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Molecular Biology and Biotechnology
A Guide for Teachers (Third Edition)

分子生物学和生物技术
（原著第三版）

Helen Kreuzer, Adrianne Massey

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生命科学新经典

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分子生物学和生物技术

（原著第三版）

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导　读

生物技术（biotechnology）是一门新兴的综合性学科，现代生物技术是在分子生物学基础上建立的、为创建新的生物类型或新生物机能而生的实用技术，是现代生物科学和工程技术相结合的产物。

科学技术的发展是人类文明的重要标志。早期的生物技术可追溯至远古时代，古埃及人已经利用酵母菌酿酒。之后，传统式的利用微生物发酵技术来进行食品发酵，和发酵生产抗生素等，都是生物技术利用的例子。自20世纪50年代DNA结构发现以来，现代生物技术随着分子生物学的飞速发展而进行了一次大革命。例如利用基因克隆技术，将胰岛素（insulin）克隆到大肠杆菌中生产，开启了现代生物技术学的工业价值。20世纪80年代中期开始的基因组研究，使得生物技术的研究开始了大科学的运作方式。

21世纪是生命科学的时代，生物技术在医疗保健、农业、环保、轻化工、食品等重要领域对改善人类健康与生存环境、提高农牧业和工业产量与质量方面都开始发挥越来越重要的作用。当今世界，生物技术已经成为许多国家，特别是发达国家研究开发的重点、国际科技竞争的关键。而生物技术领域是我国和国外差距最小的科学领域之一，基本与发达国家的发展同步。而且我国生物资源丰富，生物物种居世界第三位，生物资源的开发利用潜力巨大，完全具备和国外发达国家竞争的条件。具备了天时和地利，生物技术专业人才的培养就显得至关重要。

出于培养高水平生物技术专业人才的需求，同时也为了提高公众对生物技术的认识程度，美国西北太平洋国家实验室的Helen Kreuzer博士与北卡罗来纳州大学的Adrianne Massey博士组织编写了这本《分子生物学和生物技术》。两位编写者都具有分子生物学、细胞生物学和遗传学的多年教学经验，1994年共同开发了针对美国北卡罗来纳州中学教师培训使用的分子生物学课程。其课程内容后由美国微生物协会（简称ASM）出版为《重组DNA和生物技术》。《分子生物学和生物技术》就是这本教科书的第三版。

全书分为四个部分：基础知识（第一部分）、课堂教学活动（第二部分）、社会性问题（第三部分）和附录（第四部分）。ASM出版社同时还出版了该版本的学生指导用书。该书内容循序渐进，图文并茂，语言生动，是一本非常有趣的教科书。

第一部分“基础知识”的介绍紧跟时代前沿，在解释生物技术的科学基础之前首先介绍了其广阔的范围——细胞生物学和遗传学，特别是分子遗传学。随之介绍了科学家如何应用他们对细胞生物学和分子生物学的理解去解答科学命题，并发展解决问题的新技术，开发有用的产品。为使教育工作者能及时跟进生物学和生物技术上的进展，作者在整本书中都插入了新的知识。例如，书中对突破性新技术RNA干扰进行了介绍，该技术有望成为强有力的研究工具并拥有许多商业用途。该书中还有大量关于蛋白质组学、基因芯片技术和其他工具的知识，可以让读者用以识别并有效利用大自然丰富的遗

传变异，如多态性DNA的随机扩增、辐射杂交细胞系等。

第二部分“课堂教学活动”提供了生物实验室和虚拟实验室的课堂教学活动，指导教师如何在课堂实践中贯彻强调生物技术的基础知识和原理。由于本书主要针对教师，因而对教学活动的指导采用了教案的形式，其中对实验原理介绍言简意赅，实验目标、材料准备、方法步骤条理清晰，有关实验操作的描述简单易懂，相信大多数读者遵循其步骤即可取得明显的功效，因此适用于各层次的实验教学人员，特别是生物技术专业的教师。此部分共有A、B、C、D、E五个章节，每一章节中除了基础知识外，还包括学生主体性活动以及相关补充阅读材料，内容丰富，形式多样，非常适合课堂学习和实践。

