

As we head into the new millennium, understanding the concepts of biology and their connections to our lives is more important than ever. Whether we're concerned with our own health or the health of our planet, a familiarity with biology is essential. This basic knowledge and an appreciation for how science works have become elements of good citizenship in an era when informed evaluations of health issues, environmental problems, and applications of new technology are critical.

The "connections" to which the title of this book refers go beyond the practical applications of biology. Biology has important connections with the other natural sciences and with the humanities and social sciences as well. And the study of life has no coherence without an understanding of the connections among the different areas of biology and an appreciation of the grand unifying theme of evolution. From its first edition, the hallmarks of this book have included an emphasis on connections within biology and between biology and other fields, and a focus on engaging students from a wide variety of majors.

We could not have hoped to meet our ambitious goals for this book without extensive discussions with teaching colleagues throughout the world and feedback from many of the hundreds of instructors and hundreds of thousands of students who have used our earlier editions. We have been gratified by their enthusiastic responses and have paid close attention to their thoughtful suggestions for improvement. For this third edition, we set out to create a book that would be an even more effective tool for learning biology. In addition, we worked to ensure that the new book would integrate smoothly with an exciting new program of supporting materials in electronic media.

TEACHING STRATEGIES OF BIOLOGY: CONCEPTS & CONNECTIONS, 3RD EDITION

How can we help students learn—and enjoy—biology? How can we help instructors teach biology? Our responses to these questions are reflected in the teaching strategies we bring to the book. In this new edition, we build on the approach that has been so successful in earlier editions. Below we describe our five main teaching strategies as they are embodied in the third edition of *Biology: Concepts & Connections*.

This book brings the main concepts of biology into sharp focus—and now makes their organizing framework more explicit

Biology is a vast subject that gets bigger every year, but a general biology course is still only one or two terms long.

In that brief time, we explore all of life, from molecules to ecosystems, while also trying to share the excitement of important research breakthroughs. For beginning biology students confronting this avalanche of information, it can seem as important to memorize all the scientific terms and facts as it is to master and apply the major ideas. This situation changes, however, when students can acquire a framework of key biological concepts into which they can fit the many new things they learn. It is this framework of concepts that will serve them long after they have forgotten specific facts and terms.

Biology: Concepts & Connections was the first introductory biology textbook to use concept modules to help students recognize and focus on the main ideas of each chapter. The heading of each module is not simply a topic but a carefully crafted statement of a biological concept. Printed in large type, each concept serves as a focal point for a module, and all of the module's text and illustrations converge on that concept with explanation and, often, evidence. For example, "Sensory receptor cells convert stimuli into electrical energy" announces a key concept in Chapter 29 (Module 29.2). The text and illustrations introduce the general principles of sensory reception and transduction, using the human sense of taste as an example. In this and other modules, we integrate the words and pictures to an unprecedented degree: The text "walks" the student through the illustrations, just as an instructor would do in class. In teaching a sequential process, such as the functioning of the receptor cells of the taste buds (Figure 29.2A), we number the steps in the text to correspond to numbered steps in the figure. The synergy between a module's verbal and graphic components transforms the concept heading into an idea with meaning to the student.

In this new edition, we make the framework that connects a chapter's concepts more explicit by grouping the concept modules under prominent general headings. For example, the concept modules in Chapter 4 that describe the structures and functions of the nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, and vacuoles are grouped under the general heading "Organelles of the Endomembrane System." Students first see the framework of general headings and subordinated concepts in the outline that now opens each chapter, and the general headings are displayed on maroon bars where they fall within the chapter. They are also used to organize the Chapter Summary at the end of the chapter.

Reinforcing the message of every module in this edition is a checkpoint question. Located at the end of each module, these questions encourage students to test themselves repeatedly as they proceed through a chapter. The questions vary in approach. Some questions directly test the student's understanding of the main concept or part of it; others test understanding of the supporting evidence or ask the student to connect the concept to another concept

in the book; still others require the student to carry out a calculation using information in the module. Feedback is provided on the spot: The answer is printed upside down beneath the question. These questions are intended to make students *think* about the material they are studying and to build confidence; opportunities for more comprehensive self-testing are provided at the end of the chapter and in the materials that accompany the book.

