

Understanding Biology



EDITION

RAVEN
JOHNSON

Understanding Biology

S E C O N D ◆ E D I T I O N

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Preface

BIOLOGY AND THE CITIZENS OF THE 90s

In the three years since the first edition of UNDERSTANDING BIOLOGY was published, 270 million people have been added to the world's population. At no other time in history has the world experienced such a rapid explosion in the human population, and as biologists prove and the media attest, solutions to the problems of a crowded planet must be found, and found quickly. As citizens of the Earth, it is important that you understand the biological aspects of this expanding world so that you may play a part in affecting change. We have made every effort in the second edition of UNDERSTANDING BIOLOGY to present these biological issues to you clearly. The decisions that you will make as citizens will shape your future and the future of the world.

In recent years, it has been fashionable to lament the passive attitude of students toward the challenges that await them. As educators in the university and in the public world outside the university, we have seen that this is not so. Students are profoundly interested in their planet and in the forces that threaten it, and they are making concrete efforts to contribute toward its preservation. If there is one trend that we have noted in students in the past few years, it is a hunger for practical knowledge that will assist them with the work that they will face in the coming years. It is a daunting challenge, as the media constantly reinforce the spectre of a dying Earth. Students see these images, but rather than throwing up their hands in despair, instead ask, "What can I do?"

Answering the challenges of the 1990s will not be easy. The problems we face are truly frightening. To name but one example, consider the spread of AIDS. In the past 3 years, 130,000 new cases of AIDS have been reported in the United States alone, and as we enter the 1990s the disease continues to spread. The World Health Organization reports that 700,000 people

have developed AIDS worldwide and estimates that up to 8 million have contracted the AIDS virus. By the end of this decade, an estimated 6 million will be sick, and the total number infected may approach 20 million. AIDS is a problem that is not going to go away.

In the face of this challenge, the scientific community has been electrified by the crisis and has mounted a concerted effort to control the virus. The work that has been done to find a cure for this disease has opened up an astonishing understanding of the human immune system, and this understanding has implications for the defeat of other diseases, such as arthritis and cancer. We know more now about our bodies' defenses than ever before, thanks to the efforts of talented scientists all over the world combating AIDS. It is important for you as citizens to understand these efforts.

Another key area of concern is the environment. Rain forest destruction, acid rain, global warming, ozone depletion, and the growing roll call of endangered species all cast a pall on the future. The falling of the iron curtain in Eastern Europe was a wonderful welcome to the decade of the 1990s, but it has also revealed to Western eyes an environmental catastrophe. Communist governments have for the last 40 years permitted unrestrained industrial pollution, and only with monumental effort will it be possible to clean up. Solidifying ties with our friends in Eastern Europe should begin with contributing our expertise and technology, and most particularly our awareness, to the effort of restoring the land that was once behind the iron curtain. Today's students, we believe, will come to play a critical role in this task, an effort that will need to be carried on for many years.

While the study of biology will provide an important tool for students meeting the challenges of the 1990s, there are other tools that will also be needed, such as commitment and common sense. When all is said and done, however, understanding the problems that the world faces and the biological principles that

underlie them must be the first step in eradicating these problems. Throughout UNDERSTANDING BIOLOGY, second edition we present basic biological principles in a simple, straightforward manner. Students need to know how viruses invade the body in order to understand AIDS. Knowledge of the delicate balance that exists in the water cycle is essential for realizing the impact of industrial pollution. Understanding is the first step to making informed decisions. It is our hope that UNDERSTANDING BIOLOGY, second edition will be a valuable resource for students as they face the future.

HOW THIS BOOK IS ORGANIZED TO TEACH YOU BIOLOGY

Like the first edition, this second edition of UNDERSTANDING BIOLOGY is organized into nine parts that can be roughly ordered into two broad areas: basic biological principles (including ecology) and the structure and function of organisms (see diagram). This organization reflects what we believe to be the clearest way of teaching biology. First, by giving the student an overview of the principles of biological processes and the workings of the biosphere, it better prepares them to understand the form and function of organisms. Second, a full progression of principles that includes ecology makes logical sense: the cell and energy chapters describe the basic properties of all living things, and the three sections that follow present an ordered sequential view of how heredity shapes the world in which we live. The ge-

netics chapters are concerned with genes, the evolution chapters delineate how genes operate in populations, and the ecology section describes how evolution has shaped natural communities. A student moving through the book in this manner comes away with the understanding that ecology is the end result of evolution acting on genes.

