach its full potential in curing genetic diseases.

Stem Cell Wars (Chapter 20) examines the issues surrounding the use of these undifferentiated cells.

Tracking Our Genetic Footprints out of Africa (Chapter 22) explores human origins.

- **Revised Genetics, Technology, and Society Essays** In addition to the new essays, five existing essays have been updated.

The Twists and Turns of the Helical Revolution (Chapter 10)

Antisense Oligonucleotides: Attacking the Messenger (Chapter 13)

Mad Cows and Heresies: The Prion Story (Chapter 14)

Beyond Dolly: The Cloning of Humans (Chapter 17)

Gene Pools and Endangered Species: The Plight of the Florida Panther (Chapter 24)

- **Conversion of Major Headings to a Narrative Style** To better summarize the main point of each major section in the book, we have converted the headings to narrative statements rather than descriptive phrases.

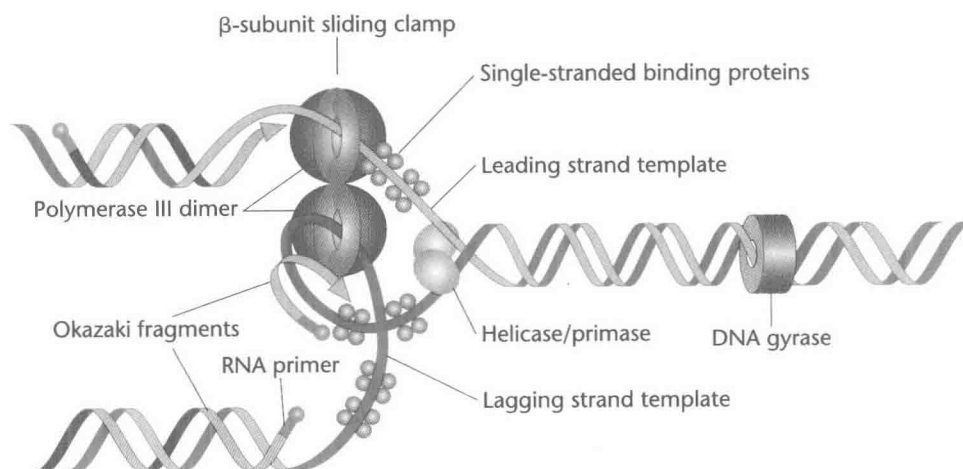
Continued Emphasis on Concepts

As in its companion volume, *Essentials of Genetics* continues to emphasize the conceptual framework of genetics. Our experience with this approach shows that students more easily comprehend and take with them to succeeding courses the most important ideas in genetics as well as an analytic view of biological problems. To aid students in identifying conceptual aspects of a major topic, each chapter begins with Chapter Concepts, the set of narrative descriptions of each major section within the chapter. Then, each chapter ends with a Chapter Summary, which enumerates the five to ten key points that have been covered. These two features help to ensure that students focus on concepts and are not distracted by the many, albeit important, details of genetics. Specific examples and carefully designed figures support this approach throughout the book.

Insights and Solutions

Genetics, more than any other discipline within biology, requires problem solving and analytical thinking. At the end of many chapters we include what has become an extremely popular and successful section called Insights and Solutions. In this section we stress:

- Problem solving
- Quantitative analysis



- Analytical thinking
- Experimental rationale

Problems or questions are posed, and detailed solutions or answers are provided. This feature primes students as they move on to the Problems and Discussion Questions that conclude each chapter.

Problems and Discussion Questions

Each chapter ends with an extensive collection of problems and discussion questions that optimize the opportunities for student growth in the important areas of problem solving and analytical thinking. Various levels of difficulty are presented, with the most challenging problems located at the end of each section. Brief answers to half of the problems are in Appendix A. The *Student Handbook and Solutions Manual* is available for faculty who wish to expose their students to detailed answers to all problems and questions. As mentioned above, we have greatly expanded the number of these problems, particularly those that are more challenging and those involving data analysis, so almost every chapter has at least 30 entries.

Acknowledgments

All comprehensive texts are dependent upon the valuable input provided by many colleagues. While we take full responsibility for any errors in this book, we gratefully acknowledge the help provided by those individuals who reviewed or otherwise contributed to the content and pedagogy of this and previous editions.

