

PREFACE

In the sixth edition of *Genetics: Analysis & Principles*, the content has been updated to reflect current trends in the field. In addition, the presentation of the content has been improved in a way that fosters active learning. As an author, researcher, and teacher, I want a textbook that gets students actively involved in learning genetics. To achieve this goal, I have worked with a talented team of editors, illustrators, and media specialists who have helped me to make the sixth edition of *Genetics: Analysis & Principles* a fun learning tool.

Overall, an effective textbook needs to accomplish four goals. First, it needs to provide comprehensive, accurate, and up-to-date content in its field. Second, it needs to expose students to the techniques and skills they will need to become successful in that field. Third, an effective textbook should have pedagogical features, such as formative assessment, that foster student learning. And finally, it should inspire students so they want to pursue that field as a career. The hard work that has gone into the sixth edition of *Genetics: Analysis & Principles* has been aimed at achieving all four of these goals!

FLIPPING THE CLASSROOM

A recent trend in science education is the phenomenon that is sometimes called “flipping the classroom.” This phrase refers to the idea that some of the activities that used to be done in class are now done outside of class, and vice versa. For example, instead of spending the entire class time lecturing over textbook and other materials, some of the class time is spent engaging students in various activities, such as problem solving, working through case studies, and designing experiments. This approach is called active learning. For many instructors, the classroom has become more learner centered rather than teacher centered. A learner-centered classroom provides a rich environment in which students can interact with each other and with their instructors. Instructors and fellow students often provide formative assessment—immediate feedback that helps each student understand if his or her learning is on the right track.

What are some advantages of active learning? Educational studies reveal that active learning usually promotes greater learning gains. In addition, active learning often focuses on skill development rather than on the memorization of facts that are easily forgotten. Students become trained to “think like scientists” and to develop a skill set that enables them to apply scientific reasoning. A common concern among instructors who are beginning to try out active learning is that they think they will have less time to teach and therefore will cover less material. However, this may not be the case. Although

students may be provided with online lectures, “flipping the classroom” typically gives students more responsibility for understanding the textbook material on their own. Along these lines, *Genetics: Analysis & Principles*, Sixth Edition, is intended to provide students with a resource that can be effectively used outside of the classroom. Here are several of the key pedagogical features:

- **NEW!** A new feature called **Genetic TIPS** provides a consistent approach to help students solve problems in genetics. This approach has three components. First, the student is made aware of the **Topic** at hand. Second, the question is evaluated with regard to the **Information** that is available to the student. Finally, the student is guided through one or more **Problem-Solving Strategies** to tackle the question.

GENETIC TIPS THE QUESTION: All of the Genetic TIPS begin with a question. As an example, let's consider the following question:

The coding strand of DNA in a segment of a gene is as follows: ATG GGC CTT AGC. This strand carries the information to make a region of a polypeptide with the amino acid sequence, methionine-glycine-leucine-serine. What would be the consequences if a mutation changed the second cytosine (C) in this sequence to an adenine (A)?

TOPIC: What topic in genetics does this question address? The topic is gene expression. More specifically, the question is about the relationship between a gene sequence and the genetic code.

INFORMATION: What information do you know based on the question and your understanding of the topic? In the question, you are given the base sequence of a short segment of a gene and told that one of the bases has been changed. From your understanding of the topic, you may remember that a polypeptide sequence is determined by reading the mRNA (transcribed from a gene) in groups of three bases called codons.

PROBLEM-SOLVING STRATEGY: Compare and contrast. One strategy to solve this problem is to compare the mRNA sequence (transcribed from this gene) before and after the mutation:

Original: AUG GGC CUU AGC

Mutant: AUG GGC AUU AGC

ANSWER: The mutation has changed the sequence of bases in the mRNA so that the third codon has changed from CUU to AUU. Because codons specify amino acids, this may change the third amino acid to something else. Note: If you look ahead to Chapter 13 (see Table 13.1), you will see that CUU specifies leucine, whereas AUU specifies isoleucine. Therefore, you would predict that the mutation would change the third amino acid from leucine to isoleucine.

