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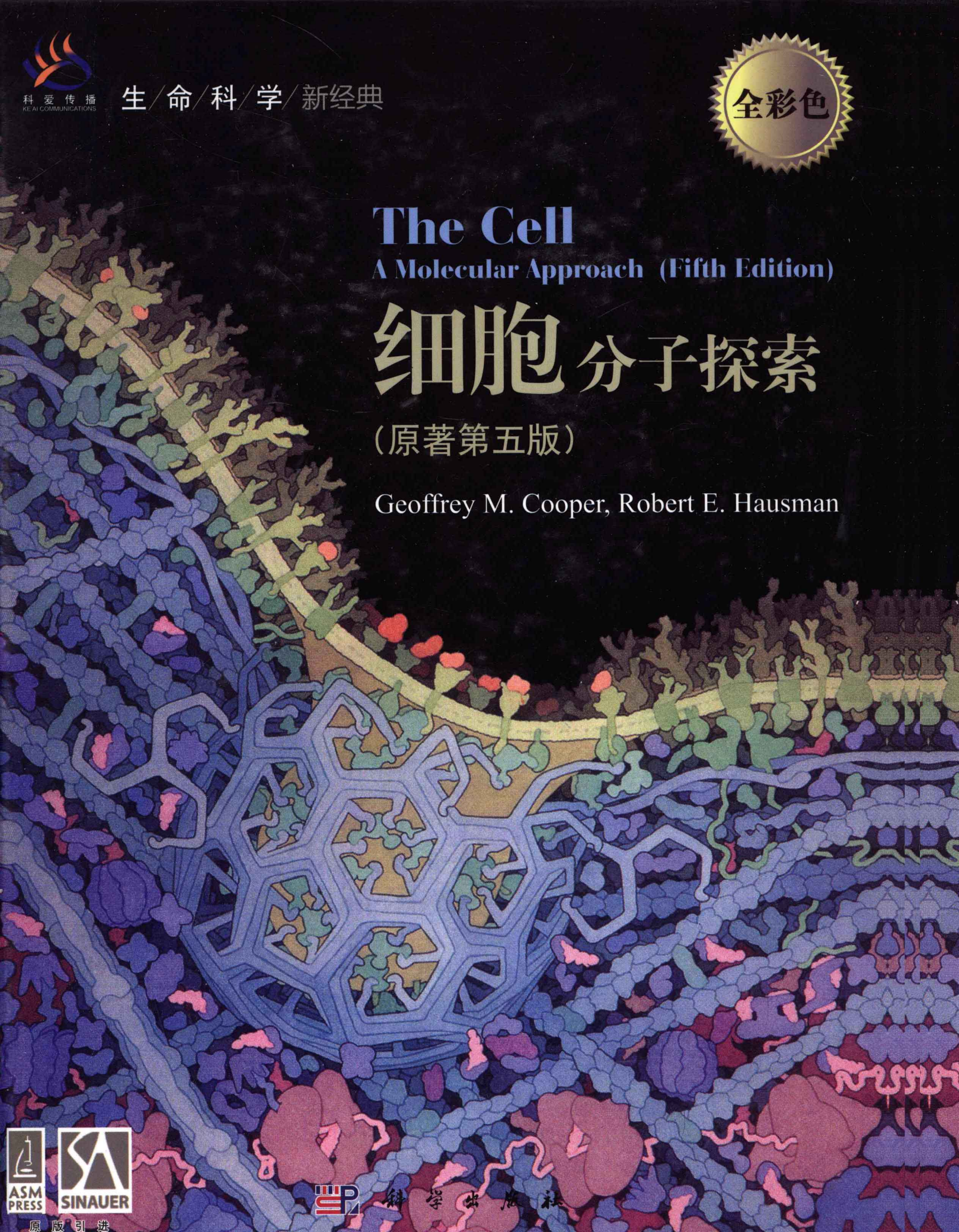
The Cell
A Molecular Approach (Fifth Edition)

