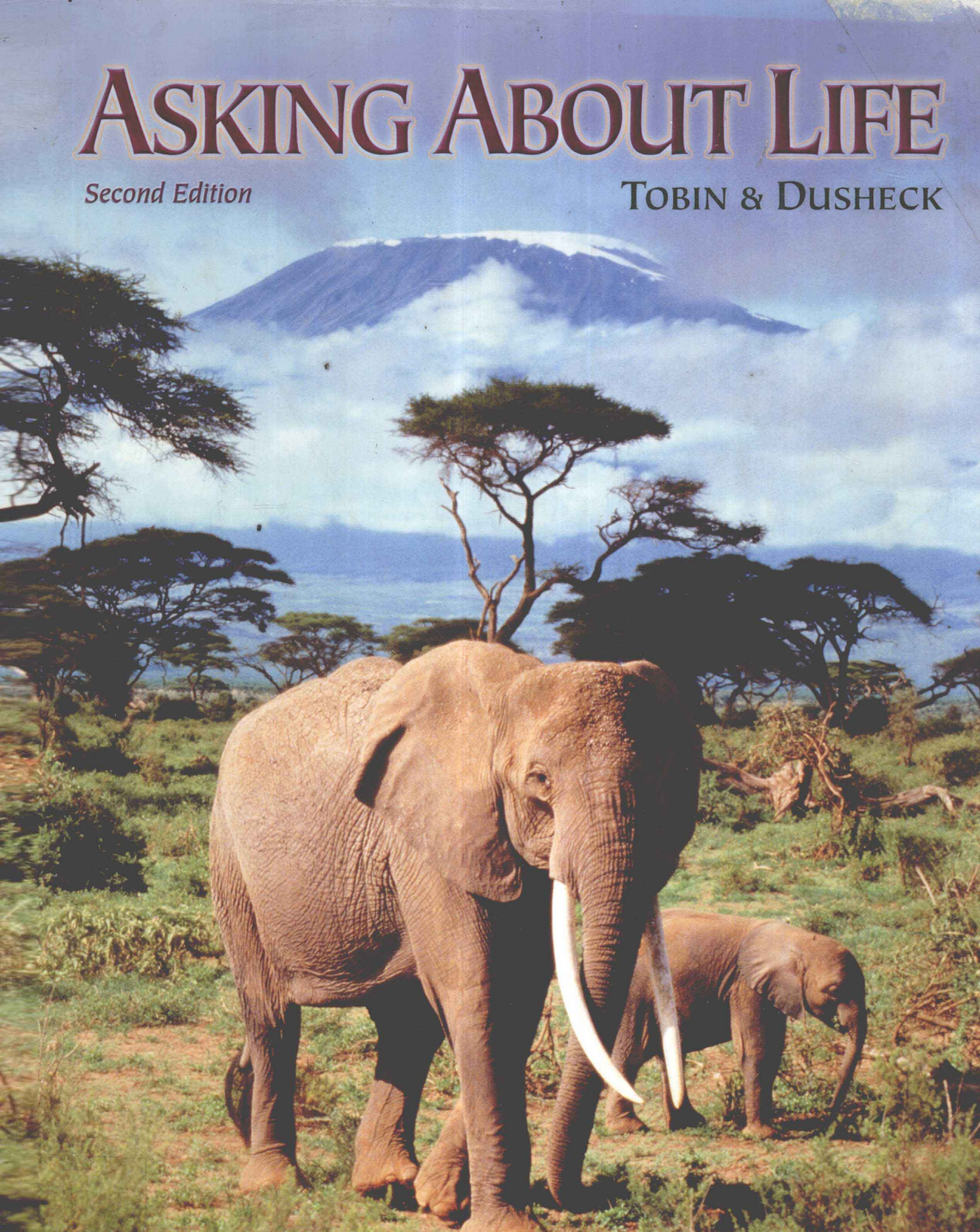
Asking About Life

Second Edition

Tobin & Dusheck



Asking About Life

Second Edition

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Preface

Many good conversations start with a question. What do you think of the new ballpark downtown? Is the new sociology professor a good lecturer? Science is one long conversation, like a thousand-year cocktail party. And, as at any party, the topics of conversation often start with questions. Why are plants green? How do cells replicate?