In particular, we thank Sarah Ward at Colorado State University for creating and revising Chapter 24, “Conservation Genetics.” We are grateful for the valuable contributions of Charlotte Spencer at the Cross Cancer Institute at the University of Alberta, who wrote and or revised most of the Genetics, Technology, and Society essays. We thank Mark Shotwell at Slippery Rock University for his contribution of several other essays. We also much appreciate the careful attention and dedication provided by Arlene Larson at the University of Colorado, Denver, and Laura Runyen-Janecky at the University of Richmond, as they proofread the entire final manuscript. And, as always, it has been a pleasure working with Harry Nickla at Creighton U. who has served many roles during the production of this text. Finally, we are pleased to have received input from many genetics colleagues during their reviews of *Essentials of Genetics*:

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 David Kass, Eastern Michigan University
 Beth A. Krueger, Monroe Community College
 M. A. Lachance, University of Western Ontario
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 Dan Panaccione, West Virginia University
 Todd Rimkus, Marymount University
 Laura Runyen-Janecky, University of Richmond
 Tom Savage, Oregon State University
 Gerald Schlink, Missouri Southern State College
 Randy Scholl, Ohio State University
 Malcolm Schug, University of North Carolina, Greensboro
 Ralph Seelke, University of Wisconsin, Superior
 Gurel S. Sidhu, California State University
 Theresa Spradling, University of Northern Iowa
 Mark Sturtevant, Northern Arizona University
 Christine Tachibana, University of Washington
 Daniel Wang, University of Miami
 R. C. Woodruff, Bowling Green State University
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For the Student

Online Media Tutorials

The most sophisticated learning and tutorial package available for students of genetics, these on-line tutorials address the concepts that students find most difficult. Each of the 44 tutorials is composed of several animations and interactive exercises, along with a post-tutorial quiz of self-grading questions to reinforce the important concepts. Found on the Student Web Site, the tutorials offer timely and relevant support for students. Look for this icon in the margin of this page to identify media tutorials that support concepts presented in the textbook.

Student Handbook and Solutions Manual

Harry Nickla, Creighton University
(0-13-143524-8)

Completely reviewed and checked for accuracy, this valuable handbook provides a detailed step-by-step solution or extended discussion for every problem in the text in a chapter-by-chapter format. The handbook also contains extra study problems and a thorough review of the concepts and vocabulary.

The New York Times Themes of the Times: Genetics and Molecular Biology

Coordinated by Harry Nickla, Creighton University
This exciting newspaper-format supplement brings together recent genetics and molecular biology articles from the pages of the highly respected *New York Times*. This free supplement, available through your local representative, encourages students to make the connections between genetics concepts and the latest research and breakthroughs in the field

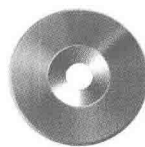
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For the Instructor

Instructor's Resource Center on CD-ROM



For adopters of *Essentials, Fifth Edition*, the Instructor's Resource Center on CD-ROM (IRC) contains

- Presentation art PowerPoints for each chapter
- Personal Response System PowerPoints for each chapter
- Image files (all illustrations, all tables, and many photographs)
- Instructor's Manual
- Test item file for each chapter (easily customized)
- 44 Web Tutorials exploring the most challenging material in genetics
- ~200 Animations and Interactive Exercises presenting key concepts in genetics
- Glossary of genetic terms
- Link to the Student Web Site for OneKey

Instructors will be able to coordinate lecture presentations with text content, knowing that students will be studying using the same animated tutorials, images, and review material.

Instructor's Resource Manual with Tests

Harry Nickla, Creighton University
(0-13-143511-6)

This manual with tests contains over 1000 questions and problems an instructor can use to prepare exams. The manual also provides optional course sequences, a guide to audio-visual supplements, and a section on searching the Web.

TestGen-EQ

(0-13-143514-0)

This text-specific testing program is networkable for administering tests. It also allows you to edit existing test items or add your own questions to create a nearly unlimited number of quizzes and tests.