细胞分子探索
（原著第五版）

Geoffrey M. Cooper, Robert E. Hausman



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Geoffrey M. Cooper
Robert E. Hausman
Boston University

科学出版社
北京

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This is an annotated version of
The Cell: A Molecular Approach, Fifth Edition
by Geoffrey M. Cooper and Robert E. Hausman

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《细胞:分子探索》第五版——一本精心打造的教本

分子和细胞生物学是大学生命科学的核心课程,它们不仅是所有生物学和医学学科的基础,而且是当代科学发展中进展快速与令人兴奋的领域。自《细胞:分子探索》(*The Cell: A Molecular Approach*)第四版问世(2006年)以来,与细胞相关的新研究、新发现层出不穷。无怪乎编著者 Geoffrey M. Copper 和 Robert E. Hausman 在不足4年的时间里,"迫不及待"地推出了新的版本——第五版(2009年)。新版的问世是细胞生物学发展的必然,是从事细胞生物学教学者的福音,对我国的细胞生物学教学有很大的帮助,它或许可直接作为教学用书,至少是十分有用的参考教材。

一、合理的结构特征

本版共分四篇,每篇均为相对独立的部分。教师讲授的主题、顺序、重点均可根据具体需要而加以调整。

第一篇包括细胞的进化、细胞的研究方法、细胞的化学以及分子生物学基础。可见第一篇只是细胞生物学的背景知识。因此,正如作者指出的那样,对于接受过分子生物学或基础生物学课程的学生,可以跳过某些章节,或者可以将它作为一种复习的资料。

第二篇重点介绍细胞的分子生物学,其中包括基因组结构和序列;DNA 复制、修复和重组;转录和 RNA 加工;蛋白质的合成、加工和调节。由上可以看出本篇是按遗传信息流向(The Flow of Genetic Information),即按 DNA→RNA→蛋白质的顺序讲授的。在这种次序安排中,学生们的脑海里会刻下"中心法则"的烙印。

第三篇是论述细胞结构与功能的核心篇章,其中包括细胞核、细胞器、细胞骨架、质膜和细胞外基质。本篇内容最为丰富,它将分子生物学与细胞结构功能有机地联系起来,即在细胞核、细胞器、细胞骨架、质膜与细胞表面这些经典的细胞生物内容中自然地渗透入分子生物学的丰富内涵。

最后的第四篇,其重点在于向学生介绍令人激奋的快速发展领域,其中包括信号转导、细胞周期、程序性细胞死亡以及干细胞。该篇的最后一章讲述癌症,作者认为以此来结束本教材是十分适宜的,因为癌症是基本的细胞调节机制不能正常运行的综合结果。

二、新颖性——高质量教材的要素

教材应随着学科的发展不断地更新,这是不断提高教学质量的关键所在。《细胞》的作者们见证了近几年生命科学尤其是细胞与分子生物学的飞速发展。如不能将这些新的激动人心的研究、新的发现、新的成果写进教材中,则这种教材只能说是死教材,甚至说是"古董系列"。因此,本书作者在他们自己的前言中明确地提到"我们自始不渝的目的是:不仅要为学生提供细胞生物学领域最新的信息,而且要阐述令人兴奋的研究与挑战"。为此新版增加了如下诸方面的新内容:

- microRNA 对基因调控的研究进展
- 以全基因组联合扫描识别人类疾病敏感基因
- 蛋白质的线粒体输入

- 诱导性多能干细胞
- 自噬在程序性细胞死亡中的作用
- 人类肿瘤中突变基因组分析

由上可以看出，本版不失其时代性，是一本“与时俱进”的活教材。

三、别具一格的特色

除了内容的新颖性之外，这一版本在具体的教学方法或手段上也有不少创新，这也构成了新版别具一格的特色。最主要的有下述几点：

(1)每章包含有“重点实验”(key experiment)与“分子医学”(molecular medicine)。“重点实验”介绍细胞生物学中那些举足轻重的发现，它不但可以巩固课堂的讲课内容，而且也是一个补充，使其更加丰富与生动，更可启发学生的思维与创造力。“分子医学”则将分子细胞学的理论与当代疾病的诊断、发病机理或是治疗结合起来，这对于读者今后无论从事临床或是科学研究皆不失有学以致用的裨益。

