preface

When I first began teaching genetics in 1989, I developed a course that covered a wide array of topics in genetics, from Mendelian genetics and chromosome mechanics to regulating gene expression and recombinant DNA technology. As I thought about my goals for this course, I knew, as do many faculty teaching genetics, that I wanted the students to both learn and be able to apply their knowledge. I felt that students who really understood the concepts could use their knowledge to solve a variety of different problems and integrate the information to develop a deeper understanding of the concepts. My job as the instructor was to carefully cover the material in each chapter, stressing concepts and information that I thought were particularly important or interesting, and assigning end-of-chapter problems and old exam questions so the students could practice solving problems before the exam.

I found, however, that the students struggled on the assigned problems. I would then go over the material and problems in review sessions and during office hours to help them reach a clear understanding of the material and how to solve the problems before the exam. Though the exam had similar problems that were only slightly modified from the homework problems we reviewed, many of the students still failed to perform at the level that I expected.

Meeting with the students, I found they had a very difficult time in two general areas of my course:

1. They lacked the ability to extract and understand the relationship between the lecture material and the underlying major concepts.
2. The students had difficulty in applying the material learned in the lecture to the average problem. Because they continued to have trouble when the problem was slightly modified, it was clear that they lacked either the understanding of how to solve a problem or the training to recognize important details and concepts in a problem.

This problem was exacerbated when I asked them to combine information and concepts from more than one chapter. For example, asking the students to find an open reading frame in a specific DNA sequence could be solved by many of the students. However, if I gave the students an image of a DNA sequencing ladder and asked them to identify the open reading frame and determine which DNA strand corresponds to the transcriptional template, many of them were baffled.

I began to look at genetics books and thought about how they dealt with problem-solving skills and the integration of material. Most of the books concentrated on the historical, factual, and conceptual topics in genetics, with very little instruction about how to solve different types of problems in a chapter. At the end of each chapter, however, there were several problems that required the student to suddenly apply this information, without providing sufficient problem-solving instruction. I already knew from my own experience that this was demanding a lot from the students.

I also found many of the books provided short summaries throughout the chapter and longer end-of-chapter summaries. The short, interspersed summaries were too concise and often did not convey much information or put the key points into a context for the students to grasp. While the end-of-chapter summaries were more thorough, they usually just reiterated the material in the short, interspersed summaries rather than putting the information in a different context. While there were occasional end-of-chapter questions that required some knowledge from another chapter, they failed to significantly reinforce the previous topics or clearly demonstrate how it related to the material that was covered in the current chapter.

Keeping these shortcomings in mind, I set out to write a genetics book that was designed for both students and instructors. I wanted this book to help students overcome the two roadblocks that I saw many students had encountered. At the same time, I wanted a textbook that contained sufficient detail for students to supplement the material that the instructor presented during lectures. I also wanted to develop a book that would assist instructors in developing problem-solving skills in their students. My hope is that this book also provides the flexibility for faculty who cover the entire book in one semester and those, like myself, who prefer to concentrate on fewer topics in the semester.

Developing Problem Solving Skills

I believe that this genetics textbook demonstrates to the student how to solve problems, which is so critical for their success in genetics classes across the country. I committed significant space in this textbook to describe how data are analyzed while solving a problem, both through text discussions and through effective pedagogical features. Each of these different features provide alternative opportunities for students to test their comprehension of the material and their ability to apply their knowledge to solving problems.

A key feature of this text is "Applying Genetic Principles to Problems." Almost every chapter contains at least one of these boxes that leads the student step-by-step through analyzing experimental data and solving a problem. A good example is on pages 134 and 135 of the text where the student learns how to create a recombination map using data from a three-point testcross. Placing these clear instructions immediately after the relevant section in the text allows the student to directly compare the concept with the application. Furthermore, these boxes provide clear locations where the student can find assistance on how to solve particular types of problems.

The "It's Your Turn" feature, located at the end of key sections in each chapter, directs students to specific end-of-chapter problems that they can attempt based on the material that was just presented (see example, page 136). This provides students the opportunity to attempt specific problems immediately after reading about a particular principle or seeing an example of how to use a specific type of data set. This immediate reinforcement helps students gain confidence before they move on, provides an assessment of their understanding of sections within a chapter, and indicates the section of the chapter that should be reviewed if they are having difficulty with specific problems.

Every chapter also contains several Solved Problems, which provides another opportunity for the student to see how related problems can be solved. Solved Problems are followed by at least 20-25 problems in the Exercises and Problems section for students to practice their problem-solving skills. Solutions to even-numbered problems are provided for students on the text website at www.mhhe.com/hyde.