Application modules relate biological concepts to students' lives

Students are more motivated to study biological concepts that they can connect to their own lives and interests—concepts associated with health issues, economic problems, environmental quality, ethical controversies, and social responsibility. In this edition, heading statements in green type with a red shading in the background distinguish the numerous application modules that go beyond the core biological concepts. We have also reorganized Unit II, Cellular Reproduction and Genetics, placing more modules dealing with human biology and medicine closer to related core concepts. At the end of each chapter in the book, “Science, Technology, and Society” questions encourage students to apply the concepts they have learned to various social and environmental issues.

Organisms and biological diversity remain center stage throughout the book

Students are more familiar with animals, plants, and other organisms than they are with molecules, cells, or even ecosystems. *Biology: Concepts & Connections* builds on that interest by keeping the spotlight on organisms in every chapter. The illustrated essay that begins each chapter usually portrays a natural scene featuring a biological species and how it is adapted to its environment. The biology of that organism and others is woven through the chapter, even when the chapter takes students inside organisms for a look at cells or stands back for a view of populations, communities, or ecosystems. Our hope is that the chapter-opening essays will help nurture students' and thus society's, appreciation for biological diversity.

This edition ends with a new, capstone chapter on conservation biology, Chapter 38, which further highlights the importance of biological diversity and scientific efforts to sustain it.

The many connections to whole organisms also contribute to the book's versatility in serving a variety of syllabi. Whether a course begins with biological chemistry, with ecology, or somewhere in between, instructors can customize the chapter sequence without having students

lose their orientation; whatever the topic, students can connect the concepts to whole organisms.

The theme of evolution unifies the book

Organisms are this book's stars, and evolution provides its story line. The history of life on Earth goes back more than three and a half billion years, and this past is the key to the present diversity of organisms. As the unifying theme of this textbook, evolution elevates biology from a bewildering collection of facts to a coherent study of changing life on a changing planet. In *Biology: Concepts & Connections*, students will study the structure, function, and behavior of organisms in an evolutionary context. And throughout the book, students will view the unity and diversity of life—the similarities and differences among organisms—as the dual consequences of descent with modification. Our updated and enhanced coverage of evolution in Chapter 1 and Unit III, including the new Chapter 19 on human evolution, strengthen the unifying theme of the book.

The process of science continues to be prominent in this new edition

A biology course should make students familiar with the scientific process of posing and testing hypotheses. With an improved introduction to the process of science in Chapter 1, students will be better equipped to appreciate the many examples throughout the book of how scientific concepts emerge from observations and experimental evidence. The book also puts human faces on science with “Talking About Science” modules. A number of these profiles of interesting scientists are new to this edition.

In the review material that concludes each chapter, questions called “Thinking as a Scientist” give students some personal practice with science as a process. Other ways of connecting to the process of science are provided to users of this book via electronic media. Activities on the Student Interactive Study Partner CD-ROM that comes with each new book, as well as activities available at the book's web site, provide further exposure to the scientific process. In fact, this book will work best for students who participate actively in learning about biological concepts and their applications.

NEW CONCEPTS AND CONNECTIONS IN THIS EDITION

Chapter 1, “Introduction: The Scientific Study of Life,” includes a modern introduction to the diversity of organisms and their classification, focusing on the three domains—Bacteria, Archaea, and Eukarya. The chapter now

features ongoing studies of rainforest epiphytes as an extended example of how the process of science works. Module 1.5 presents life's fundamental features more explicitly than in previous editions.

In **Unit I, The Life of the Cell**, our introduction to the basic chemistry, structure, and energetics of cells, we have fine-tuned a number of modules to help clarify topics that students find difficult. Topics that have been updated include the functions of the cytoskeleton (Module 4.17) and the extracellular matrix (Module 4.19). Among the improved figures is Figure 7.6B, showing the interaction of light with chloroplasts; the same module has new information about the functions of carotenoids in plant cells. A new Talking-About-Science module (7.14) features Nobel laureate Mario Molina, who discusses his research on the Earth's ozone layer.