(2)问题与解答。与一般教科书相同的是，本书每章后面都附有问题。但一般的教科书都未给出正确的或标准的答案，与国内外同类书不同，本书给出了标准答案(附在书末)，我觉得对于大学生(而非研究生)这样做是必要的。因为对于大学生更重要的是让他们尽快掌握基本的理论、概念。只有打下了坚实的理论基础之后，方可有今后正确独立治学的基础。

(3)网站与“侧吧”。网站资源是免费使用的，但内容极其丰富，其中有小测验、可灵活运用所学知识而提出的可深入探讨的问题、关键概念与过程的动漫、视频显微术(显示细胞生物学的某些作用过程、细胞结构)。此外还有每章的小结、全部词汇等。

“侧吧”(sidebar)是一种“花絮”，也是本书的一个特色。每章都有几个侧吧，它简明扼要地叙述了某些概念、原理、方法。这也是课文的一种补充。譬如在最后一章中的一个侧吧中，介绍了巴氏染色方法诊断子宫颈癌的原理及方法。这种安排起着锦上添花的作用。

四、“苦其心志，劳其筋骨”的精品之作

无论国内国外，细胞生物学教材已是洋洋大观，“汗牛充栋”，甚至有点难以计数(因为不时又会冒出一本)。虽然各有千秋，各具特色，并且有些是为具体学校、一定的使用对象而编写的，但对照起《细胞：分子探索》来，或多或少都有点失色。作为一本大学生使用教材，应具有全面性、系统性、新颖性、适用性，以及讲授的灵活性、对学生的启发性。这几方面的优点我已在前面阐述。但要做到这几点作者是需下一番苦功夫的。“他山之石，可以攻玉”，希望不久的将来我国也可编出与此媲美的教材来，但在此之前不妨采取“拿来主义”，将它消化、吸收融会到我们的教学之中，相信这样做对提高我国的细胞生物教学质量不无裨益。

章静波
中国医学科学院 基础医学研究所

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前　言

《细胞》第五版保持前几个版本所特定的撰写格式与宗旨，着重于帮助学生理解在该快速发展的科学领域中令人兴奋的研究及其发展的基础。自 2006 年前一版问世以来，我们已见证了许多重要的进展，这些我们都已集结到该版之中。基因组学的进展是最令人兴奋的。其新技术使人们可以快速筛查个人的基因组，其中包括 James Watson 和 Craig Venter，以及那些令个体对多种常见病敏感的基因。事实上可以预期，不断的进步会使得个人的基因组测序成为一个适宜的措施，它主要可用于个体化医学。除此以外，大规模的基因组分析也已使我们能够窥察到一系列与肿瘤相关的遗传学改变，并藉此开发出新的靶向药物以及更精湛的治疗方法。

与基因组学发展同时，表观遗传学也并驾齐驱，其中涉及对高等真核生物中着丝粒表观遗传的阐明、对基因调控中组蛋白修饰复杂性的更多认识，以及在理解由非编码 RNA 所致 X 染色体失活方面所取得的进展。此外，我们还了解到微 RNA 不仅在正常细胞的行为，也在癌症和心脏病等疾病的病理学中起着转录后基因调节的广泛作用。最后，干细胞潜在临床应用方面也取得了重大进展。最值得注意的是，科学家们令人惊奇地发现成体体细胞也可以重编程，在培养中表现出多能干细胞性质。自《细胞》前一版问世以来，其他进展还包括解决了在细胞和分子生物学中长期存在的那些未能解决的议题，如不同真核生物 DNA 聚合酶在复制叉的作用问题，以及经高尔基体的蛋白质转运机制问题。