The end-of-chapter assessment materials also contain a series of questions called "Chapter Review Questions" that assesses the student's comprehension of the text through definitions, drawing relationships, and listing features of a process. The student's ability to see a new problem and know how to tackle it would be severely compromised without this basic understanding.

While using actual data in the problems adds a sense of reality to the student, this type of data is not often transparent so the student can see the concept at work. The use of actual data often requires much statistical analysis to determine how well it fits the model. Because I feel it is more important for the students to see, understand, and then apply the concepts while they are solving the problems, the problems in this book usually use fabricated data to better fit and demonstrate the principles being discussed. I believe that this makes the same instructional point in a more obvious way. As students become more comfortable with the data and its analysis, they will be able to move on to analyzing real scientific data.

Identifying and Integrating Key Concepts

Genetics is a broad discipline that is used in all areas of modern biology, from cell and developmental biology, through physiology to ecology and evolution. This textbook provides the student with several ways to see how each topic integrates within the larger landscape of genetics.

At key points throughout the chapter, "Restating the Concepts" distills the preceding section down to a few main points (example, page 189). Rather than trying to make these overly concise to fit within a restricted amount of space, I allowed sufficient space for these summaries to contain enough information to effectively transmit the key points.

Reviewers of early drafts of this manuscript agreed that the "Restating the Concepts" reviews eliminated the necessity of a standard end-of-chapter summary. I used that opportunity to conclude each chapter with the "Genetic Linkages" box, which describes how the different topics in that chapter are related to material covered in both previous and future chapters. Students then have the opportunity to be directed between chapters if a particular aspect interests them or is somewhat unclear. Providing this larger roadmap to the student gives him or her some freedom to explore genetics and gain a deeper appreciation of the field rather than focusing on, and getting lost in, the individual details.

Finally, at the end of almost every chapter is a Chapter Integration problem, such as the example on page 261. These problems require the student to draw on some information or concepts from previous chapters. This reinforces their existing knowledge from other chapters and integrates this information through a multi-part problem. Students in my course find these problems challenging, but successfully solving the problem gives them a clear understanding of the material and a renewed confidence in their ability to manipulate the data. Chapter Integration problems also provide an excellent assessment of how well students retain and integrate the material.

Visualizing Genetics Through Accurate and Instructional Art

While emphasizing the problem-solving and integrative nature of the textbook, we also placed great importance on the visual program. My students rely heavily on visual representations to sort out the many structures and processes in genetics, thus, we tried to provide a piece of art for every major concept, which could then complement the description in the text. This resulted in a much larger number of figures (15–30% greater) compared to the other genetics textbooks on the market. These visual aids are critically important for the current student to understand the concepts and to place that information into a larger context.

Great care was also placed on developing a consistent and informative art program for this textbook. You will find that not only is the color of the artwork striking, but that similar elements maintain the same color and shape from chapter to chapter. For example, generic DNA is always blue and mRNA is yellow. We used a hand structure for DNA polymerase and a bi-lobed oval for RNA polymerase. The ribosome is always a red triangular element. This continuity will reduce the amount of confusion for the student and allow them to be more comfortable when they see a familiar element within a new topic or concept.

Furthermore, many of the figures were designed to show the basic concept in a larger framework. See figure 17.25, page 609 for example; rather than simply showing the proteins that are in a signal transduction cascade, we placed the corresponding proteins in their correct cellular compartments so the students can see what restrictions are placed on the different proteins.

Modern Molecular Genetics With a Traditional Approach

There are two different views of how to present genetics. The first is a historical view that allows the students to see the progression of the field and how advances are built on the previous work of others. This is an important concept that students who want to stay in science need to understand. The second approach is a more modern approach, where DNA is presented as the genetic material at the start. This approach is based on the idea that the students have seen much of this material for many years prior to taking the genetics course and that this familiarity makes it easier for students to move into genetics.