Transparencies

(0-13-143513-2)

Two hundred figures from the text are included in the transparency package: 150 four-color transparencies from the text plus 50 transparency masters. The font size of the labels has been increased for easy viewing from the back of the classroom.

OneKey

OneKey offers the best teaching and learning resources all in one place. Conveniently organized by textbook chapter, these compiled resources

help you save time and help your students reinforce and apply what they have learned in class. The student media program in OneKey includes web tutorials, self-grading quizzes, problems and discussion, and much more.

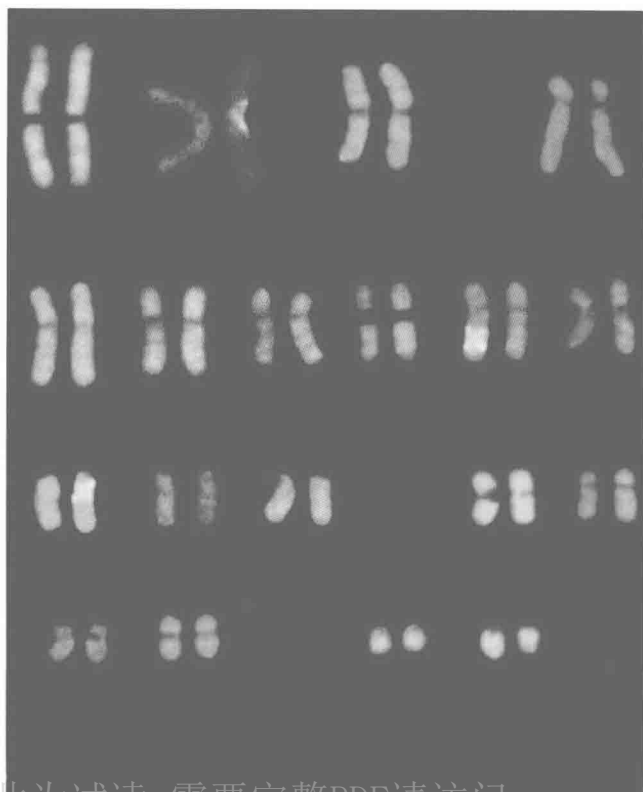
Course Management Tools

If your campus is currently an adopter of either the WebCT or Blackboard course management environment, you can use our pre-formatted cartridges to help you get a jump-start building your course.

WebCT**Blackboard**

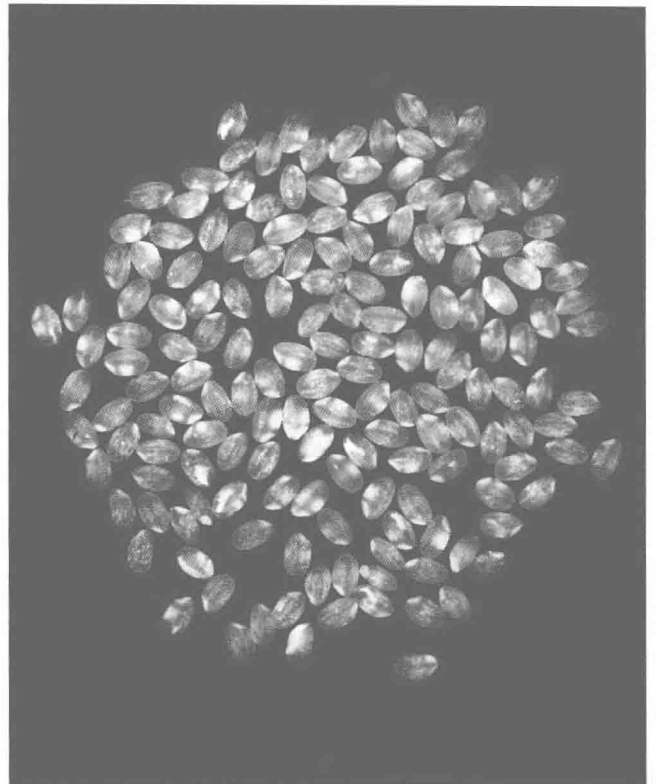
Both of these options include all the on-line study opportunities and multimedia resources that accompany *Essentials of Genetics, Fifth Edition*. Extensive on-line support and information is provided to help you more effectively build, customize, and manage your on-line course.

