Preface

When we got together to discuss the third edition of the book formerly known as *Recombinant DNA and Biotechnology,* we reflected on the stunning progress in molecular biology and biotechnology that has occurred in the 10 years since ASM Press first published our book. As we were writing the first edition:

- Geneticists were still 5 years away from having the entire sequence of a single human chromosome—chromosome 22. By 2003, the Human Genome Project, which provided the sequence of all human chromosomes, had been completed. Now, scientists have the complete genome sequences for more than 500 organisms.
- The only media star named Dolly was a country music singer, not a sheep, and most biologists believed that a fully differentiated cell could not be forced back to its undifferentiated state. Scientists have now used somatic cell nuclear transfer to clone more than 13 mammalian species.
- No one was concerned about the ethics of using embryonic stem cells to treat diseases, for biologists were still 5 years away from perfecting techniques that would allow them to keep these cells alive in cell culture.
- We were all quite familiar with tRNA (transfer RNA), mRNA (messenger RNA), and rRNA (ribosomal RNA), but no one was talking about miRNA (micro-RNA), dsRNA (double-stranded RNA), siRNA (small interfering RNA), and shRNA (short hairpin RNA), all of which are involved in RNAi (RNA interference). The 1998 elucidation of RNAi as a mechanism for regulating gene expression was so significant that it has already garnered its discoverers the Nobel Prize for Physiology and Medicine.

We also could not resist reminiscing about the events that brought us to this most unexpected place of writing a third edition of a textbook.

You see, we never set out to write a first edition of this book. Our more modest goal had been to produce a three-ring binder of lesson plans and background material for North Carolina's science teachers. We both worked for the North Carolina Biotechnology Center, one of the first biotechnology institutions to appreciate the fundamental importance of public understanding and well-trained workers to biotechnology development. To that end, in 1987, the Center established the first statewide biotechnology training initiative with the goal of helping teachers incorporate modern biotechnology into the state-mandated science curriculum.

In 1994, with money provided by North Carolina's biotechnology companies and General Assembly, we published and distributed the three-ring binder, *Teaching Basic Biotechnology,* to the 700-plus teachers who had been trained through the Center's summer workshops. And that was that. Or so we thought.

Shortly after we released *Teaching Basic Biotechnology,* Bruce Alberts happened to be visiting North Carolina. Most people know Bruce as the past president of the National Academy of Sciences. What they do not know is that Bruce is the father of a high school chemistry teacher and, not surprisingly, a very vocal champion of science teachers and a tireless advocate for improving science education in primary and secondary schools. Bruce looked through our book and announced, with great certitude, that it needed to be published nationally. He was convinced that teachers across the country would benefit from the information we created for North Carolina teachers.

We greatly appreciated the compliment; Bruce had authored a textbook on cell biology that we both admired greatly. It was beautifully written and infused with the sort of awe for living organisms that had inspired us both to become biologists. But, if truth be told, we thought no one would be interested in publishing our book, and we also had no idea how to go about finding a publisher. In addition, our temperaments are not inclined toward self-marketing.

A colleague just happened to have an ancient business card from someone in the book-publishing business who, according to the card, was a book editor for the American Society for Microbiology (ASM) Press. We thought this fellow, Patrick Fitzgerald, might be able to point us toward a potential publisher. Had we known that Patrick had become the director of ASM Press, we never would have been so bold as to call him. True to Patrick's style, he answered his own phone, so it never occurred to us that we were speaking with the number-one guy. He did not say a word as we described the book and asked if he could tell us how to go about finding someone who might be interested in publishing it. After a painfully long (for us) silence, Patrick said, "Wait. Let me get this straight. This book is already written?" He received assurances from Stanley Falkow, a professor at Stanford University, and Marshall Bloom, a researcher at the National Institutes of Health, both of whom generously agreed to review a high school textbook by unknown authors, that our book was scientifically accurate, and Patrick decided that ASM Press would publish it.

Patrick's decision to publish *Recombinant DNA and Biotechnology* was quite brave, as ASM Press had never tried to enter the already crowded market of high school biology textbooks. ASM Press had a well-defined audience that it knew how to serve quite well: professional scientists, universities, and medical schools. Patrick took a risk with us, and we are forever grateful to him. Patrick also did not blink when we told him we wanted to dedicate a science textbook to Bear Bryant, the former head football coach at the University of Alabama. We knew we had a friend for life.

Bruce Alberts, who generously authored the foreword of our second book with ASM Press, *Biology and Biotechnology: Science, Applications, and Issues,* continues to support our efforts to produce accurate and engaging texts and works diligently to improve science education at all levels. Patrick has moved on to become Publisher for the Life Sciences at Columbia University Press. Our book is now published in three languages and used by teachers at secondary schools and universities across the United States and the European Union and in Brazil, Taiwan, India, Japan, Turkey, and even Antarctica! However, without Bruce and Patrick, *Recombinant DNA and Biotechnology* would never have existed, which is why we are dedicating this edition to them.

Those of you who are loyal users of this text will notice a number of significant changes in this edition, the most obvious being the book's new title, *Molecular Biology and Biotechnology*. The previous title no longer captured the breadth of the book's content.