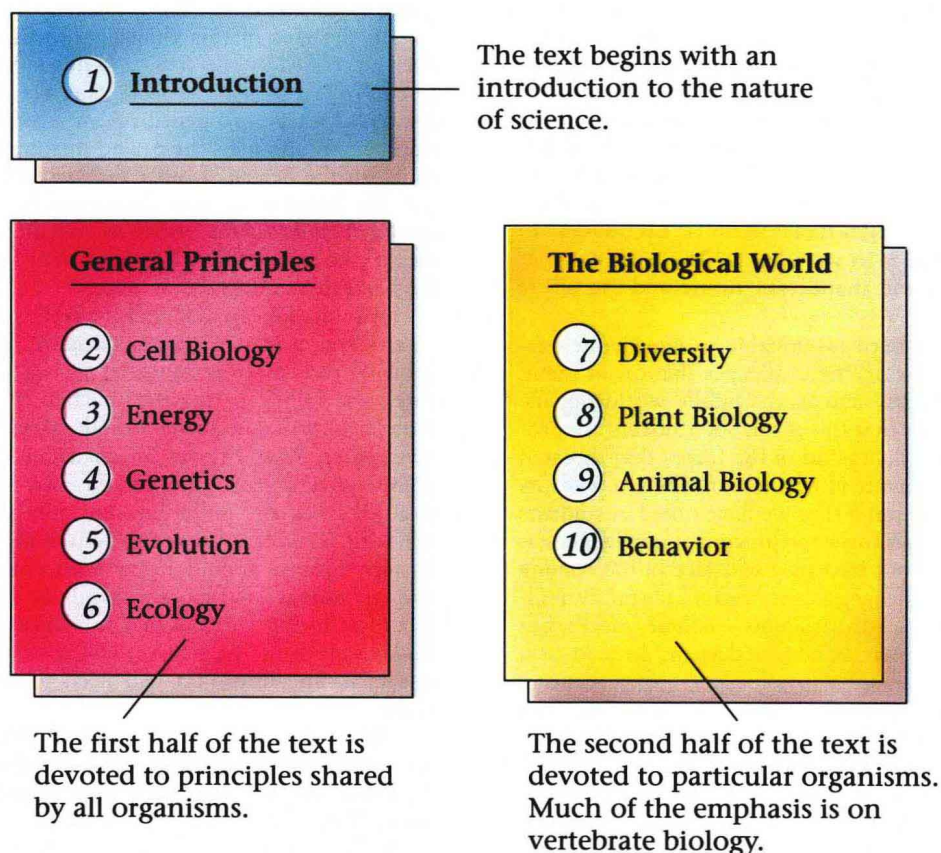
The framework provided by these principles in turn makes possible a rich treatment of form and function in the latter half of the book, as these principles apply to every living creature. Those familiar with the first edition will know that evolution is the grounding feature of this text. Evolution is also the guiding perspective of the second edition, and our organization of the form and function chapters reflects this perspective.

GOALS FOR THE SECOND EDITION

Although the first edition enjoyed great success and was heralded for its unique evolutionary approach, we decided that the second edition would benefit from a major revision effort. The importance of biology to students today cannot be overstressed, and every effort has been made in this edition to provide students with a readable, accessible, visually compelling text. Some of our goals for the second edition are listed below.

Simplification of Presentation

Most of this book has been rewritten. In some cases, paragraphs have been rewritten for clarity; in other cases, whole chapters



were discarded and rewritten from scratch. Language has been simplified in an effort to make the prose more friendly and readable. This type of revision sounds easy to effect, but in reality it takes countless hours of strenuous concentration. However, we believe that text that is easy to read and understand is the absolute *minimum* requirement of a biology textbook.

In addition, legends to the illustrations have been rewritten. Detail in the legends has been cut, and each legend now bears an illustration title.

Reorganization of Presentation

An important facet of rewriting is reorganization of the internal structure of chapters. Within each chapter, the organization of topics was carefully scrutinized. Headings have been rearranged and rewritten to provide a better “blueprint” to the chapter material. This type of reorganization should aid the student in outlining the chapters and guide the student through the hierarchy of concepts he or she is expected to master for each chapter.

The order of chapters in the text has also been reorganized. Based on the suggestions of those who used the first edition, we have rearranged in several key ways. First, we have pulled together topics that were scattered over several chapters: all the material on DNA is now presented in Chapter 12, all the material on genetic engineering is now presented in Chapter 14, and so on. Second, several sections have been rearranged to provide a better flow of topics. The ecology section has been completely reorganized, and another chapter has been added. The animal biology section has also been reorganized, and it has also been augmented with an all-new chapter.

Updating of Material

Three years is a century where biological advances are concerned. New, exciting discoveries such as the first tunneling microscopy photograph of DNA, the first use of gene therapy to combat cancer, and the discovery of the gene that determines human sex are but a few examples of biological progress that have been included in this edition.