- 1 An Introduction to Genetics 1
- 2 Mitosis and Meiosis 17
- 3 Mendelian Genetics 38
- 4 Modification of Mendelian Ratios 60
- 5 Sex Determination and Sex Chromosomes 92
- 6 Quantitative Genetics 113
- 7 Chromosome Mutations: Variation in Number and Arrangement 133
- 8 Linkage and Chromosome Mapping in Eukaryotes 156



- 9 Mapping in Bacteria and Bacteriophages 182
- 10 DNA Structure and Analysis 205
- 11 DNA—Replication and Synthesis 231
- 12 Chromosome Structure and DNA Sequence Organization 253
- 13 The Genetic Code and Transcription 272
- 14 Translation and Proteins 295
- 15 Gene Mutation, DNA Repair, and Transposable Elements 322

- 16** Regulation of Gene Expression 352
- 17** Recombinant DNA Technology 377
- 18** Genomics, Bioinformatics, and Proteomics 401
- 19** Applications and Ethics of Biotechnology 433
- 20** Genes and Development 460
- 21** The Genetic Basis of Cancer 480
- 22** Population Genetics 501
- 23** Genetics and Evolution 528
- 24** Conservation Genetics 552



PREFACE xiv

CHAPTER 1

An Introduction to Genetics 1

- 1.1 Genetics Has a Rich and Interesting History 2
- 1.2 Nucleic Acids and Proteins Serve as the Molecular Basis of Genetics 6
- 1.3 Genetics Has Been Investigated Using Many Different Approaches 8
- 1.4 Genetics Has a Profound Impact on Society 10

GENETICS, TECHNOLOGY, AND SOCIETY

The Frankenfood Debates: Genetically Modified Foods 14

Chapter Summary 15

Key Terms 15

Problems and Discussion Questions 15

Selected Readings 16

CHAPTER 2

Mitosis and Meiosis 17

- 2.1 Cell Structure Is Closely Tied to Genetic Function 18
- 2.2 Chromosomes Exist in Homologous Pairs in Diploid Organisms 20
- 2.3 Mitosis Partitions Chromosomes into Dividing Cells 22
- 2.4 The Cell Cycle Is Genetically Regulated 26
- 2.5 Meiosis Reduces the Chromosome Number from Diploid to Haploid in Germ Cells and Spores 27
- 2.6 The Development of Gametes Varies During Spermatogenesis and Oogenesis 31
- 2.7 Meiosis Is Critical to the Successful Sexual Reproduction of All Diploid Organisms 32
- 2.8 Electron Microscopy Has Revealed the Cytological Nature of Mitotic and Meiotic Chromosomes 32

Chapter Summary 34

Key Terms 34

Insights and Solutions 35

Problems and Discussion Questions 36

Selected Readings 37

CHAPTER 3

Mendelian Genetics 38

- 3.1 Mendel Used a Model Experimental Approach to Study Patterns of Inheritance 39
- 3.2 The Monohybrid Cross Reveals How One Trait Is Transmitted from Generation to Generation 40
- 3.3 Mendel's Dihybrid Cross Generated a Unique F₂ Ratio 43
- 3.4 The Trihybrid Cross Demonstrates that Mendel's Principles Apply to Inheritance of Multiple Traits 46
- 3.5 Mendel's Work Was Rediscovered in the Early Twentieth Century 47
- 3.6 Independent Assortment Leads to Extensive Genetic Variation 49
- 3.7 Laws of Probability Help to Explain Genetic Events 49

How Mendel's Peas Become Wrinkled:

A Molecular Explanation 49

- 3.8 Chi-Square Analysis Evaluates the Influence of Chance on Genetic Data 50
- 3.9 Pedigrees Reveal Patterns of Inheritance in Humans 52

