

Preface

Cultural evolution can be defined as a change in the frequency of ideas and practices over time. Introductory biology courses and *Biological Science* are textbook examples.

The courses we design for our majors are changing in response to selection pressure from two sources: the knowledge explosion in biology and dramatic advances in research on how introductory students learn. The knowledge explosion has made it less and less viable to teach an introductory biology course that emphasizes the memorization of facts. At the same time, research on student learning has shown that introductory students struggle to differentiate key unifying concepts from supporting details and that the greatest gains in understanding occur when students have to apply the facts and concepts they are learning to new situations. In a recent article, Handelsman et al.¹ noted that “There is mounting evidence that supplementing or replacing lectures with active learning strategies and engaging students in discovery and scientific process improves learning and knowledge retention.”

Instead of being satisfied with memorization, instructors are training students to use facts. The goal is to have students demonstrate a mastery of content and concepts by applying them in new contexts.

The second edition of *Biological Science* is designed to make the transition to active, higher-level learning easier for both professors and students. Every sentence and figure in the text has been revised with that goal in mind.

Ease of Use

To make the transition to inquiry-based active learning easier, I made two major changes to the second edition: I increased the amount of content coverage to give you more flexibility in the topics you emphasize, and I added study aids to help students with the task of stepping up to a college-level biology course.

Increased Content Coverage

Compared with the first edition of *Biological Science*, this book contains much more content. Recommendations from well over 500 instructors guided decisions on which topics and terms to add. The goal was to provide students with more core coverage and vocabulary, and thereby provide instructors with more flexibility in designing a syllabus and better support for organizing lectures and labs. Experiments still play a central role in this edition, but I trimmed the overall number so that the re-

maining experiments could be developed more thoroughly and with a clearer focus on the concept they illustrate. Throughout, the text retains its commitment to presenting topics in the context of questions, hypotheses, tests, and conclusions. Facts are tools for understanding—not ends in themselves.

New Study Tools

As introductory biology instructors, one of our most important jobs is to help our students become better students. As my colleague Mary Pat Wenderoth says, “We need to help them learn how to learn.” The students in our courses are novices in biology. Like novices in any field, they have a difficult time distinguishing important points from unimportant points. They also struggle with self-diagnosis—to recognize that they do not understand something well. To help students get better at studying biology, and to take some of the burden for doing so off you, this edition offers several new features:

- **Key Concepts** are listed at the start of the chapter and then revisited in the Summary of Key Concepts. Each chapter’s “big ideas” are laid out at the start, developed in detail, and then summarized.
- **Check Your Understanding** boxes appear at the ends of key sections within each chapter. These features briefly summarize one or two fundamental points and then present two to three tasks that students should be able to complete in order to demonstrate a mastery of the material. These boxes are checkpoints—a way for students to make sure that they understand what is going on before they move ahead.
- **Diversity Boxes** serve as the capstone for each of the chapters on biodiversity (Chapters 27–34). Their goal is to present a focused summary of features in key lineages. The detailed information about each group is tied to (1) where it occurs on the tree of life and (2) how and why the featured lineage diversified. Instead of swamping students with details during a traditional “march through lineages,” the diversity boxes present selected information in a well-developed conceptual context.

The Forest and the Trees: Helping Students Synthesize and Unify

In addition to coping with an enormous amount of content in this course, instructors have to manage its diversity. In *Biological Science*, the emphasis on inquiry and experimentation provides a unifying theme from biochemistry through ecosystem ecology. In addition, the text highlights the fundamental how and why

¹Handelsman, J., D. Ebert-May, R. Beichner, P. Bruns, A. Chang, R. DeHaan, J. Gentile, S. Lauffer, J. Stewart, S. M. Tilghman, and W. B. Wood. April 23, 2004. Scientific teaching. *Science* 304(5670): 521–522.

questions of biology. How does this event or process occur at the molecular level? In an evolutionary context, why does it exist?