该书有一个非常显著的特点：作者凝结了多年宝贵教学经验，在某些教学活动中利用纸模型或其他物体模拟分子现象或实验室技术。比如利用串珠模仿蛋白质合成，表演转录和翻译，或者通过剪贴美术纸模仿基因的剪切。这些看似简单的游戏，其实是学习的重要步骤和组成部分，能够提高课堂教学的趣味性，极大地帮助学生理解那些抽象的分子事件。

然而现代生物技术从它诞生之日起，其负面影响就是无法回避的问题。任何新的技术都是一把“双刃剑”，有利也有弊，生物技术也不例外。生物学及生物技术的应用必将对21世纪产生重要的影响，它不仅能促进人类社会的文明与进步，也会带来一系列环境问题和严重的伦理问题。因此，该书还特别注重培养学生的批判性思维能力。第三部分“社会性问题”让学生在学习了有关基因工程、克隆技术等现代生物技术知识以后，了解当今社会有关生物技术的安全性和伦理等热点问题，并引领他们科学地、理性地看待这一问题。例如，书中有关于“转基因食品安全性”问题的讨论。首先，在概述转基因成果的基础上提出问题，如食用转基因食品会不会对人体健康造成隐性伤害、转基因生物会不会对生态环境造成破坏等；然后，从食物安全、生物安全和环境安全等方面分别介绍了不同的观点、态度，并列举了相关的论据。这样编写，不仅形式新颖，还使学生能够依据人们所生活的不同社会环境，从多个角度了解和认识转基因生物安全性问题，感受问题的重要性和复杂性。又如，在关注生物技术的伦理问题方面，关于克隆人、基因诊断、基因治疗等热点问题的讨论，能够帮助学生树立科学的态度和价值观，理性地看待生物技术中的伦理争论。

最后，我们可以从这本书中深刻地感受到作者对生物技术和分子生物学的热爱，她们将这种执着和热爱转化为对生物学的尊重和敬畏，并希望将自己所知传递给读者。我相信无论是传授生物技术知识的教育工作者，还是生物技术研究者，也包括那些对生物学感兴趣的读者，都可以从此书中受益。相信在21世纪，生物技术必将同其他各领域的科技发展一起，为人类更好的生存做出前所未有的贡献。

马文丽
南方医科大学基因工程研究所

序

我们聚在一起讨论编写第三版的书（以前名为《重组DNA和生物技术》）前，仔细回顾了自从ASM出版社首次出版此书后十年间，分子生物学和生物技术所取得的惊人进步。

当我们撰写第一版时：

• 遗传学家还需要五年的时间才能测出一条完整的人染色体——第22号染色体的全部序列。直到2003年，揭示人类全部染色体基因序列的人类基因组计划才宣告完成。今天，科学家已经完成了超过500种物种的全基因组测序。

• 唯一名为“多莉”的媒体明星是一名乡村音乐歌手，而不是绵羊；大多数生物学家认为已完全分化的细胞无法被诱导回到未分化的状态。但是在今天，科学家已经可以应用体细胞核转移法克隆超过13种哺乳动物。

• 没人担忧胚胎干细胞治疗疾病的伦理学问题，因为还需要5年时间，生物学家才能成功进行胚胎干细胞的体外培养。

• 我们都非常熟悉tRNA（转运RNA）、mRNA（信使RNA）和rRNA（核糖体RNA），但是没有人知道miRNA（微小RNA）、dsRNA（双链RNA）、siRNA（小干扰RNA）和shRNA（短发夹RNA）的存在，所有这些小RNA都可参与RNAi（RNA干扰）。1998年，RNAi作为基因表达调控机制的阐明获得了诺贝尔生理学或医学奖。