- **Genes → Traits:** Because genetics is such a broad discipline, ranging from the molecular level to populations, many instructors have told us that it is a challenge for students to see both “the forest and the trees.” It is commonly mentioned that students often have trouble connecting the concepts they have learned in molecular genetics with the traits that occur at the level of a whole organism (i.e., What does transcription have to do with blue eyes?). To try to make this connection more meaningful, certain figure legends in each chapter, designated **Genes → Traits**, remind students that molecular and cellular phenomena ultimately lead to the traits that are observed in each species (see Figure 14.8).
- **Learning Outcomes:** Each section of every chapter begins with a set of learning outcomes. These outcomes help students understand what they should be able to do once they have mastered the material in that section.
- **Formative Assessment:** When students are expected to learn textbook material on their own, it is imperative that they are regularly given formative assessment so they can gauge whether they are mastering the material. Formative assessment is a major feature of this textbook and is bolstered by Connect—a state-of-the-art digital assignment and assessment platform. In *Genetics: Analysis & Principles*, Sixth Edition, formative assessment is provided in multiple ways.
 1. As mentioned, a new feature called Genetic TIPS is aimed at helping students refine their problem solving skills.
 2. Each section of every chapter ends with multiple-choice questions. Also, compared with the previous edition, many chapters in the sixth edition are divided into more sections that are shorter in length. Formative assessment at the end of each section allows students to evaluate their mastery of the material before moving on to the next section.
 3. Most figures have Concept Check questions so students can determine if they understand the key points in the figure.
 4. Extensive end-of chapter questions continue to provide students with feedback regarding their mastery of the material.
 5. The textbook material is supported by digital learning tools found in Connect. Questions and activities are assignable in Connect, and students also have access to our valuable adaptive study tool, SmartBook. With this tool, students are repeatedly given questions regarding the textbook material, and depending on their answers, they may advance ahead in their reading, or they are given specific advice on what textbook material to go back and review.

Overall, the pedagogy of *Genetics: Analysis & Principles*, sixth edition, has been designed to foster student learning. Instead of being a collection of facts and figures, *Genetics: Analysis & Principles*, Sixth Edition, by Rob Brooker, is intended to be an engaging and motivating textbook in which formative assessment allows students to move ahead and learn the material in a productive way. We welcome your feedback so we can make future editions even better!

SIGNIFICANT CONTENT CHANGES IN THE SIXTH EDITION

- **NEW!** A new problem-solving feature called Genetic TIPS has been added to the sixth edition. The Genetic TIPS are found within each chapter and three or four are found at the end of each chapter.
- **NEW!** The topic of Epigenetics has been expanded to a whole chapter, which is now Chapter 16.
- **NEW!** A new chapter on non-coding RNA has been added, which is Chapter 17. This long-overdue chapter is in response to a remarkable explosion in our appreciation for the roles of non-coding RNAs in many aspects of molecular biology. Note: Although two new chapters have been added to this edition, the overall page length of the sixth edition is not longer than the fifth edition.
- **NEW!** CRISPR-Cas systems: The role of the CRISPR-Cas system in providing prokaryotes with a genome defense mechanism is described in Chapter 17, and its use by researchers to mutate genes is described in Chapter 21.

Examples of Specific Content Changes to Individual Chapters

- Chapter 2. Mendelian Inheritance: Several Genetic TIPS have been added to help students work through problem-solving strategies involving Mendelian inheritance.
- Chapter 3. Chromosome Transmission During Cell Division and Sexual Reproduction: The discussion of the random alignment of homologs during metaphase of meiosis I was expanded.
- Chapter 4. Extensions of Mendelian Inheritance: The topic of gene interaction was streamlined to focus primarily on examples in which the underlying molecular mechanisms are known.
- Chapter 5. Non-Mendelian Inheritance: A common misconception among students is that you can use a Punnett square to deduce non-Mendelian inheritance patterns. Throughout the chapter, this misconception has been laid to rest, and students are given effective strategies to predict offspring genotypes and phenotypes.
- Chapter 6. Genetic and Linkage Mapping in Eukaryotes: When looking at experiments involving linkage, student often find it very difficult to identify the recombinant offspring. In various parts of the chapter, a strong effort has been made to make it clear that recombinant offspring have inherited a chromosome that is the product of a crossover. Along these same lines, a new figure (see Figure 6.6) has been added involving the experiments of Curt Stern showing that recombinant offspring carry chromosomes that are the product of a crossover. Also, Figure 6.8 has been revised to emphasize this point.
- Chapter 7. Genetic Transfer and Mapping in Bacteria: Figure 7.13 is a new figure showing the increase in methicillin resistance in certain *Staphylococcus aureus* strains.