我们自始不渝的目的是：不仅要为学生提供细胞生物学领域最新的信息，而且要阐述令人兴奋的研究与挑战。同时，我们坚持认为对于初次接受细胞和分子生物学课程的大学生来说，《细胞》的显著特点包括分子医学和重点实验的描述，它们分别强调临床应用和介绍了相关的学术研究论文。本版中所列出的新的小实验中包括 RNA 干扰的发现，这是 Andrew Fire 和 Craig Mello 的特殊贡献；还有作为 G 蛋白耦连受体大家族的气味受体的识别，这是 Linda Buck 和 Richard Axel 的特殊贡献。这些小实验以及全书中所讨论的其他实验均可以告诉学生们，我们的这一领域中进展是如何取得的，并让他们领会到假说如何形成以及结果当如何解释。也如前一版一样，每一章都会包含有几个“侧吧”(sidebar)，旨在强调有趣的领域或是相关的医学事件。此外，每章之后都提出了一系列问题，并在书末给出了答案。为了与本书实验分析的目的相一致，许多问题旨在让学生们去思索实验途径和结果的解释，以及提供对教材的一个复习机会。

无论本版或是前几版，我们最主要的目的均在于传达当代细胞和分子生物学中令人兴奋的研究及其挑战。在我们这一领域中的机会空前之大，我们希望《细胞》可激励今天的莘莘学子去面对未来研究的挑战。

（章静波 译）

致　　谢

《细胞》第五版得益于采用该书前一版的诸多评审人、同道、导师和学生们的评阅和建议。我们十分感谢下列人士：密歇根州立大学 Felipe Kierszenbaum 博士，坎贝尔大学的 Karen Guzman 博士，康涅狄格学院的 T. Page Owen 博士，波姆那加州州立大学的 Junjun Liu 博士，Creighton 大学的 Floyd Knoop 博士，弗雷斯诺加州大学的 Jason Bush 博士，亚利桑那大学的 Gene Settle 博士，波特兰大学的 Amelia Ahern Rindell 博士（以及她学生的评议），波士顿大学的 Cynthia Bradham 博士，以及波士顿大学的 Ulla Hansen 博士等。

我们再次对出版者和编辑们始终一贯的支持表示感谢。同样地，我们感谢 Sinauer 联合会的 Andy Sinauer 以及 ASM 出版社的 Jeff Holtmeier，和他们合作共事是令人愉快的事情。Christopher Small 和 Janice Holabrid 出色的工作使本书增色不少，我们特别感激 Chelsea Holabrid 在本书制作过程中所表现出的细心、耐性与耐人寻味的幽默。

（章静波 译）

Preface

The Fifth Edition of *The Cell* maintains the approaches and goals that have characterized earlier editions, with an emphasis on helping students understand the excitement of research and the basis for progress in this rapidly moving area of science. We have seen a number of important advances since publication of the previous edition in 2006, and these have been incorporated into the current volume. Progress in genomics has been particularly striking, with new technologies having enabled the rapid sequencing of individual genomes—including those of James Watson and Craig Venter—as well as the identification of genes that confer susceptibility to a variety of common diseases. Indeed, it can be anticipated that continuing advances will soon bring us to a point where personal genome sequencing becomes a feasible undertaking, with major implications for personalized medicine. Along these lines, large scale genomic analyses have provided new insights into the array of genetic alterations responsible for many types of cancer, with potential implications for the development of new targeted drugs and more refined treatments.

Along with advances in genomics have come advances in epigenetics, including elucidation of the epigenetic inheritance of centromeres in higher eukaryotes, a growing appreciation of the complexity of histone modifications in gene regulation, and advances in understanding X chromosome inactivation by noncoding RNA. We have also come to appreciate the widespread role of microRNAs in post-transcriptional gene regulation, not only with respect to normal cell behavior but also in pathologies such as cancer and heart disease. Finally, major progress has been made toward the potential clinical applications of stem cells, most notably with the exciting discovery that adult somatic cells can be reprogrammed to behave as pluripotent stem cells in culture. Additional advances since the publication of the last edition of *The Cell* have included progress in resolving long-standing issues in cell and molecular biology, such as the roles of different eukaryotic DNA polymerases at the replication fork and the mechanism of protein transport through the Golgi apparatus.