The history of science reveals that the answers to such questions change over time, but the questions themselves, if they are good ones, remain the same. One good question has been, "How do new species form?" Ever since biologists realized that species do form, we have been trying to find out *how* they do it. But it is a question with many overlapping answers. The answers that seemed correct in 1880 or 1960 continue to be refined, expanded, or even overthrown.

In this new edition of *Asking About Life,* we present some new answers and some new approaches. But our starting point, that science is about curiosity, remains the same. We emphasize *how* and *why* scientists ask questions, how they test hypotheses, and how they reach conclusions. As much as possible, rather than merely presenting dry conclusions, we show our readers how science actually works. For example, we present the many pieces of evidence that convinced scientists that all life evolved from simple organisms. And we present the experimental steps that revealed how plants use sunlight to build sugar molecules, during photosynthesis.

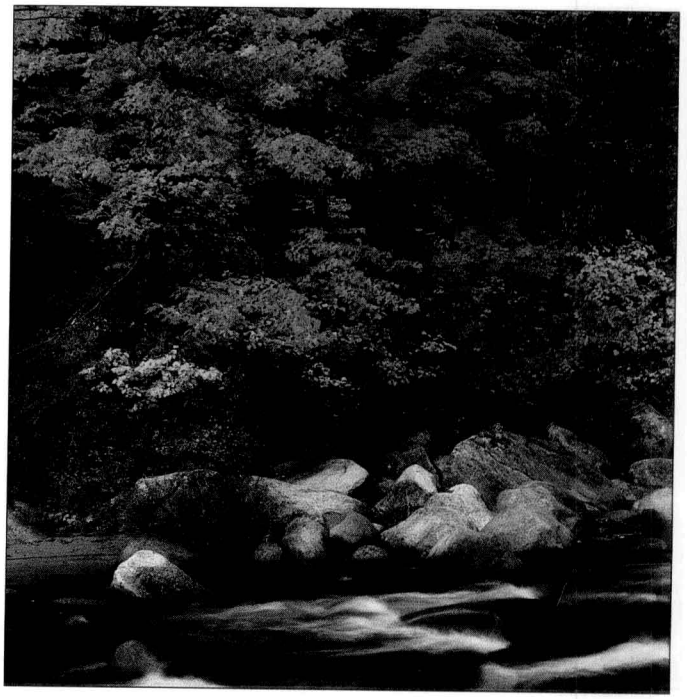
Although our philosophy remains the same, we have improved the book in several important ways. Above all else, we have continued to refine and clarify our written explanations. As we write each sentence, we think first and foremost about how we can help our readers better understand biology.

We have added new metaphors and analogies, new lead-in stories, and new art. Some of our metaphors appear in the text alone, while others appear in figures as art or photos. As in the first edition, we compare chromosomes to socks and the functional groups of molecules to the attachments on a Swiss Army knife. But we have introduced new metaphors, such as the windmill in Chapter 25 that illustrates the idea that organisms recycle materials but not energy. Good visual metaphors help readers remember important concepts.

We regard illustration as a teaching tool in its own right, not just a reinforcement of the text. We have continued to work closely with nationally prominent illustrator Elizabeth Morales, whose skill, attention, and insight have contributed not only to the art manuscript but to the text as well. Morales, the current president of the Guild of Natural Science Illustrators, has been our art developmental editor since the first art meetings for the first edition. She has created a warm, friendly style that perfectly complements the conversational tone of our text. Her clean designs and precise illustrations greatly clarify sometimes difficult material. In addition, we retain many of the beautiful pieces done by natural science illustrator Elizabeth McClelland for the first edition.

We have updated and expanded our coverage of ecology. We think students need to know, for example, that ecology now includes global oceanic and atmospheric studies. Readers can also learn that population biologists study not only questions about how populations regulate their numbers (or fail to), but also the sad story, repeated all too often in modern times, of how species go extinct.

We have introduced a new section on statistics in Chapter 1. We hope this brief overview will be especially useful in



Stephen J. Krasemann/Photo Researchers, Inc.

classes where students encounter the first rudiments of statistics in a lab component of a course. Our purpose, however, is not to teach statistics *per se,* but to help students see why statistics is an essential analytical tool in biology and how it affects experimental design. We hope our brief introduction to the concepts of sample size and variation will prompt students to ask skeptical questions about science stories in the news.