Chapter Summary 54

Key Terms 54

Insights and Solutions 54

Problems and Discussion Questions 56

Selected Readings 59

CHAPTER 4

Modification of Mendelian Ratios 60

- 4.1 Alleles Alter Phenotypes in Different Ways 61
- 4.2 Geneticists Use a Variety of Symbols for Alleles 62
- 4.3 Neither Allele Is Dominant in Incomplete, or Partial, Dominance 62
- 4.4 In Codominance, the Influence of Both Alleles in a Heterozygote Is Clearly Evident 63
- 4.5 Multiple Alleles of a Gene May Exist in a Population 63
- 4.6 Lethal Alleles Represent Essential Genes 64
- 4.7 Combinations of Two Gene Pairs with Two Modes of Inheritance Modify the 9:3:3:1 Ratio 66
- 4.8 Phenotypes Are Often Affected by More than One Gene 66

- 4.9 Complementation Analysis Can Determine if Two Mutations Causing a Similar Phenotype Are Alleles 71
- 4.10 X-Linkage Describes Genes on the X Chromosome 72
- 4.11 In Sex-Limited and Sex-Influenced Inheritance, an Individual's Sex Influences the Phenotype 74
- 4.12 Phenotypic Expression Is Not Always a Direct Reflection of the Genotype 75
- 4.13 Extranuclear Inheritance Modifies Mendelian Patterns 78

GENETICS, TECHNOLOGY, AND SOCIETY

Improving the Genetic Fate of Purebred Dogs 83

Chapter Summary 84
 Key Terms 84
 Insights and Solutions 85
 Problems and Discussion Questions 86
 Selected Readings 91

CHAPTER 5

Sex Determination and Sex Chromosomes 92

- 5.1 Life Cycles Depend on Sexual Differentiation 93
- 5.2 X and Y Chromosomes Were First Linked to Sex Determination Early in the Twentieth Century 96
- 5.3 The Y Chromosome Determines Maleness in Humans 98
- 5.4 The Ratio of Males to Females in Humans Is Not 1.0 102
- 5.5 Dosage Compensation Prevents Excessive Expression of X-Linked Genes in Humans and Other Mammals 103
- 5.6 The Ratio of X Chromosomes to Sets of Autosomes Determines Sex in *Drosophila* 105
- 5.7 Temperature Variation Controls Sex Determination in Reptiles 107

GENETICS, TECHNOLOGY, AND SOCIETY

A Question of Gender: Sex Selection in Humans 108

Chapter Summary 109
 Key Terms 109
 Insights and Solutions 110
 Problems and Discussion Questions 110
 Selected Readings 112

CHAPTER 6

Quantitative Genetics 113

- 6.1 Continuous Variation Characterizes the Inheritance of Quantitative Traits 114
- 6.2 The Study of Polygenic Traits Relies on Statistical Analysis 119

- 6.3 Heritability Is a Measure of the Genetic Contribution to Phenotypic Variability 121
- 6.4 Quantitative Trait Loci Can Be Mapped 124

GENETICS, TECHNOLOGY, AND SOCIETY

The Green Revolution Revisited 126

Chapter Summary 127
 Key Terms 127
 Insights and Solutions 128
 Problems and Discussion Questions 129
 Selected Readings 132

CHAPTER 7

Chromosome Mutations: Variation in Number and Arrangement 133

- 7.1 Specific Terminology Describes Variations in Chromosome Number 134
- 7.2 Variation in the Number of Chromosomes Results from Nondisjunction 134
- 7.3 Monosomy, the Loss of a Single Chromosome, May Have Severe Phenotypic Effects 135
- 7.4 Trisomy Involves the Addition of a Chromosome to a Diploid Genome 136
- 7.5 Polyploidy, in Which More than Two Haploid Sets of Chromosomes Are Present, Is Prevalent in Plants 139
- 7.6 Variation Occurs in the Structure and Arrangement of Chromosomes 141
- 7.7 A Deletion Is a Missing Region of a Chromosome 142
- 7.8 A Duplication Is a Repeated Segment of a Chromosome 142
- 7.9 Inversions Rearrange the Linear Gene Sequence 145
- 7.10 Translocations Alter the Location of Chromosomal Segments in the Genome 146
- 7.11 Fragile Sites in Humans Are Susceptible to Chromosome Breakage 149

Chapter Summary 151
 Key Terms 151
 Insights and Solutions 152
 Problems and Discussion Questions 153
 Selected Readings 154