We have once again sought to present not only current information, but also the excitement and challenges of research in cell biology. At the same time, we have maintained *The Cell* as an accessible and readable text for undergraduates who are taking their first of course in cell and molecular biology. Distinguishing features of *The Cell* include the Molecular Medicine and Key Experiment essays, which highlight clinical applications and describe seminal research papers, respectively. New Key Experiment essays in this edition include the discovery of RNA interference, featuring the work of Andrew Fire and Craig Mello, and the identification of odorant receptors as a large family of G protein coupled receptors, featuring the work of Linda Buck and Richard Axel. Together with additional experiments discussed throughout the text, these essays give the students a sense of how progress

in our field is made and a feel for how hypotheses are framed and results interpreted. As in the previous edition, each chapter also includes several short "sidebars" designed to highlight areas of interest or medical relevance, as well as a set of questions at the end of each chapter with answers at the back of the book. In keeping with the focus of *The Cell* on experimental analysis, many of these questions ask the student to think of experimental approaches or interpret results, as well as providing a review of the material.

In this as in previous editions of *The Cell*, our most important goal has been to convey the excitement and challenges of research in contemporary cell and molecular biology. The opportunities in our field have never been greater, and we hope *The Cell* stimulates today's students to meet the challenges of future research.

Acknowledgments

The Fifth Edition of *The Cell* has benefited from the comments and suggestions of reviewers, colleagues, and instructors and students who used the previous edition. We are grateful to the following for their advice: Dr. Felipe Kierszenbaum, Michigan State University; Dr. Karen Guzman, Campbell University; Dr. T. Page Owen, Jr., Connecticut College; Dr. Junjun Liu, California State University, Pomona; Dr. Floyd Knoop, Creighton University; Dr. Jason Bush, California State University, Fresno; Dr. Gene Settle, University of Arizona, Dr. Amelia Ahern-Rindell, University of Portland (plus her student comments); Dr. Cynthia Bradham, Boston University; and Dr. Ulla Hansen, Boston University.

We are once again grateful to our publishers and editors for their continuing support. As always, Andy Sinauer and Dean Scudder at Sinauer Associates and Jeff Holtmeier at ASM Press have been a pleasure to work with. Christopher Small and Janice Holabird did an excellent job crafting this book, and we are especially pleased to again thank Chelsea Holabird for her care, patience, and good humor in production of the book.

Geoffrey M. Cooper and Robert E. Hausman
February 2009

Organization and Features of THE CELL A Molecular Approach

The Cell has been designed to be an approachable and teachable text that can be covered in a single semester while allowing students to master the material in the entire book. It is assumed that most students will have had introductory biology and general chemistry courses, but will not have had previous courses in organic chemistry, biochemistry, or molecular biology. Several aspects of the organization and features of the book will help students to approach and understand its subject matter.

Organization

The Cell is divided into four parts, each of which is self-contained, so that the order and emphasis of topics can be easily varied according to the needs of individual courses.

Part I provides background chapters on the evolution of cells, methods for studying cells, the chemistry of cells, and the fundamentals of modern molecular biology. For those students who have a strong background from either a comprehensive introductory biology course or a previous course in molecular biology, various parts of these chapters can be skipped or used for review.

Part II focuses on the molecular biology of cells and contains chapters dealing with genome organization and sequences; DNA replication, repair, and recombination; transcription and RNA processing; and the synthesis, processing, and regulation of proteins. The order of chapters follows the flow of genetic information (DNA → RNA → protein) and provides a concise but up-to-date overview of these topics.