Despite all these new features, the basic vision of *Asking About Life* remains the same. We continue to present biology in the context of the development of biological ideas, never as disconnected facts. We present a relatively few ideas in some depth rather than many ideas superficially.

Asking About Life consistently emphasizes the importance of questions and the process of finding answers. To remind ourselves and our readers of this emphasis, headings and subheadings are more often questions than statements. In addition, at the end of most subsections we summarize the main points covered. The question heading and the summary statement together act as a reality check for both readers and the authors. In our first edition, many readers pointed out that we didn't always answer the questions in the headings. Did we ask the wrong question? Or, did we not answer our own question? Truth to tell, sometimes the former, sometimes the latter. In this edition, we have taken special pains to improve our questions, as well as answers.

Fixing our mistakes has convinced us more than ever that asking explicit questions is the best way to talk about science. We have done our best to improve the question headings. But we welcome sharp-eyed readers to catch us up now and again. Readers of this edition who do not think we have answered the question in the heading should alert us at jennie.dusheck@pobox.com. We look forward to hearing from you.

Refining questions and fixing mistakes is the way science works. What scientist hasn't been brought up short by an insightful comment from a colleague? The way questions, or hypotheses, are phrased determines how they can be answered. Sometimes scientists ask the wrong questions. Sometimes they come up with the wrong answers to the right questions. The process is a delightfully social one, in which everyone can play a key role.

Throughout *Asking About Life,* we have emphasized the passionate engagement of individual scientists. Each chapter begins with a story illustrating how an individual biologist or group of biologists pursued a scientific question—often in the face of intense intellectual and social adversity. We tell the story, for example, of how Barry Marshall convinced first himself and then others that bacteria, not "frustrated personalities," cause ulcers; and how Rosalind Franklin struggled in deep social isolation to elucidate the structure of DNA. Our anecdotes are about real people—their triumphs, their frustrations, their genius, and their persistence. Biology is a story, and, as such, it must be presented as continuously as possible.

In every kind of learning, story and context give shape and meaning to dry facts and ideas. When we are told that someone named Charles Drew invented a way to supply clean blood plasma, a new technology that saved many lives, we may remember this fact briefly. But what if, as happens in Chapter 37, we also learn that Drew was one of only a handful of African-American physicians in the United States in the 1940s? At that time, black physicians did little or no research, but were mostly relegated to quiet country practices in the rural South. Yet Drew ran the "Plasma for Britain" program for the American Red Cross during World War II and invented a way to preserve blood plasma so that it could be shipped across the Atlantic to Great Britain. His work saved the lives of thousands of Londoners injured by Nazi bombs. Midway through the program, however, the American Red Cross decided to refuse blood from any American donor whose skin was black, and Drew resigned in protest. An eminent professor of surgery at Howard University, Drew suffered serious injuries in an auto accident a few years later. Within hours of the accident, he was dead. He bled to death in a small Southern emergency room where neither whole blood nor plasma could save him.

Life's too short not to hear the whole story. Our philosophy of telling the stories of biology sometimes runs counter to current trends. Many textbooks break up information into modules in which each bit of information is presented dictionary-fashion, as if unrelated to the information in the rest of the book. Important ideas may be marooned on illustration islands. The result is a series of disconnected facts. Publishers say that such an approach is necessary because today's students belong to the "visual-information generation" and are incapable of sustained reading or synthesis.

We have more faith in students. We know they enjoy reading, provided the reading is interesting and rewarding. Indeed, student reviewers have raved about the clarity of the writing and the engaging stories that reveal scientists as ordinary human beings.

In the evolution section, for example, we mention the intense frustration Charles Darwin experienced while struggling to distinguish among different species of barnacles. Each species seemed to blend into the next. In the next chapter, on classification, we show readers that biologists have been arguing about the definition of a species for nearly 200 years. In the context of Darwin's difficulties, the highly politicized debate over whether the red wolf is a species (that deserves legal protection) or a hybrid (that doesn't) takes on a different and deeper meaning. At the same time, the red wolf story brings to life what might otherwise be an abstract discussion of classification.