New Illustration Program

We are very proud to present an entirely new illustration program for the second edition of UNDERSTANDING BIOLOGY. Working closely with our designer, art coordinator, and developmental editor, we have revised and redrawn virtually every illustration in the book. Illustrations are an important tool for teaching complex concepts and today’s students, versed as they are in the potential impact of visual images, are more likely to read and enjoy a text whose illustrations captivate the eye. We have spared no expense with this new illustration program, and we believe that the results speak for themselves.

New Design

In keeping with the changes in text and art, we’ve introduced an entirely new design to complement the outstanding features of UNDERSTANDING BIOLOGY, second edition. You will notice that the typeface is bigger and bolder than that of the first edition, making the second edition much easier on the eyes. We’ve also increased the size of the figures an average of 33%, with the result that the art is much more prominent and compelling, as well as easier to comprehend. The new design of the end-of-chapter pedagogy makes this section easier to find and

refer to. And although we’ve added two completely new chapters to the text, increased the size of the typeface and art, and opened up the design of the pedagogy, we’ve increased the overall length of the text by just 14%. We thank our designer, Liz Rudder, for successfully undertaking this challenge and delivering a beautifully designed book.

New Teaching Technology

Over the last several years the information revolution has caught up with college textbooks, many of which are now available with video disks and other novel ancillaries. We have joined that progress with great enthusiasm, presenting what we believe is the most user friendly—and useful—video disk on the market. It is keyed directly to the text with bar codes, and incorporates many of the key illustrations.

WHAT’S NEW AND WHY

Given the fact that this revision of UNDERSTANDING BIOLOGY has focused intensely on both the text and the art, it has been necessary for us to garner help from a number of sources. We both began the revision process by collecting information from scientific literature, from colleagues in our respective fields, and from our own research efforts to use in the updating and upgrading of the text. A team of reviewers examined the first edition of the text and offered their suggestions for change, enhancement, and deletion. After a first draft was written, we convened two focus groups to “test” what we had accomplished. These focus groups, composed of experienced professors from across the country, focused separately on the principles section and the animal biology section. Based on focus group comments and comments from another team of reviewers, we wrote the second draft of the manuscript. Between the second and final drafts came numerous intermediate drafts, in which concepts and language were refined. This exhaustive process has yielded a text that is both readable and accurate.

While it is impossible to list every change that has taken place in the text, listed below are the major highlights of the revision:

1. Former Chapters 1 and 2 have been combined to focus more clearly on the scientific method. Following the suggestion of numerous reviewers, the discussion of creationism has been moved to Chapter 15 (The Evidence for Evolution)—students will understand the argument better if they have a background in the evidence for evolution. There are new boxes on scientific progress and how biologists do their work.

2. The chemistry chapter has been extensively revised with the introductory student in mind. Excess detail has been deleted, but information that introductory students need has been added—energy levels, building macromolecules, and nucleotides are all new additions.

3. The energetics section has been rethought and rewritten. Chapter 6 (Energy and Metabolism) has been augmented by new material on biochemical pathways and the evolution of metabolism. Chapter 7 (Cellular Respiration) has a new overview of the entire respiration process that gives the student a sound introduction before the details. Because of the comments of several reviewers, fermentation has been moved to precede oxidative respiration. There is a new boxed essay on metabolism, and

a new art piece on coupled reactions uses a simple spring analogy to teach this difficult concept. A miniglossary of terms pertinent to respiration appears in this chapter; miniglossaries are scattered throughout the text to help the student learn scientific vocabulary. We have added a new discussion of C_3 and C_4 photosynthesis to Chapter 8 (Photosynthesis).

4. The genetics section of the text (Chapters 9 through 14) has received very careful attention. Chapter 9 (How Cells Reproduce) has benefited from a lowering of the language level and the deletion of some advanced terms and concepts, all done at the suggestions of reviewers. There are new sections on the sexual life cycle, an introduction to sexual reproduction, and a discussion of the evolutionary consequences of sexual reproduction. The new illustration program for this chapter is, in short, stunning. New mitosis and meiosis illustrations clarify these difficult concepts. There is also a new illustration explaining exactly what a chromosome is composed of (chromatid, sister chromatid, homologous pair). Codominance, incomplete dominance, and pleiotropy have been moved from Chapter 10 (Mendelian Genetics) to Chapter 13 (Genes and How They Work). We added Rh blood groups and RFLPs to Chapter 11 (Human Genetics). All DNA information has been concentrated in Chapter 12 (DNA: The Genetic Material). In Chapter 13, the discussion of gene expression has been rewritten to improve precision and clarity. The art for Chapter 13 is another *tour de force*—three dimensional paintings bring the process of protein synthesis to life for students. Finally, Chapter 14 (Gene Technology)—a completely new chapter—discusses the fascinating topic of genetic engineering and incorporates diagrammatic illustrations of genetic engineering techniques.