CHAPTER 8

Linkage and Chromosome Mapping in Eukaryotes 156

- 8.1 Genes Linked on the Same Chromosome Segregate Together 157
- 8.2 Crossing over Serves as the Basis of Determining the Distance Between Genes During Mapping 159

- 8.3 Determining the Gene Sequence During Mapping Relies on the Analysis of Multiple Crossovers 162
- 8.4 As the Distance Between Two Genes Increases, Mapping Estimates Become More Inaccurate 168
- 8.5 *Drosophila* Genes Have Been Extensively Mapped 169
- 8.6 Lod Score Analysis and Somatic Cell Hybridization Were Historically Important in Creating Human Chromosome Maps 169
- 8.7 Linkage and Mapping Studies Can Be Performed in Haploid Organisms 171
- 8.8 Other Aspects of Genetic Exchange 173
- 8.9 Did Mendel Encounter Linkage? 175

Why Didn't Gregor Mendel Find Linkage? 175

Chapter Summary 176

Key Terms 176

Insights and Solutions 176

Problems and Discussion Questions 178

Selected Readings 181

CHAPTER 9

Mapping in Bacteria and Bacteriophages 182

- 9.1 Bacteria Mutate Spontaneously and Grow at an Exponential Rate 183
- 9.2 Conjugation Is One Means of Genetic Recombination in Bacteria 184
- 9.3 Rec Proteins Are Essential to Bacterial Recombination 190
- 9.4 F Factors Are Plasmids 191
- 9.5 Transformation Is Another Process Leading to Genetic Recombination in Bacteria 191
- 9.6 Bacteriophages Are Bacterial Viruses 192
- 9.7 Transduction Is Virus-Mediated Bacterial DNA Transfer 195
- 9.8 Bacteriophages Undergo Intergenic Recombination 197

GENETICS, TECHNOLOGY, AND SOCIETY

Eradicating Cholera: Edible Vaccines 199

Chapter Summary 200

Key Terms 200

Insights and Solutions 201

Problems and Discussion Questions 202

Selected Readings 204

CHAPTER 10

DNA Structure and Analysis 205

- 10.1 The Genetic Material Must Exhibit Four Characteristics 206

- 10.2 Until 1944, Observations Favored Protein as the Genetic Material 207
- 10.3 Evidence Favoring DNA as the Genetic Material Was First Obtained During the Study of Bacteria and Bacteriophages 207
- 10.4 Indirect and Direct Evidence Supports the Concept that DNA Is the Genetic Material in Eukaryotes 211
- 10.5 RNA Serves as the Genetic Material in Some Viruses 213
- 10.6 The Structure of DNA Holds the Key to Understanding Its Function 214

Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid 219

- 10.7 Alternative Forms of DNA Exist 220
- 10.8 The Structure of RNA Is Chemically Similar to DNA, but Single-Stranded 221
- 10.9 Many Analytical Techniques Have Been Useful During the Investigation of DNA and RNA 222
- 10.10 Nucleic Acids Can Be Separated Using Electrophoresis 225

GENETICS, TECHNOLOGY, AND SOCIETY

The Twists and Turns of the Helical Revolution 226

Chapter Summary 227

Key Terms 227

Insights and Solutions 228

Problems and Discussion Questions 228

Selected Readings 230

CHAPTER 11

DNA—Replication and Synthesis 231

- 11.1 DNA Is Reproduced by Semiconservative Replication 232
- 11.2 DNA Synthesis in Bacteria Involves Three Polymerases, as Well as Other Enzymes 236
- 11.3 Many Complex Issues Must Be Resolved During DNA Replication 238
- 11.4 A Coherent Model Summarizes DNA Replication 241
- 11.5 Replication Is Controlled by a Variety of Genes 242
- 11.6 Eukaryotic DNA Synthesis Is Similar to, but More Complex than, Synthesis in Prokaryotes 242
- 11.7 The Ends of Linear Chromosomes Are Problematic During Replication 244
- 11.8 DNA Recombination, Like DNA Replication, Is Directed by Specific Enzymes 245