While we stress the continuity of ideas within a discipline, however, we know that every instructor takes a different approach to teaching biology. Therefore, each unit of the book is understandable on its own terms. Nothing prevents instructors from teaching the units in a different order.

The first edition of *Asking About Life* was well received. The Italian publisher Edizioni Bruno Mondadori selected *Asking About Life* for translation into Italian. And, in 1999, the

Text and Academic Authors association conferred on the book an award of excellence for best new textbook in life sciences. But we are most proud of the many instructors and students who have told us they love our book. Thanks to them for their remarkable support.

Who Made This Book?

Our developmental editor, Lee Marcott, continues to be an active participant in the work on *Asking About Life.* In addition to editing the manuscript, and choosing excellent reviewers, Lee has also tactfully managed the two authors—pushing us to meet deadlines, organizing us, and giving us pep talks.

Photo researcher Amy Ellis Dunleavy's novel photo ideas continue to give the book much of its personality. Project editor Bonnie Boehme kept the flow of paper moving smoothly during production and broke up many a logjam with quick-witted solutions and generous contributions of her own time. Art director Caroline McGowan's consistent sense of design gives the book much of its unity and elegance, and her sharp eye caught mistakes in biology as well as the occasional misplaced "leader line" or missing label.

We also thank production manager Charlene Catlett Squibb, manager of art and design Carol Bleistine, and designers Ruth Hoover and Kim Menning. And we deeply appreciate the work of many others who have contributed to this book—including Donald Jackson, Michael Brown, Edward Murphy, Elizabeth Widdicombe, Julie Alexander, and Edith Beard Brady. We thank especially publisher Emily Barrosse for her special combination of toughness and warmth and executive editor Nedah Rose for her cool head and patience. Senior marketing strategist Kathleen Sharp and field editorial specialist Dave Theisen have made creative contributions to the sales and marketing efforts of both the first and second editions.

Special thanks also to Naomi Cappuccino of Carleton University, Mary Kay Cassani of Edison Community College, Kerry S. Kilburn of Old Dominion University, and Jorge Rey of the University of Florida, all of whom helped us with the ecology section in different ways. We also thank science writer Marina Chicurel, who wrote the new story about Stanley Prusiner (Chapter 3); science writer Liese Greensfelder, who revised the discussion of phylloxera in Chapter 31; Marni Fylling, who wrote and illustrated the accompanying lab manual; Harry W. Greene of Cornell and Daniel J. Meinhardt of St. Olaf College, both of whom helped ease us through the subtleties of cladistics; Nancy Segal of Cal State Fullerton, who provided the striking pictures of twins in Chapter 9 and suggested changes to the text; Barney Schlinger and Gordon Fain, of UCLA, Warren Burggren, of the University of North Texas, and Michael Stryker of UCSF for their help in refocusing some of the physiology chapters; John E. Wilkes of the University of California, Santa Cruz, who read and skillfully copyedited many chapters of this edition; Primavera Hernandez, Annie Gallo, April Hosein, and Vanessa Flores, who helped with the book in dozens of ways; and the students in Life Sciences 2 at UCLA, whose comments, suggestions, and enthusiasm were especially valuable in preparing the second edition. Finally, we thank Richard Robinson, Mary K. Miller, Karen Scanlon, and Natalie Peretti for their work on the Web site that accompanies this book.

We thank all the reviewers who took the time to read and comment on this manuscript—correcting our errors, asking thought-provoking questions, and suggesting examples, alternative wordings, or new ways of thinking. Although we have met only a few of our reviewers in person, working with them has been a rewarding intellectual experience. Both the process of writing this book and the resulting book itself would not have been the same without the reviewers.

What Kinds of Pedagogy Does *Asking About Life* Employ?

Asking About Life has a variety of features designed to engage the reader and to aid student learning. Each chapter begins with a story about a piece of research that draws students into the subject of the chapter and also introduces the key questions and ideas that are discussed. The chapter-opening image is described at the end of each chapter in a new feature called **About the Chapter-Opening Image.**

At the start of each chapter, readers will find a list of **Key Concepts,** which are the most basic ideas covered in the chapter. Most headings are posed in the form of questions. These question headings focus the reader's attention on the most significant question to be explored in that section. Following most subsections is a **Summary Statement**—a brief summary of the take-home message. Summary Statements provide students with a reality check. If the student doesn't understand the summary statement, that is a cue to study the preceding material more closely.