The problem with the second approach is twofold. First, there are many different ways to proceed after introducing DNA as the genetic material. You can move into gene regulation or into a description of a mutation, or into classical genetics. This variety of downstream directions makes writing a textbook using this approach very difficult. More importantly, after trying to teach my class using the DNA first approach, I found that the students lose some of the appreciation of the subsequent genetic analyses because they know that the ultimate cause is the DNA sequence. They lack a desire to learn the importance of genetic crosses, they become very confused with the definitions of genetic terms, such as a null mutation, compared to the molecular definition of a null mutation. Possibly the most disturbing outcome of the DNA-first approach is the students try to simplify all the concepts down to a DNA sequence, which makes it difficult for them to understand how some forms of gene regulation, such as epigenetics, can occur without affecting the DNA sequence. Teaching a genetics course from a DNA-first approach is like trying to read a novel after first reading the last chapter. Once you know the outcome, you often second-guess the rationale behind every event as the story evolves. The students lose the beauty of seeing the story unfold and the excitement of discovering why different events happen and their consequences. Thus, based on my previous experiences, I wrote this book using the historical approach. However, the level of detail provided in each chapter would likely permit this book to be used in a DNA-first approach, if the chapters were not followed sequentially.

The Conflict Between the Breadth and the Depth of the Material

One of the most difficult decisions that I encountered in writing this book was how much breadth I wanted to expose the students to versus the level of depth that I wanted them to appreciate. In an ideal world, this book would convey the breadth of the topics within the field of genetics and provide sufficient detail to satisfy the most highly motivated student. Unfortunately, there are limits to the amount of material that can be placed in a genetics book at this level and the amount of material that can be covered in a one-semester genetics course.

I opted to fall somewhere in the middle of the two extremes. I admit that there were several aspects of genetics that were excluded from this book, such as the variety of different ways to generate the organismal body axes shortly after fertilization of the egg (chapter 21). Instead, I felt that it was more important to present one fairly well understood example in greater detail, hoping that the students would gain a deeper appreciation of both the details of the process and some of the experimental techniques used to study the concept. My intention is to provide enough breadth about genetics, without morphing into the areas that utilize genetics. For example, I wanted to demonstrate a variety of different ways that genetics is used to understand developmental biology (chapter 21), without writing a detailed chapter about developmental biology. It was important to give the students sufficient detail so they can become excited about genetics as a field and appreciate its application in other areas of biology.

To help generate student interest in genetics, I knew that the textbook had to be up-to-date. In some ways that is impossible to achieve in a published book, which is only updated every three years. However, it was important to me to keep the information and figures as current as possible. Thus, in our discussion of genome sequencing projects, I used the most recent available data from www.genomesonline.com and updated it as late in the publication process as possible.

I also updated the text and figures associated with several techniques. I made a sincere attempt to keep the discussion of some topics very current, including the generation and function of microRNAs, nonsense-mediated mRNA decay, the creation of a phenocopy through small molecule screens, and the use of TILLING to screen for mutants. For each of these topics there are multiple diagrams to illustrate these concepts and methodologies.

In the cases where the topics are more complex, I incorporated a figure that shows an example of the use of the concept or technique. For example, in the discussion of the small molecule screen, I used a figure that illustrates how different small molecules may affect two different transmembrane receptors that are linked through a common intracellular signaling pathway and how this could relate to the phenotype associated with a genetic mutation in one of the corresponding genes (Figure 20.37). This figure not only demonstrates the potential targets of a small molecule screen, but also how the resulting phenocopy may differ from a standard mutation. This is important for students who want to think that all processes can be reduced to a simple operation, which takes away much of the beauty of biology.

Similarly, I attempted to provide real examples in places to summarize complex topics. For example, after discussing a variety of mechanisms used to control the expression of a protein in eukaryotes, such as transcriptional regulation, translational regulation, and posttranslational regulation, I then discussed Prader-Willi syndrome and Angelman syndrome in humans (chapter 17), where many of these different processes converge on the complex topic of imprinting. I hope that these real examples, particularly as they relate to humans, will help to grab the interest of the students and motivate them to work through the processes in greater detail.

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The Precision Graphics art group, especially Jen Gibas and Matt Mabry, did an outstanding job with the artwork. I attempted to show many of the pieces of art in a larger conceptual framework to allow the students an opportunity to place the information into their knowledge base, rather than simply having each figure represent a different, and separate, piece of information. The individuals at Precision Graphics took many of my rudimentary sketches and produced outstanding pieces of artwork that I am sure will greatly enhance the learning experience for the student.

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kept me focused on my numerous goals and allowed this project to be completed in a relatively timely manner. Late in the writing process, we realized that the book was 50–75 pages longer than budgeted. Rather than removing or reducing the outstanding artwork or slashing large amounts of text, Anne and Patrick fought to keep the book intact. The result is a significantly better textbook, without the cost of the increased length being passed on to the students. Pat and Anne, you are two outstanding individuals who actually made writing this textbook an enjoyable experience.

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