In reorganizing **Unit II, Cellular Reproduction and Genetics**, we have integrated topics in human genetics that were formerly in the last chapter of the unit into earlier chapters to support the core genetic concepts where they are first presented. The result is a unit that will be more accessible and appealing to students. Other highlights of the revision of Unit II include clearer diagrams of mitosis and meiosis (Modules 8.6 and 8.14), a new emphasis on human pedigrees in Module 9.8, updated coverage of animal cloning (Module 11.3), and a more focused account of the regulation of gene expression in eukaryotes (see especially Module 11.6). To our already strong coverage of the genetic basis of cancer (Modules 11.13–11.15), we have added an interview with leading breast-cancer researcher Mary-Claire King. The final chapter in the unit, Chapter 12, is now titled “DNA Technology and the Human Genome,” highlighting the book's updated description of human DNA and the progress of the Human Genome Project (Modules 12.13–12.15). The verbal and graphic explanations of the major methods of DNA technology and their applications to law, industry, medicine, and agriculture have been improved. Two modules on the risks and ethical questions arising from the use of the technology conclude the chapter and the unit.

Major new features in this edition's **Unit III, Concepts of Evolution**, include a discussion of alternative species concepts (Module 14.2) and a new interview with popular author and educator Richard Dawkins (Module 14.9). Also, in Chapter 15, we have added new material on evolutionary trends in horses (Module 15.8) and have extensively revised our coverage of DNA and RNA sequence analysis in evolutionary research (Module 15.12). The new Module 15.14 provides a step-by-step illustration of cladistic analysis.

Unit IV, The Evolution of Biological Diversity, includes a modern treatment of archaea (Modules 16.8 and 16.12) and recent hypotheses about the origins of metabolism (Module 16.11). In Module 16.15, on pathogenic bacteria,

we explain how certain strains of *E. coli* can cause life-threatening illness. Module 17.9 now includes a discussion of the loss of biological diversity in harvested forests and includes some thoughts on forest management by Michael Dombeck, Chief of the U.S. Forest Service. Several new photos enhance our coverage of animal diversity in Chapter 18. We also have added a section on incomplete and complete metamorphosis (Module 18.13), and updated our discussion of the evolutionary relationships between annelids and arthropods (Module 18.12), lungfishes and amphibians (Module 18.19), and dinosaurs and birds (Module 18.21). Module 18.23 includes a discussion of the current controversy about the origins of segmentation. Opening with an illustrated essay on the Tyrolean Ice Man, Chapter 19, Human Evolution, now completes this unit.

Our revision of **Unit V, Animals: Form and Function**, includes new information on the hormonal control of fat metabolism (Module 21.15), more attention to the health hazards of tobacco and smoking (Module 22.7), updated applications of monoclonal antibodies (Module 24.12), and a clearer account of the roles of T cells in immunity (Module 24.13). The introduction to Chapter 26 has an updated discussion of the hormone melatonin. Reflecting the rapid pace of research in neurobiology, our revision of Chapter 28, Nervous Systems, was the most extensive in this unit. New art and added text enhance our survey of nervous-system structure in Modules 28.10 and 28.11. In Modules 28.14 and 28.15, a new figure and a table illustrate human brain development and adult structure. The chapter ends with a new module on cellular changes in long-term potentiation and long-term depression.

Reflecting exciting new discoveries in plant biology, the most extensively revised chapter of **Unit VI, Plants: Form and Function**, is Chapter 33, Control Systems in Plants. New to this chapter are an updated discussion of biological clocks in plants (33.10), an interview with leading *Arabidopsis* researcher Gloria Coruzzi (33.13), and an up-to-date account of the defenses against herbivores and pathogens that have evolved in plants (33.14).

A significant new feature of **Unit VII, Ecology**, is a greater emphasis on disturbance and environmental change, both natural and human-caused. We make the connection between habitat alteration and the current high rate of species loss early in the unit (Module 34.9). Module 36.6 elaborates on the pivotal roles of disturbance in communities, providing the necessary background for a detailed look at ecosystem alteration and its effects in our new conservation biology chapter (Chapter 38). New topics in this capstone chapter include the value of biodiversity, human impacts on habitats in developed and developing nations, biodiversity hotspots and endemic species, population fragmentation, source and sink habitats, population viability analysis, landscape ecology, gap analysis, movement corridors, and restoration ecology. Other highlights