Visual metaphors rendered as photos or illustrations drive home key points introduced in the text. Drawings and photographs support concepts covered in the text and help students visualize the structures of objects as diverse as molecules and ecological communities. Photographs of structures that are too small to be seen with the naked eye are accompanied by size bars to give a sense of scale. And **tables** and **graphs** summarize key facts and additional material. Most chapters feature one or more **Boxes,** which introduce science in the news or discuss special topics in greater depth. Figure legends are designed to stand alone, so that a student flipping through the chapter for the first time, glancing at the diagrams and reading the legends, will learn something.

The second edition of *Asking About Life* introduces our book-specific Web site with additional material in the form of **Web Bits.** An icon in the margin lets the reader know that a trip to the *Asking About Life* Web site offers related information, extra exercises, quizzing, and so on.

Throughout the text, **boldface key terms** help students to locate key terms and their definitions. At the end of each chapter, all of the boldface terms are used again in a highly compressed summary called the **Study Outline with Key Terms.** The Study Outline provides students with another opportunity to check their understanding of the chapter. If they encounter terms they don't remember or ideas that seem unfamiliar, they can return to the main text and illustrations.

Following the Study Outline is a set of **Review and Thought Questions.** Our Thought Questions are especially engaging, frequently bringing ideas in the chapter into the everyday world. At the end of the book, a periodic table (Appendix A), a table of standard weights and measures (Appendix B), and a **Glossary** provide useful reference information for students.

Supplements

To further facilitate learning and teaching, we provide a carefully designed supplements package for students and instructors.

Marni Fylling's **Laboratory Manual to accompany *Asking About Life,*** Second Edition, covers laboratory topics drawn from six units of the text. Each of the 15 labs accompanies a specific chapter (or chapters) from the book. These interactive labs use familiar materials to give students a hands-on approach to basic biological principles. Author Marni Fylling is an accomplished artist/illustrator, and the manual is fully illustrated with nearly 150 full-color line drawings and photographs.

The **Study Guide,** by Lori Garrett of Danville Area Community College, includes the Key Concepts, an Extended Chapter Outline that gives an overview of the most important topics covered in the chapter, Vocabulary Building exercises, and Chapter Tests. Each Chapter Test has four parts: Multiple Choice; Matching; Short Answer; and Critical Thinking—Using Your Knowledge. All answers are provided, with the exception of the Critical Thinking—Using Your Knowledge questions.

A Guide to *Asking About Life* for Teachers and TAs by Donald Cronkite of Hope College is an instructor's manual for teaching biology using the inquiry-based approach of the textbook. It includes suggested syllabi for teaching using various themes, such as biodiversity, cellular and molecular approaches, and social issues, as well as one- and two-semester courses. Chapters offer intriguing demonstrations, interactive exercises, and group learning. The Preface provides a listing of where the various types of exercises can be found in the manual. Answers to the Review and Discussion Questions from the textbook also appear in the teaching guide.

The **Test Bank,** by Alma Moon Novotny of the University of St. Thomas, and Frederick Peabody of University of South Dakota, consists of 2950 questions of assorted type (multiple choice, fill-in-the-blank, and short-answer essay questions). These are organized by the main chapter headings. The **Computerized Test Bank** is available for both Windows™ and Macintosh® platforms. The computer program allows the instructor to sort the questions by chapter, section head, and question type.

The *Asking About Life* supplements package also includes a set of 200 **Overhead Transparencies** consisting of drawings from the book and a **Student Art Notebook,** which is a set of 300 unlabeled, full-color line drawings from the text. Our Custom Overhead Transparency Program allows instructors to choose additional four-color images from the text.

An **Instructor's Resource CD-ROM for Biology 2001** features selected photographs and all the line art illustrations from *Asking About Life,* Second Edition, and can be used with PowerPoint™ and Persuasion™ on both Macintosh® and Windows™ platforms. A variety of file formats include Web-ready PDFs, print-ready PDFs, and files for use in creating custom overhead transparencies and custom PowerPoint™ presentations. Eric Rabitoy and Terry Damron of Citrus College have created a **PowerPoint™ Presentation** that is available at the *Asking About Life* Web site for downloading as well as on the IRCD-ROM.