我们无法抗拒回忆起一些事，是这些事促使我们撰写这本第三版的教科书，这是非常不可思议的。

首先，我们从未打算写这本书的第一版。我们最初的目标只是写一本三孔活页的教案和背景材料给北卡罗来纳州的科学教师使用。当时我们都在北卡罗来纳州的生物技术中心工作，该中心作为一家生物技术研究机构，首先意识到公众理解以及训练有素的工作者对生物技术的发展至关重要。为了这个目的，中心在1987年成立了首家全州范围的生物技术培训班，其主旨在于帮助教师将现代生物技术与政府委托的科学课程相融合。

1994年，在北卡罗来纳州的生物技术公司和州议会提供的资金支持下，我们出版了三孔活页教材《基础生物技术教学》（*Teaching Basic Biotechnology*），并分发给参加中心夏季培训班的700多名教师。事情开始就是这样，或者我们认为是这样。

我们发行《基础生物技术教学》后不久，Bruce Alberts恰好访问北卡罗来纳州。大多数人都知道Bruce Alberts是国家科学院的前任主席，而大家并不知道的是，Bruce是一名高中化学教师的父亲，同时还是一个坚定的科学教师拥护者，孜孜不倦地促进科学教育在小学和中学的改进。Bruce读了我们的书，绝对确定这本书应该在全国出版。他相信全国的教师都将从本书的知识中受益。

我们非常感激他给予的肯定，Bruce也曾撰写过一本令我们非常钦佩的细胞生物学

教科书。这本书语言优美，充满了对生命体的敬畏，我们俩都是受这本书的鼓舞而成为生物学家的。不过老实说，我们担心没有人会对出版我们的书感兴趣，也不知道如何去找一个出版商。此外，我们不具备自我行销的能力。这时一个同事碰巧有一张出版社某人的旧名片，名片上显示他是美国微生物协会（ASM）出版社的图书编辑。我们猜想这个人，Patrick Fitzgerald，也许能指引我们找到潜在的出版商。如果我们知道他已经是 ASM 出版社的社长，绝不会如此大胆地直接给他打电话。而 Patrick 的风格是，他会自己接电话，所以我们永远不可能想到他是出版社社长。当我们描述这本书并咨询他是否可以推荐可能对本书出版感兴趣的人时，他不发一言。在令人痛苦的长时间沉默后，Patrick 说："等等，让我直说吧。这本书是已经写好了吗?"在得到斯坦福大学 Stanley Falkow 教授和国家卫生研究院 Marshall Bloom 研究员（这两位学者慷慨同意审阅一本由不知名的作者编写的高中教科书）对本书科学准确性的保证后，Patirck 决定出版这本书。

由于 ASM 出版社从未涉及竞争激烈的中学生物教科书市场，Patirck 出版《重组 DNA 和生物技术》这一决定是非常冒险的。ASM 对读者的界定非常明确，知道如何提供更好地为他们服务：专业的科学家、大学和医学院校。Patirck 和我们一起承担了很大的风险，因此我们永远对他充满感激。而当我们提出希望在这本科学教科书上为亚拉巴马大学的前任橄榄球教练 Bear Bryant 题献辞时，Patirck 也没有异议。这让我们知道他将会是我们的终生挚友。

Bruce Alberts 慷慨地为我们第二本由 ASM 出版的书《生物学和生物技术：科学、应用和争议》(*Biology and Biotechnology*：*Science*，*Applications*，*and Issues*）写序，他继续支持我们编写准确、有吸引力的教科书，并勤勉地致力于提高各层次的科学教育水平。我们的书现在已用三种语言出版，并被美国、欧盟、巴西、台湾、印度、日本、土耳其甚至南极洲的许多中学和大学教师使用。如果没有 Bruce 和 Patirck 的帮助，《重组 DNA 和生物技术》一书也不会存在，所以我们将这一版本献给他们。

这本书的忠实读者一定会注意到这一版有一些显著的改变，最明显的是新书名《分子生物学和生物技术》，以前的书名已不能涵盖现在该书的内容。

另一处明显的改变则是这一版本附上了 CD。CD 中包含了书中所有图、表和某些课堂活动所需模板的电子文件。此外，CD 中还包括第二版的附录，这对生物实验室来说是必需的：