GENETICS, TECHNOLOGY, AND SOCIETY

Telomerase: The Key to Immortality? 248

Chapter Summary 249

Key Terms 249

Insights and Solutions 250

Problems and Discussion Questions 250

Selected Readings 251

CHAPTER 12**Chromosome Structure and DNA
Sequence Organization 253**

- 12.1 Viral and Bacterial Chromosomes Are Relatively Simple DNA Molecules 254
- 12.2 Mitochondria and Chloroplasts Contain DNA Similar to Bacteria and Viruses 255
- 12.3 Specialized Chromosomes Reveal Variations in the Organization of DNA 258
- 12.4 DNA Is Organized into Chromatin in Eukaryotes 260
- 12.5 Eukaryotic Genomes Demonstrate Complex Sequence Organization Characterized by Repetitive DNA 264
- 12.6 The Vast Majority of a Eukaryotic Genome Does Not Encode Functional Genes 267

Chapter Summary 267

Key Terms 268

Insights and Solutions 268

Problems and Discussion Questions 269

Selected Readings 271

CHAPTER 13**The Genetic Code and
Transcription 272**

- 13.1 The Genetic Code Exhibits a Number of Characteristics 273
- 13.2 Early Studies Established the Basic Operational Patterns of the Code 274
- 13.3 Studies by Nirenberg, Matthaei, and Others Deciphered the Code 274
- 13.4 The Coding Dictionary Reveals the Function of the 64 Triplets 278
- 13.5 The Genetic Code Has Been Confirmed in Studies of Bacteriophage MS2 279
- 13.6 The Genetic Code Is Nearly Universal 280
- 13.7 Transcription Synthesizes RNA on a DNA Template 280
- 13.8 RNA Polymerase Directs RNA Synthesis 281
- 13.9 Transcription in Eukaryotes Differs from Prokaryotic Transcription in Several Ways 282
- 13.10 The Coding Regions of Eukaryotic Genes Are Interrupted by Intervening Sequences 285
- 13.11 RNA Editing Modifies the Final Transcript 288

GENETICS, TECHNOLOGY, AND SOCIETY

Antisense Oligonucleotides: Attacking the Messenger 289

Chapter Summary 290

Key Terms 290

Insights and Solutions 291

Problems and Discussion Questions 291

Selected Readings 294

CHAPTER 14**Translation and Proteins 295**

- 14.1 Translation of mRNA Depends on Ribosomes and Transfer RNAs 296
- 14.2 Translation of mRNA Can Be Divided into Three Steps 299
- 14.3 Crystallographic Analysis Has Revealed Many Details About the Functional Prokaryotic Ribosome 303
- 14.4 Translation Is More Complex in Eukaryotes 303
- 14.5 The Initial Insight that Proteins Are Important in Heredity Was Provided by the Study of Inborn Errors of Metabolism 304
- 14.6 Studies of *Neurospora* Led to the One-Gene: One-Enzyme Hypothesis 305
- 14.7 Studies of Human Hemoglobin Established that One Gene Encodes One Polypeptide 307
- 14.8 The Nucleotide Sequence of a Gene and the Amino Acid Sequence of the Corresponding Protein Exhibit Colinearity 309
- 14.9 Protein Structure Is the Basis of Biological Diversity 309
- 14.10 Posttranslational Modification Alters the Final Protein Product 312
- 14.11 Protein Function Is Directly Related to the Structure of the Molecule 313
- 14.12 Proteins Consist of Functional Domains 314

GENETICS, TECHNOLOGY, AND SOCIETY

Mad Cows and Heresies: The Prion Story 316

Chapter Summary 317

Key Terms 317

Insights and Solutions 318

Problems and Discussion Questions 318

Selected Readings 320

CHAPTER 15**Gene Mutation, DNA Repair, and
Transposable Elements 322**

- 15.1 Mutations May Be Classified in Various Ways 323
- 15.2 Genetic Techniques, Cell Cultures, and Pedigree Analysis Are All Used to Detect Mutations 324
- 15.3 The Spontaneous Mutation Rate Varies Greatly Among Organisms 327
- 15.4 Mutations Occur in Many Forms and Arise in Different Ways 327
- 15.5 Ultraviolet and Ionizing Radiation Are Mutagenic 331
- 15.6 Gene Sequencing Has Enhanced Understanding of Mutations in Humans 332
- 15.7 The Ames Test Is Used to Assess the Mutagenicity of Compounds 334