- Chapter 8. Variation in Chromosome Structure and Number: Several Genetic TIPS have been added to help students solve problems that involve changes in chromosome structure and chromosome number.
- Chapter 9. Molecular Structure of DNA and RNA: The section on the discovery of the DNA double helix has been streamlined to focus on the key experiments.
- Chapter 10. Chromosome Organization and Molecular Structure: The topic of bacterial chromosome structure has been updated, which includes a new figure (see Figure 10.3) and a discussion of microdomains.
- Chapter 11. DNA Replication: A new figure has been added on the initiation of DNA replication in eukaryotes (see Figure 11.20).
- Chapter 12. Gene Transcription and RNA Modification: The information on alternative splicing has been moved to this chapter.
- Chapter 13. Translation of mRNA: Several Genetic TIPS have been added to help students understand the relationship between the genetic code and the synthesis of polypeptides.
- Chapter 14. Gene Regulation in Bacteria: The information on catabolite activator protein has been updated.
- Chapter 15. Gene Regulation in Eukaryotes I: Transcriptional and Translation Regulation: The material on eukaryotic gene regulation is now divided into two chapters. Chapter 15 focuses on transcriptional and translational regulation.
- Chapter 16. Gene Regulation in Eukaryotes II: Epigenetics: This topic has now been expanded to an entire chapter. A new subsection has been added on the role of epigenetics in vernalization, which is the process in which some plant species require an exposure to cold in order to flower the following spring. Also, a new section has been added on the intriguing topic of paramutation.
- Chapter 17. Non-coding RNA: This new chapter begins with an overview of the general functions of non-coding RNAs, and then the subsequent sections explore certain topics in greater detail, such as their role in chromatin modification, transcription, translation, protein targeting, and genome defense (e.g., the CRISPR-Cas system).
- Chapter 18. Genetics of Viruses: The material on the integration of phage λ has been added to this chapter, along with a brief discussion of Zika virus. Also, information on the origin of HIV and the occurrence of HIV infection worldwide and in the US has been updated.
- Chapter 19. Gene Mutation and DNA Repair: The information on the mismatch repair system has been updated.
- Chapter 20. Recombination, Immunogenetics, and Transposition: Section 20.2 has been revised to focus on immunogenetics.
- Chapter 21. DNA Technologies: A new subsection has been added on gene mutagenesis, which includes a description of the Crispr-Cas system for inactivating and mutating genes.
- Chapter 22. Biotechnology: Several Genetic TIPS have been added to help students appreciate the uses of molecular techniques in biotechnology.
- Chapter 23. Genomics I: Analysis of DNA: The information has been updated regarding completed genome sequences and other aspects of genomics.
- Chapter 24. Genomics II: Functional Genomics, Proteomics, and Bioinformatics: A new subsection has been added on the method called RNA-Seq (see Figure 24.3). The Bioinformatics section has been reorganized with an emphasis on gene prediction and homology.
- Chapter 25. Medical Genetics and Cancer: Several Genetic TIPS have been added to help students understand how mutations play a role in certain diseases, including cancer.
- Chapter 26. Developmental Genetics: The information on *Hox* genes in development, and the role of the *SRY* gene in human sex determination, have been updated.
- Chapter 27. Population Genetics: The topic of inbreeding has been expanded.
- Chapter 28. Complex and Quantitative Traits: The topic of the identification of QTLs is now found in its own subsection.
- Chapter 29. Evolutionary Genetics: The cladistics method for constructing a phylogenetic tree is compared with the UPGMA method.

Suggestions Welcome!

It seems very appropriate to use the word *evolution* to describe the continued development of this textbook. I welcome any and all comments. The refinement of any science textbook requires input from instructors and their students. These include comments regarding writing, illustrations, supplements, factual content, and topics that may need greater or less emphasis. You are invited to contact me at:

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