- 溶液和培养基的配方和配制方法
- 无菌技术和实验室生物安全方面的信息
- 某些活动需要的实验室仪器说明和使用说明，例如微量移液管和电泳槽

我们在这一版本的书中添加了大量的新材料。第一部分"基础知识"中现在有一章非常有必要的关于细胞生物学的内容。既然我们将生物技术定义为利用细胞和生物分子解决问题和制造有用的产品，那么这新的章节早就应该存在了。

在第二部分"课堂教学活动"中，有一个新章节名为"基因组学"。这一章包括来自早期版本中的内容以及全新的内容，如"疾病基因的作图"和"基因组表达谱分析芯片"；新的阅读材料"个体化基因组"描述了药物基因组学的新领域；"比较基因组学"

建立在第二版中“分析遗传变异”的基础上。第二部分的另一个补充是“医学侦测：遗传学应用的故事”，如同本章其他内容一样，这一节将帮助学生将 DNA 基因表达、蛋白质功能以及传统遗传学联系起来。

我们越来越意识到帮助学生理性思考生物技术的重要性，所以在第三部分“社会性问题”中增加了大量内容。让人遗憾的是，媒体聚焦于忧虑和争议的趋势随着时间的推移更加严重了。这一趋势由于分布在网络上的大量错误信息而更加恶化。教师在对抗这些错误信息和纠正这种草率思维中的作用变得更为重要。我们希望合理分析所需的批判性思维工具和过程，以及植物、动物克隆、遗传筛选和胚胎肝细胞中关于基因流动的真实信息，能协助你完成这一重要任务。

最后，为使教育工作者更了解生物学和生物技术上的进展，我们贯穿整本书插入了新的知识。例如，我们加入了对突破性新技术 RNA 干扰的介绍，该技术有望成为强有力的研究工具并具有许多商业用途。在本书中，你还能找到大量关于蛋白质组学、基因芯片技术和其他工具的知识，以识别并有效利用大自然丰富的遗传变异，如多态性 DNA 的随机扩增、辐射杂交细胞系。

可能有些读者是第一次使用我们的教科书，还不熟悉本书的目标。起初，我们希望提供背景知识，以帮助教育工作者随时了解生物学的进展。由于许多教师在分子生物学兴起以前就开始了教学生涯。因此，教育者对科学知识的更新是让他们把新发现的知识带入课堂必可不少的第一步。本书的第一部分“基础知识”提供了生物技术及支持其发展的科学基础知识。

然而，在大多数教育者所处的条件约束下，如果没有明确的、易学的活动，是不可能完成从教师到学生成功的新知识传输的。第二部分“课堂教学活动”提供了生物实验室和计算机虚拟实验室的教学活动，教授分子遗传学的基础科学和以 DNA、蛋白质为基础的实用技术。这些活动以教案的形式呈现，对从中学生到大学生高年级的读者都适用。

全国教育者的经验告诉我们，无论是指导材料——基础科学知识，还是教案形式的教学活动，对希望将生物技术融入生物课程教学的教师来说都是不可缺少的。

与高中教师的合作带给我们另一个宝贵的生物学教学经验，这个经验适用于所有教育水平。第二部分中某些教学活动利用纸模型或其他物体模拟分子现象或实验室技术。这些活动可能对高中以上的生物教师作用不太明显。实际上，这些活动可能看上去是使学生白白忙碌一场的游戏。

我们赞成这种看法，因为曾经我们也这样认为。起初，我们相信精确的语言和清晰的图片能使几乎每个人都掌握本书的概念。然而，当离开了学术研究环境，教过不同年级和教育水平的对象并从教师身上学习教学时，我们意识到，抽象思维的能力和通过视觉及口头信息学习的能力比我们所想的少见得多。那些原先对我们来说可笑的活动——利用串珠模仿蛋白质合成、表演转录和翻译，或者通过剪贴美术纸模仿基因的剪切，现在则是学习的重要步骤组成部分。对大多数人来说，无论年龄和教育水平，只有通过操纵模型或将细胞、分子事件表演出来才能让他们理解。无论我们的语言多么适当，图片多么明晰易懂，还是常常看不到理解的迹象——闪现在学生眼中的光芒，直到我们让学