The **Process of Science: Discovering Biology™** CD-ROM reflects the spirit of inquiry that characterizes *Asking About Life,* Second Edition. It allows students to explore the discoveries of some of the most important concepts in biology. In the *Interactive Investigations,* students retrace the steps of scientists' experiments and discoveries using the scientific process as their road map. An *Investigator's Notepad* allows the students to track their progress through each investigation, to pose new questions for themselves to pursue, or to initiate a discussion with the instructor or other students via an Internet connection. *Concept Tutorials* provide students with essential background information in general biology for the course and the investigations.

The CD-ROM set **Introduction to Biology,** created by Archipelago Distributed Learning, consists of four CD-ROM disks with an **Instructor's Guide** and a **Student User Guide.** The course covers all the topics that would be covered in a two-term introduction to general biology and can be used as an ancillary to any general biology text, such as *Asking About Life.* Heavily illustrated and complete with animations and videoclips it can be used by students for self-study or as projection software for the instructor. A demonstration of the course is posted at the *Asking About Life* site.

A **WebCT** course for *Asking About Life,* Second Edition, is in development for the text, the first semester of which will be ready for use in Fall, 2000. A demonstration of Chapter 4 from the WebCT course can be accessed at the book site.

Please visit our *Asking About Life* Web site at http://www.harcourtcollege.com/lifesci/aa2/

Students will find:

- A set of Web links for each chapter, including a bibliography of books, readings, and other media for each unit of the text.

- Sets of quiz questions and answers for self-testing of each chapter.
- On-line glossary of words in *Asking About Life.*
- View-only versions of the PowerPoint™ Presentation.
- **Web Bits**—short articles that expand ideas from certain chapters. (These are indicated by an iconic spider web.)
- Samples of the **Lab Manual, Study Guide,** and **Student Art Notebook** will be posted so that students are aware that these study aids are available to them for purchase.

Instructors will find:

- The **Teacher's Guide** posted chapter-by-chapter.
- Sample syllabi for one- and two-semester courses and courses emphasizing a particular theme or approach.
- Answers to the Review and Thought Questions in the text.
- Downloadable **PowerPoint™ Presentations** for all the line drawings in the text.
- **Test Bank** for the Second Edition.
- Image bank of the line art illustrations from the text.
- WebCT demo of Chapter 4.

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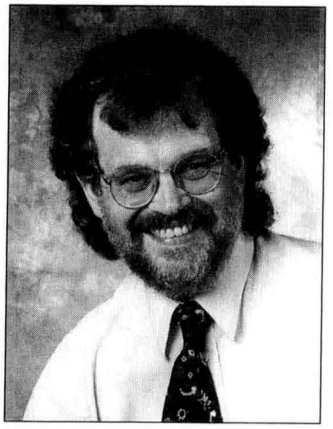
Andrew Scala, *Dutchess Community College*
Shirley Seagle, *Jacksonville State University*
Phillip R. Shelp, *Brookhaven College*
John Simpson, *Gadsden State College*
Linda Simpson, *University of North Carolina, Charlotte*
Michael E. Smith, *Valdosta State University*
Fred L. Spangler, *University of Wisconsin, Oshkosh*
Steven Spilatro, *Marietta College*
Herbert Stewart, *Florida Atlantic University*
Cindy Stokes, *Kennesaw State College*
Jeffrey Thompson, *California State University, San Bernadino*
Janice Toyoshima, *Bakersfield College*
John Tramontano, *Orange County Community College*
Michael J. Ulrich, *Elon College*
Kristin Vessay, *Bowling Green University*
James A. Winsor, *The Pennsylvania State University, Altoona Campus*
Daniel Wivagg, *Baylor University*
Tom Worcester, *Mt. Hood Community College*

For George Dusheck and Eve Tobin
And in Loving Memory of Nina Dusheck and Maurice Tobin