Most chapters include at least one case history of an analysis done at the molecular level. Natural selection is introduced by exploring the evolution of antibiotic resistance via point mutations in the RNA polymerase gene of *Mycobacterium tuberculosis*. A box in the chapter on behavior features research on alleles that influence fruit-fly foraging behavior.

Similarly, evolutionary analyses do not begin or end with the unit on evolution. Concepts such as adaptation, homology, natural selection, and phylogenetic thinking are found in virtually every chapter. Unit 1, for example, presents traditional content in biochemistry—ranging from covalent bonding to the structure and function of macromolecules—in the context of chemical evolution and the origin of life. Meiosis is analyzed in terms of its consequences for generating genetic variation and hypotheses to explain the evolution of sex.

The overriding idea is that molecular and evolutionary analyses can help unify introductory biology courses, just as molecular tools and evolutionary questions are helping to unify many formerly disparate research fields within biology.

Supporting Visual Learners

Clear, attractive, and extensive graphics are critical to our success in the classroom. The second edition offers a major improvement in the visual presentation of the material. Kim Quillin has revised virtually every figure in the book to increase clarity, accuracy, and visual appeal and to tighten the focus on the central teaching point. Compared with the first edition, this book has 350 additional diagrams and 325 additional photographs.

To support active learning and conceptual understanding, the figures contain several important features:

- **Caption Questions and Exercises** challenge students to critically examine the information in the figure—not just absorb it.
- **Experiment Boxes** offer a standardized design to help students see how biologists answer questions by posing hypotheses and testing predictions, and to give students practice with interpreting data. In some experiment boxes, space is left blank for the null hypothesis, predicted outcomes, or conclusion. Students are challenged to fill them in.
- **Figure Pointers** act like your hand at the whiteboard so that students can easily find a figure's central teaching point.

Throughout the revision, the goal was to build an art program that supports the book's focus on thinking like a biologist. Color is used judiciously to distinguish important points from supporting details and general context. Layouts flow from top to bottom or left to right, and extensive labeling lets students work through each figure in a step-by-step manner. The overall look and feel of the art is clean, clear, accessible, and inviting.

Serving a Community of Teachers

As instructors, we have at least four major texts available that are essentially well organized, well written, and beautifully illustrated encyclopedias of the life sciences. *Biological Science* is different. By de-emphasizing the encyclopedic approach to learning biology and focusing more on the questions and experimental tools that make the science come alive, my aim is to offer a book that is more readable, attractive, and contemporary than traditional texts. Learning concepts well enough to apply them to new examples and data sets may be more challenging for some students than simply memorizing facts, but also it is more compelling. By motivating the presentation with questions and then using facts as tools to find answers, students of biology may come to think and feel more like the people who actually do biology.

Thank you for your devotion to biology, for your commitment to teaching, and for considering *Biological Science*.

Scott Freeman
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Acknowledgments

Contributors

First and foremost, I'd like to acknowledge the second edition contributors for lending their expertise and for providing new ideas and material for this revision. Their commitment to scholarship and their passion for teaching resonated throughout the contributed chapters and had an enormous impact on the published version. In writing an introductory text, it is challenging to appeal to biologists of all specialties yet focus on what a student needs. The contributors were invaluable. They made the material more accurate and teachable and gave me much-needed partners in this endeavor.

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Focus Group Participants

I have been fortunate to be the beneficiary of advice and inspiration from biology instructors attending a series of workshops at Sundance, Utah, since the inception of this book. The first and second editions are influenced by the experiences and wisdom of these visionaries. The focus group attendees read through chapters and helped me make countless critical decisions about content that should be added or deleted or handled differently.

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Media and Supplements Contributors

The media and support materials that accompany the second edition were created by a team of talented and dedicated introductory biology instructors who brought an extraordinarily high level of creativity, experience, and ability to their re-

spective projects. Our goal was to provide an innovative and tightly focused support package that addresses the unique challenges facing instructors and students in introductory biology today. I thank the instructors who attended workshops in which the critical roles of assessment and media in this course were carefully considered and discussed and that lead to guidelines inspiring the creation of content throughout the textbook's support package.