生动手做点什么。

随着时间的推移，我们开始从另一个角度肯定这种“多余”的活动。当学生们使用新的实验室仪器和技术时，由于专注于动手能力，往往不能将精力集中在其中的生物学原理上。如果先用虚拟实验室的活动教授基本原理，再用生物实验室教授技术方法，进一步强化原理，则能够提高理解程度。

由于生物技术在许多重要的社会议题上引发了广泛的公众争论，如果我们只描述生物技术的科学基础和技术应用就太疏忽了。关于科学技术影响力的讨论时常仅仅是情感交流，与事实无关。这些无谓的争论会扩大而不是减轻混乱。在第三部分“社会性问题”中，我们提供了理性分析和讨论生物技术问题的知识和工具，包括潜在的环境影响、生物伦理学，以及政府在促进和阻碍科学研究和技术变迁上所发挥的不同作用。

本书的第四部分“附录”中包括了生物安全信息和无菌技术的说明以及词汇表。

在此书中，我们不仅希望提供知识和活动方案，还希望分享我们在多年的学术环境中产生的对生物学的理解和敬意。在那些日子，我们非常幸运能够沉浸在生物学中。学习生物学时，需要花费多年时间执着追求知识，并将知识转化为理解，再将理解转变为一种对自然世界的运作方式非常强烈的尊重和敬畏。假如我们能将这种敬畏传递一小部分给读者，就已经成功了。

Helen Kreuzer，Adrianne Massey

To Bruce Alberts and Patrick Fitzgerald—without their insight, encouragement, and concern for science education, this book would not exist.

About the Authors

Helen Kreuzer
received her B.S. degree in chemistry from the University of Alabama and her Ph.D. degree from Duke University's Department of Microbiology and Immunology and the Duke University Program in Genetics. She worked as an educator for many years, both as a college professor and in the area of teacher professional development. She and Dr. Adrianne Massey first met one another when Dr. Kreuzer became coordinator of the North Carolina Biotechnology Center's nationally recognized teacher education program. There, they developed the molecular biology curriculum that was later published as the text *Recombinant DNA and Biotechnology: A Guide for Teachers* by the American Society for Microbiology. The present volume is the third edition of that curriculum. Dr. Kreuzer and Dr. Massey have also written a college-level textbook for general audiences, *Biology and Biotechnology: Science, Applications, and Issues.*

Dr. Kreuzer has developed and taught numerous molecular biology minicourses for practicing secondary school and college faculty members. She served on the faculties of Salem College and Elon University, where she taught introductory cell biology, genetics, biology for non-science majors, molecular biology, and evolutionary biology. In 2002, Dr. Kreuzer returned to research in the Department of Biology at the University of Utah. There, she learned to use stable isotope ratios as tools in forensic science, environmental research, and basic biology. She has become an expert on the use of stable isotopes in microbial forensics and serves on an advisory panel for the Federal Bureau of Investigation. Dr. Kreuzer joined the scientific staff of Pacific Northwest National Laboratory in September 2005.

Adrianne Massey
received her B.S. and M.S. degrees from the Biological Sciences Department at the University of Georgia and her Ph.D. in zoology from North Carolina State University. Her company furthers informed science and technology policy development by counseling governments, mediating consensus-building activities, helping nonscientists understand biology, and training scientists in communications. Prior to founding her company, she was Vice President for Education and Training at the North Carolina Biotechnology Center, where she directed the Center's public education and workforce-training programs.