Part III contains the core block of chapters on cell structure and function, including chapters on the nucleus, cytoplasmic organelles, the cytoskeleton, the plasma membrane, and the extracellular matrix. This part of the book starts with coverage of the nucleus, which puts the molecular biology of Part II within the context of the eukaryotic cell, and then works outward through cytoplasmic organelles and the cytoskeleton to the plasma membrane and the exterior of the cell. These chapters are relatively self-contained, however, and could be used in a different order should that be more appropriate for a particular course.

Finally, Part IV focuses on the exciting and fast-moving area of cell regulation, including coverage of topics such as cell signaling, the cell cycle, programmed cell death, and stem cells. This part of the book concludes with a chapter on cancer, which synthesizes the consequences of defects in basic cell regulatory mechanisms.

Features

Several pedagogical features have been incorporated into *The Cell* in order to help students master and integrate its contents. These features are reviewed below as a guide to students studying from this book.

Chapter organization. Each chapter is divided into three to five major sections, which are further divided into a similar number of subsections. An outline listing the major sections at the beginning of each chapter provides a brief overview of its contents.

Key Terms and Glossary. Key terms are identified as boldfaced words when they are introduced in each chapter. These key terms are reiterated in the chapter summary and defined in the glossary at the end of the book.

Illustrations and micrographs. An illustration program of full-color art and micrographs has been carefully developed to complement and visually reinforce the text.

Key Experiment and Molecular Medicine Essays. Each chapter contains either two Key Experiment essays or one Key Experiment and one Molecular Medicine essay. These features are designed to provide the student with a sense of both the experimental basis of cell and molecular biology and its applications to modern medicine. We have also found these essays to be a useful basis for student discussion sections, which can be accompanied with a review of the original paper upon which the Key Experiments are based.

Sidebars. Each chapter contains several sidebars that provide brief descriptive highlights of points of interest related to material covered in the text. The sidebars supplement the text and provide starting points for class discussion.

Chapter Summaries. Chapter summaries are organized in outline form corresponding to the major sections and subsections of each chapter. This section-by-section format is coupled with a list of the key terms introduced in each section, providing a succinct but comprehensive review of the material.

Questions and Answers. An expanded set of questions at the end of each chapter (with answers in the back of the book) are designed to further facilitate review of the material presented in the chapter and to encourage students to use this material to predict or interpret experimental results.

References. Comprehensive lists of references at the end of each chapter provide access to both reviews and selected papers from the primary literature. In order to help the student identify articles of interest, the references are organized according to chapter sections. Review articles and primary papers are distinguished by [R] and [P] designations, respectively.

Companion Website icons. New icons in the margin direct students to the website's animations, videos, quizzes, problems, and other review material.

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Media and Supplements to Accompany THE CELL, Fifth Edition

eBook (ISBN 978-0-87893-356-3)

New for the Fifth Edition, *The Cell* is available as an online interactive ebook, at a substantial discount off the list price of the printed textbook. The interactive ebook features a variety of tools and resources that make it flexible for instructors and effective for students. For instructors, the ebook offers an unprecedented opportunity to easily customize the textbook with the addition of notes, Web links, images, documents, and more. Students can readily bookmark pages, highlight text, add their own notes, and customize display of the text. All of the Companion Website's resources are integrated into the eBook, so that students can easily access animations, videos, quizzes, problems, and more while reading the text. For more information, please visit www.sinauer.com/ebooks.

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For the Student

Companion Website (www.sinauer.com/cooper5e)

The Cell's Companion Website is a valuable study aid that is available free of charge to all students. (Instructor registration is required for student access to the online quizzes and problems.) This robust site features a wealth of study and review material coupled with rich multimedia resources including detailed animations, video microscopy, and micrographs. The companion site also includes online quizzes and problem sets that can be assigned by the instructor. The companion website features the following resources:

- Narrated animations of key concepts and processes described in the textbook (listed inside the front cover of the textbook)
- Online quizzes that test student comprehension of chapter material
- Problem sets that help students learn to apply their knowledge
- Micrographs that illustrate cellular structures and components
- Videos showing cellular processes in action
- Flashcard activities to help students learn the important terminology introduced in the textbook
- Web links for further study and research
- Chapter summaries for a quick review of each chapter
- Complete glossary for easy access to definitions of terms

For the Instructor

(Available to qualified adopters)

Instructor's Resource Library (ISBN 978-0-87893-349-5)

The Fifth Edition Instructor's Resource Library includes a wide range of digital resources to aid in course planning, lecture preparation and creation, and assessment. Included are:

- A convenient browser interface
- All textbook figures (art and photos) and tables in both high- and low-resolution JPEG formats
- A variety of PowerPoint® resources:
  - All figures, photos, and tables
  - Complete lecture presentations
  - Supplemental photos and micrographs
  - Videos
  - Animations
- An expanded collection of video microscopy
- The entire collection of animations from the student website
- Over 100 supplemental micrographs
- Problems and quizzes from the student website, with answers
- Textbook end-of-chapter questions, with answers
- The complete Test File, in Microsoft® Word® format
- The computerized Test File (includes Wimba Diploma® software)
- Chapter outlines

Test File by Dennis Goode

(Included on the Instructor's Resource Library)

The Cell's Test File includes a collection of over 1300 multiple-choice, true/false, and short answer questions covering the full range of content covered in every chapter. Questions are organized by chapter heading, making it easy for the instructor to find questions on specific topics, and each question includes a specific textbook page reference. The Test File also includes the quiz questions and problems from the companion website, as well as the textbook end-of-chapter discussion questions. The Test File is provided both as Microsoft Word files and in the Wimba Diploma exam-creation software (software included). Diploma enables the instructor to easily create exams from the bank of questions provided, as well as add their own questions, publish secure Internet exams, and more.

Online Quizzes and Problems by Robert E. McGehee and Brian Storrie

The Fifth Edition online quizzes and problems are available for student use on the companion website. These quizzes and problems are linked to an online grade book that makes it easy to track student performance. In addition, instructors can add their own questions to the quizzes and problem sets, control quiz availability, and more. Instructor registration is required in order for students to access the quizzes. Instructors can register online at the companion website (www.sinauer.com/cooper5e).

Overhead Transparencies

A set of 150 full-color figures from the textbook is available as overhead transparencies. These have been formatted and color-adjusted for optimal projection in the classroom.

Course Management System Support
e-Packs/Course Cartridges

New for the Fifth Edition, *The Cell* now offers a complete e-pack/course cartridge for Blackboard and WebCT. This e-pack includes resources from the Companion Website and the Instructor's Resource Library, as well as the complete Test Bank, making it easy to quickly include a wide range of book-specific material into your WebCT or Blackboard course.

Assessment

Instructors using course management systems such as WebCT®, Blackboard®, and Angel® can easily create and export quizzes and exams (or the entire test bank) for integration into their online course. The entire test file is provided in WebCT® and Blackboard® formats, and other formats can be easily generated from the Brownstone Diploma® software (included).

Additional Media Resources

The following videos are available to qualified adopters of the text:

- Fink, CELLebration (DVD, ISBN 978-0-87893-330-3)
- Pickett-Heaps and Pickett-Heaps, *Diatoms: Life in Glass Houses* (DVD, ISBN 0-9586081-7-2)
- Pickett-Heaps and Pickett-Heaps, *The Dynamics and Mechanics of Mitosis* (DVD, ISBN 978-0-9775222-3-1)
- Pickett-Heaps and Pickett-Heaps, *Living Cells: Structure, Function, and Diversity* (DVD, ISBN 0-9775222-2-9)
- Pickett-Heaps and Pickett-Heaps, *Remarkable Plants: The Oedogoniales (Green Algae)* (DVD, ISBN 0-9586081-8-0)
- Sardet, Larsonneur, and Koch, *Voyage Inside the Cell* (DVD, ISBN 0-87893-755-2)

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