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The Book Team

The production team for this edition brought a high level of experience and expertise to bear and was characterized by a single-minded focus on quality. The tenacity, work rate, and attention to detail of Senior Development Editor Karen Karlin were both instrumental and exemplary. Production Editor Donna Young held the reins with an expert's touch as a large team moved forward at high speed. Illustrator Kim Quillin acted as lead on the figure program and is a talent that comes along once in a generation. In addition to coordinating what is probably the largest review program in the history of textbook publishing, Project Manager Karen Horton managed focus groups, contributors, and media and supplements authors. Senior Media Editor Patrick Shriner worked tirelessly to revise and improve the quality of the media program—never losing sight of the fact that

media must solve problems for professors and students. Photo Researcher Yvonne Gerin again provided superb photo research and was particularly effective at contacting scientists for images of research results that are not available from stock agencies. Formatters Karen Stephens, Vicki Croghan, and Julita Nazario worked patiently under relentless deadlines to create pages for the book and ensure that the layout works for students. Research Scientist Kathleen Hunt, of the University of Washington, is responsible for the dramatically improved Glossary. The entire team was assembled and inspired by Publisher Sheri Snavely, who has been the driving force behind this project since its inception. Her commitment to innovative biology publishing and devotion to meeting the needs of instructors are the reasons that this book exists.

The art program was executed by the talented crews at Pearson Artworks, Quade Paul, and Imagineering; a special note of thanks goes to Managing Editor Patricia Burns and AV Editor Connie Long. I'm particularly grateful to Lee Wilcox, of the University of Wisconsin, who worked with Kim Quillin to upgrade the photo and art program dramatically for all of the plant chapters, and to Robin Manasse, of RMBLueStudios, who worked with Kim to improve the illustrations in the anatomy and physiology unit. Project Art Director Kenny Beck managed multiple rounds of revision on the design and cover and added key creative input. Designer Joseph Sengotta is responsible for creating a clear and accessible text design and a striking cover.

A textbook can help students and professors only if it ends up on their desks. The marketing and sales efforts for this edition are directed by Director of Science Marketing Linda Taft MacKinnon, who was instrumental in making the first edition the most successful launch in the history of majors' biology. Sincere thanks to Senior Marketing Manager Shari Meffert and to Marketing Manager Andrew Gilfillan for their work on the thoughtful preview booklet and their continued tireless efforts in the field on behalf of *Biological Science*. I extend a special thank you to Director of ESM Sales Programs Meghan O'Donnell and to the Sales Directors—especially Don O'Neal, Rebecca Bersagel, Kate Brousseau, Brian Buckley, Megan Donnelly, Meghan Duffy, Christine Henry, Tom Johnson, and Michelle Renda—for their input, travel, and commitment to this effort. I'm also deeply grateful to Dave Theisen, National Sales Director for Key Markets, for his tactical skill and devotion to this book.

Finally, I thank my students at the University of Washington for inspiration, Barb Radin for invaluable help with cataloging and organizing reviewer comments, and Ben and Peter Freeman for love and support.

This book has two dedications. The first is to the memory of Bill Keeton and Neil Campbell, whose books inspired two generations of introductory biology students. As teachers and authors, they are the giants whose shoulders I try to stand on. The second is to my wife, Susan. After 24 years together, I have one thing to say: I am the luckiest man alive.

Reviewers

The review program for the second edition was even more rigorous than that for the first edition. The chapters were reviewed three times as they moved through the revision process. Reviewers included star instructors who addressed issues such as level, pacing, accuracy, and student comprehension. Other reviewers were experts in particular fields who focused primarily on making sure that the details are correct and that chapters are authoritative and current. In addition, all 55 chapters underwent a fourth and final review for accuracy just prior to publication. To a person, our reviewers supplied exemplary attention to detail, expertise, and empathy for students. I am deeply indebted to all of the colleagues who reviewed chapters of *Biological Science*; it is not possible to overstate how crucial these individuals are to the success of this book. Their effort reflects a deep commitment to excellence in teaching and a profound belief in the importance of introductory courses for training the next generation of professionals.

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