Dr. Massey served as the science advisor for the PBS series *BREAKTHROUGH: Television's Journal of Science and Medicine,* was the original director of the North Carolina Environmental Technology Consortium, served on the biological sciences faculty at North Carolina State University, and developed interactive exhibits for science and technology museums. In addition to publishing scientific articles on her research in evolutionary ecology, she has been an invited contributor to a number of government reports on biotechnology. She has served on a number of federal and state advisory panels on science education and training, technology development, and public policy. Internationally, she has worked with a variety of governments in Africa and Asia on issues related to biotechnology research and policy, and she participated in the international negotiations of the Biosafety Protocol. At the request of the U.S. State Department, she has served as an advisor to government officials, universities, and citizens' groups in the United Kingdom, Italy, and India and to international organizations, such as the World Trade Organization and the U.N. Food and Agriculture Program.

Note to Readers
This book, *Molecular Biology and Biotechnology: A Guide for Teachers,* is the third edition of the book formerly known as *Recombinant DNA and Biotechnology: A Guide for Teachers.* It contains four parts: *Laying the Foundation* (Part I), *Classroom Activities* (Part II), *Societal Issues* (Part III), and *Appendixes* (Part IV). ASM Press also publishes a student version of this text, *Molecular Biology and Biotechnology: A Guide for Students.*

Parts I of the teacher guide and student guide are identical. However, Parts II, III, and IV of the teacher guide contain materials intended solely for teachers, as well as all of the corresponding pages found in the student guide. Thus, the page numbers for the teacher and student guides are different from Part II on. Pages from the student guide are clearly labeled as *"Student Activity"* in the teacher guide.

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 new-found 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.

Helen Kreuzer
and Adrianne Massey

Acknowledgments

We are indebted to all who have shared their time, insights, and talents with us during the production of all three editions of this textbook.

First and foremost, we thank teachers across the country, especially those in North Carolina. Their enthusiasm for learning new and difficult material, determination to introduce this exciting science to their classes, willingness to share so generously with their colleagues, and unflagging devotion to their students have inspired and reinforced us. We feel blessed to have had the opportunity to work with all of them, but those who deserve special thanks because of their help in the production and field-testing of the first and second editions are Sherri Andrews, Leslie Brinson, Beverly Cea, Nancy Evans, Marilyn Garner, Britt Hammond, Bobbie Hinson, Marlene Jacoby, Elizabeth Rue, Thea Sinclair, and Brian Wood.

A number of people made significant contributions to some of the classroom activities. Karyn Hede tested the new genomics activities and improved the writing in all three editions. Louisa Stark, Director of the Genetic Science Learning Center at the University of Utah, gave us permission to use the microarray activity they developed. Amy Clark helped us develop the protein and bioinformatics activities. Marlene Jacoby provided us with the ethical decision-making model she uses successfully with her classes. Thomas Martin assisted with photography, graphics, and computer applications.

The text has benefited from the skills of our copy editor, Elizabeth McGillicuddy, and the artwork of Patrick Lane. Their conscientious oversight and attention to detail improved the quality of the book immensely.

Finally, thanks to those at ASM Press who over the years have become like family to us: Susan Birch, our production editor for all three editions; Jennifer Adelman and Laura Ledbetter; and, especially, Jeff Holtmeier, director of ASM Press, for his encouragement, support, and eagerness to improve the quality of biotechnology education.

目　　录

第一部分　基础知识

第一部分介绍了关于生物技术的科学基础和背景知识。本书在解释生物技术的科学基础之前首先介绍了其广阔的范围——细胞生物学和遗传学，特别是分子遗传学。随之介绍了科学家如何应用细胞生物学和分子生物学知识解答科学命题，发展新技术，开发有用的产品。

第二部分　课堂教学活动

第二部分介绍了生物实验室和计算机虚拟实验室的课堂教学活动。本书将这些课堂教学活动分为五个章节（A，B，C，D，E），以教案的格式呈现。章节 A 阐述了分子生物学的基本概念：DNA 的结构与功能。章节 B 和 C 聚焦于 DNA 的操作和 DNA 的物种间转移。章节 D 将遗传学和分子生物学领域联系起来，在分子水平上解释生物体的遗传观察结果。章节 E 是第三版中新增加的章节，介绍了用于基因组分析的技术，以及如何应用基因组研究促进我们对进化和个体变异的理解。