About the Authors

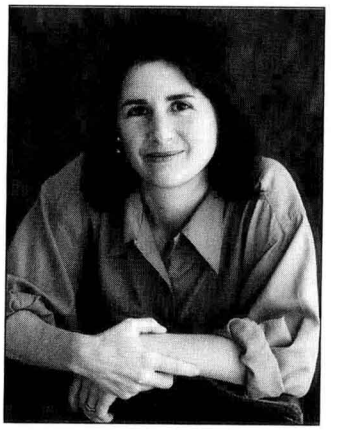


Allan J. Tobin

Is Director of the UCLA Brain Research Institute. He holds the Eleanor Leslie Chair in Neuroscience at UCLA, where he is both Professor of Neurology and Professor of Physiological Science. Tobin is also Scientific Director of the Hereditary Disease Foundation (HDF), where he helped organize the consortium that identified the gene responsible for Huntington's disease. Both at UCLA and at HDF, he has encouraged close interactions among cell and molecular biologists, geneticists, physiologists, and clinicians, with the goal of bringing basic science discoveries from the laboratory bench to the patient's bedside.

Tobin's undergraduate degree is in literature and biology (MIT, 1963), and his doctoral degree is in biophysics, with an emphasis on physical biochemistry (Harvard, 1969). Tobin did postdoctoral work at the Weizmann Institute of Science, in Israel, and at MIT. At UCLA, his active research laboratory studies the production and action of GABA, the major inhibitory signal in the brain. These studies may eventually lead to new therapeutic approaches to epilepsy, Huntington's disease, and juvenile diabetes. Tobin is the recipient of a Jacob Javits Neuroscience Investigator Award from the National Institute of Neurological Disorders and Stroke.

For more than 35 years, Tobin has taught introductory courses in general biology, cell biology, molecular biology, developmental biology, and neuroscience. He is the recipient of a UCLA Faculty Teaching and Service Award and is regarded as an excellent and highly interactive teacher.



Jennie Dusheck

Is a writer living in Santa Cruz, California. She is a lecturer in science writing and illustration at the University of California, Santa Cruz, and a member of the National Association of Science Writers. Her undergraduate degree is in zoology (U.C. Berkeley, 1978) and her master's degree (by thesis) is in zoology (U.C. Davis, 1983). She also holds a certificate in science writing from U.C. Santa Cruz (1985).

Dusheck has written for *Science News, Science* magazine, and other publications. From 1985 to 1993, she worked as a Principal Editor at U.C. Santa Cruz. She has received several national awards, including the Gold Medal for Best-in-Category from the National Council for the Advancement and Support of Education. Besides *Asking About Life,* she recently coauthored *Life Science,* a middle school text in the Holt Science & Technology Series.

In her previous life as a biologist, Dusheck studied the effects of light intensity on bird song; social behavior in field mice; food preferences of deer, cattle, and skipper butterflies; as well as axis formation in *Xenopus laevis.* While working for the Department of Molecular Biology at U.C. Berkeley, she designed and wrote the protocol for a Space Shuttle experiment that sent live frog embryos into space in the fall of 1992. She has taught university labs in introductory zoology, embryology, and comparative anatomy.

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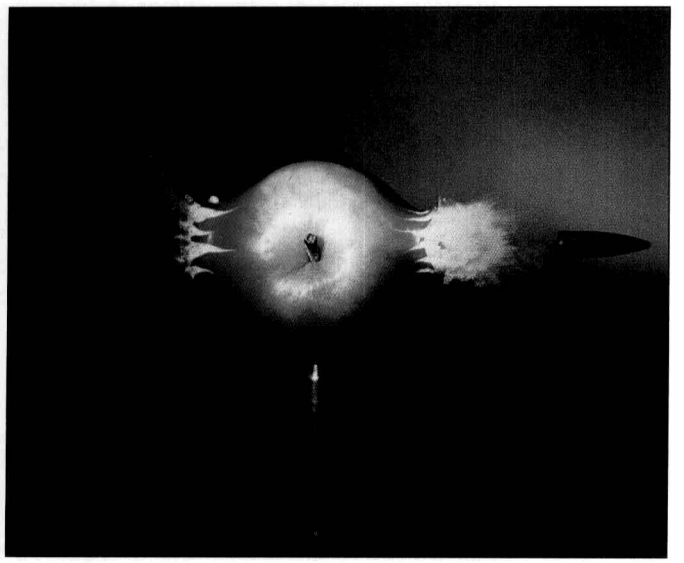

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