- 15.8 Organisms Can Counteract DNA Damage by Activating Several Types of Repair Systems 335
- 15.9 Site-Directed Mutagenesis Allows Researchers to Investigate Specific Genes 340
- 15.10 Transposable Genetic Elements Move Within the Genome and May Disrupt Genetic Function 341

GENETICS, TECHNOLOGY, AND SOCIETY

Chernobyl's Legacy 345

Chapter Summary 346

Key Terms 346

Insights and Solutions 347

Problems and Discussion Questions 348

Selected Readings 350

CHAPTER 16

Regulation of Gene Expression 352

- 16.1 Prokaryotes Exhibit Efficient Genetic Mechanisms to Respond to Environmental Conditions 353
- 16.2 Lactose Metabolism in *E. coli* Is Regulated by an Inducible System 353
- 16.3 Crystal Structure Analysis of Repressor Complexes Has Confirmed the Operon Model 359
- 16.4 Tryptophan Metabolism in *E. coli* Is Controlled by a Repressible Gene System 360
- 16.5 Eukaryotic Gene Regulation Differs from Regulation in Prokaryotes 362
- 16.6 Regulatory Elements and Transcription Factors Control the Expression of Eukaryotic Genes 363
- 16.7 Steroid Hormones Regulate Some Genes 368
- 16.8 Posttranscriptional Events Also Regulate Gene Expression 368

GENETICS, TECHNOLOGY, AND SOCIETY

Why Is There No Effective AIDS Vaccine? 370

Chapter Summary 371

Key Terms 371

Insights and Solutions 372

Problems and Discussion Questions 372

Selected Readings 376

CHAPTER 17

Recombinant DNA Technology 377

- 17.1 An Overview of Recombinant DNA Technology 378
- 17.2 Recombinant DNA Molecules Are Constructed Using Several Components 378
- 17.3 Cloning in Prokaryotic Host Cells 382
- 17.4 Cloning in Eukaryotic Host Cells 382
- 17.5 The Polymerase Chain Reaction Permits Cloning Without Host Cells 383
- 17.6 Libraries Are Collections of Cloned Sequences 385

- 17.7 Specific Clones Can Be Recovered from a Library 386
- 17.8 Cloned Sequences Can Be Characterized in Several Ways 388
- 17.9 DNA Sequencing: The Ultimate Way to Characterize a Clone 392

GENETICS, TECHNOLOGY, AND SOCIETY

Beyond Dolly: The Cloning of Humans 395

Chapter Summary 396

Key Terms 396

Insights and Solutions 396

Problems and Discussion Questions 397

Selected Readings 400

CHAPTER 18

Genomics, Bioinformatics, and Proteomics 401

- 18.1 Genomics: Sequencing Helps Identify and Map All Genes in a Genome 402
- 18.2 Bioinformatics Provides Tools for Analyzing Genomic Information 403
- 18.3 Functional Genomics Classifies Genes and Identifies Their Functions 405
- 18.4 Prokaryotic Genomes Have Some Unexpected Features 408
- 18.5 Eukaryotic Genomes Have a Mosaic of Organizational Patterns 411
- 18.6 Genomics Provides Insight into Genome Evolution 416
- 18.7 Comparative Genomics: Multigene Families Diversify Gene Function 419
- 18.8 Proteomics Identifies and Analyzes the Proteins in a Cell 422

GENETICS, TECHNOLOGY, AND SOCIETY

Footprints of a Killer 426

Chapter Summary 427

Key Terms 427

Insights and Solutions 428

Problems and Discussion Questions 428

Selected Readings 432

CHAPTER 19

Applications and Ethics of Biotechnology 433

- 19.1 Biotechnology Has Revolutionized Agriculture 434
- 19.2 Pharmaceutical Products Are Synthesized in Genetically Altered Organisms 436
- 19.3 Biotechnology Is Used to Diagnose and Screen Genetic Disorders 439