Another conspicuous change is the inclusion of a CD with this edition. The CD contains electronic files of the text's graphics, worksheets, and templates required for certain activities. In addition, the CD has the appendixes from the second edition that are essential for conducting the wet laboratories:

- Recipes and instructions for making solutions and media
- Information on sterile technique and laboratory biosafety
- Descriptions of laboratory equipment needed for some activities, such as micropipettes and gel boxes, and instructions on how to use it

We have added a substantial amount of new material to the text. Part I, *Laying the Foundation,* now has a much-needed chapter on cell biology. Since we define biotechnology as using cells and biological molecules to solve problems or make useful products, the new chapter is long overdue.

In Part II, *Classroom Activities,* you will see a new section entitled *Genomics*. This section contains activities from earlier editions, as well as brand new activities, *Mapping a Disease Gene* and *Microarray Analysis of Genome Expression;* a new reading, *Personal Genomics,* which describes the new field of pharmacogenomics; and *Comparing Genomes,* which builds on *Analyzing Genetic Variation* from the second edition. Another addition to Part II is *Medical Sleuth: A Story of Genetics in Action,* which, like the rest of the material in that section, helps students make connections among DNA gene expression, protein function, and classical genetics.

We added a significant amount of information to Part III, *Societal Issues,* because we are increasingly impressed by the importance of helping students learn how to think rationally about technology. Sadly, the media's tendency to focus on fear and controversy has worsened over time. This predilection is exacerbated by a wealth of misinformation dispensed via the Internet. The teacher's role in countering misinformation and correcting sloppy thinking has become even more essential. We hope the critical-thinking tools and processes for rational analysis, as well as the factual information on gene flow in plants, animal cloning, genetic screening, and embryonic stem cells, will assist you in this important task.

Finally, to update educators on advances in biology and biotechnology, we have inserted new information throughout the text. For example, we have added a description of the breakthrough technology RNA interference, which promises to be a powerful research tool and will have many commercial applications. You will also find substantially more information on proteomics, microarray technology, and other tools for identifying and making productive use of nature's rich supply of genetic variation, such as random amplification of polymorphic DNA, total-community genomics, and radiation hybrid cell lines.

Some of you may be using our textbook for the first time and are unfamiliar with our goals in writing this book. First, we wanted to provide background information to help educators stay abreast of advances in biology. Many educators began teaching before the molecular biology explosion occurred. As a result, updating educators on scientific findings is a requisite first step in enabling them to bring newfound knowledge into their classrooms. The first part of this book, *Laying the Foundation,* provides this fundamental information on biotechnology and the science underlying its development.

However, without clear, easy-to-follow activities that respect the constraints under which most educators operate, successful transmission of new understandings from teachers to students is unlikely. Part II, *Classroom Activities,* provides wet- and dry-laboratory activities for teaching both the basic science of molecular genetics and the hands-on techniques of DNA- and protein-based technologies. The activities, which are appropriate for audiences ranging from middle school students to upper-level undergraduates, are presented in lesson plan format.

Our experience with educators across the country has taught us that both types of instructional materials—fundamental grounding in the science and activities in lesson plan format—are essential for teachers interested in incorporating biotechnology into biology courses.

Working with high school teachers has taught us another invaluable lesson about teaching biology at all educational levels. Some of the activities in Part II utilize paper models or other objects to mimic molecular phenomena or laboratory techniques. The value of these activities may not be apparent to some postsecondary biology instructors. In fact, the activities may seem like superfluous games intended to keep students busy.

We are sympathetic to that point of view because it used to be ours. Originally, we believed that precise words and clear pictures would allow almost anyone to grasp the concepts contained in this book. However, after leaving an academic research environment, teaching audiences of various ages and educational levels, and learning about teaching and learning from teachers, we realized that the ability to think abstractly and to learn through visual and verbal information is much rarer than we knew. Activities that seemed silly to us originally—mimicking protein synthesis by stringing beads together, acting out transcription and translation, or splicing genes by cutting and pasting pieces of construction paper—we now accept as crucial components of learning. For most people, irrespective of age and educational level, molecular events can be understood *only* through manipulating models or acting out cellular and molecular events. No matter how apt our words or lucid our graphics, we often do not see that telltale sign of understanding—the light that appears in a student's eyes—until we have them *do* something.

Over time, we have come to appreciate these "superfluous" activities for another reason. When students are working with new laboratory equipment and techniques, they are unable to focus on the biological principle the activity is intended to teach because they are preoccupied with learning the requisite hands-on skills. Using dry-laboratory activities to teach the principle prior to the wet laboratories that teach the technique and reinforce the principle greatly increases comprehension.

Because biotechnology has generated wide public debate about a number of important social issues, we would be remiss if we described only the scientific foundations and technological applications of biotechnology. All too often, discussions about the impacts of science and technology are merely emotional exchanges of opinions that may have nothing to do with facts. These unproductive debates contribute to rather than alleviate confusion. In Part III, *Societal Issues,* we offer information and tools for rationally analyzing and discussing biotechnology issues, including potential environmental impacts, bioethical ramifications, and various roles governments play in facilitating and impeding scientific research and technological change.

The final segment of the book, Part IV, provides appendixes that contain biosafety information and instructions on aseptic technique, and it is followed by a glossary.

In this book, we want not only to provide information and activities, but also to share our understanding and appreciation of biology, which comes from years spent in an academic environment. During that time, we were fortunate enough to be able to immerse ourselves in biology. With biology, it takes years of single-minded pursuit of knowledge for that knowledge to be transformed into understanding. With that understanding comes a very deep respect and reverence for the workings of the natural world. If we convey just a fraction of that reverence to our readers, then we will have succeeded.

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and Adrianne Massey