5. The evolution chapters have benefited greatly from revision. The discussion of macroevolution and microevolution in Chapter 15 has been expanded and suffused throughout the chapter as a unifying theme. A helpful illustration comparing the two types of evolution also appears in this chapter. Hardy-Weinberg equilibrium has been clarified and expanded—more examples are used to teach the student this fundamental principle. A miniglossary appears in this chapter to aid students in learning unfamiliar vocabulary. In Chapter 16 (How Species Form), the explanations of isolating mechanisms have been completely rewritten; and please note the new illustration explaining the controversial debate between gradualism and punctuated equilibrium. Chapter 17 (The Evolution of Life on Earth) sports a new discussion of C-14 dating and an expanded discussion of continental drift, a specialty of one of the authors (Raven). Chapter 18 (How We Evolved: Vertebrate Evolution) gives a new, comprehensive review of the first vertebrates, emphasizing the significance of their appearance on earth.

6. The ecology chapters have been completely reorganized according to the following scheme:

- *Chapter 19 (Population Dynamics) now covers the principles of population genetics.
- *Chapter 20 (How Species Interact within Communities) covers community ecology—coevolution, predator-prey interactions, and mimicry.
- *Chapter 21 (Dynamics of Ecosystems) covers biogeochemical cycles and succession. All the biogeochemical cycle illustrations have been reconceptualized to give a more accurate picture of the circulation of these chemicals throughout the environment.
- *Chapter 22 (Atmosphere, Oceans, and Biomes) covers climate and biomes.
- *Chapter 23 (Our Changing Environment) covers the future of

the biosphere and emphasizes solutions to environmental problems. This chapter benefits from both authors' expertise in and commitment to this area.

7. The chapters on animal and plant diversity (Chapters 24 through 31) have been improved by the addition of new photographs that more closely exemplify the featured organism. The discussion of plants incorporates the new division names of Hepatophyta, Bryophyta, and Anthocerotophyta.

8. The chapters on Animal Biology (Chapters 32 through 44) have been extensively rewritten and reorganized. Our thanks to Warren Burrgren, Ph.D. of the University of Massachusetts, who read and reviewed the first edition chapters and suggested numerous changes, and to Charles Schauf, Ph.D. of the School of Science at Indianapolis and author of HUMAN PHYSIOLOGY, who contributed material to this section. We are also indebted to James Traniello, Ph.D. of Boston University, who made major contributions to the animal behavior chapter. Highlights of the revision to this section are as follows:

- *The order of the chapters have been rearranged to provide a more logical flow of topics. The nervous system is presented first, followed by hormones, locomotion, digestion, respiration, the immune system, and water balance. Sex and reproduction and development follow, and the section ends with animal behavior.
- *Chapter 32 (The Vertebrate Body) features an all-new discussion of homeostasis and feedback loops. This discussion introduces the student to the broad topic of homeostasis in preparation for the chapters that follow.
- *Chapter 33 (How Animals Transmit Information) has been extensively revised. The entire chapter has been reorganized and rewritten and includes clearer definitions of the sodium-potassium pump and gated channels. A miniglossary is included in this chapter to assist the student in learning the terminology.
- *Chapter 34 (The Nervous System) includes new information on the spinal cord and a clearer description of antagonistic controls.
- *A discussion of the skeletal system has been added to Chapter 35 (How Animals Move). The chapter also includes a miniglossary. A rearrangement of topics that places the structure of the actin/myosin mechanism before its function makes this topic much easier to understand. The discussion of the function of the actin/myosin mechanism interaction has been clarified. The discussion of acetylcholine has been rewritten at a lower level.
- *Chapter 36 (Hormones) is now a more cohesive chapter on hormones. Discussions of water balance and the control of digestion have been moved to more appropriate chapters (Chapters 41 and 37). There is a new introduction to receptors, target cells, and glands as well as extensive new coverage of the adrenal glands, thyroid gland, parathyroid gland, pancreatic islets, thymus gland, and pineal gland. Diabetes is discussed in more detail.
- *Chapter 37 (How Animals Digest Food) features a new general introduction to the digestive process in addition to new information on the pancreas and liver. One new illustration in particular that should be pointed out is a figure on the fate of food (Figure 37-15) that depicts what happens to each class of nutrient in the digestive process.
- *Partial pressure, a notoriously difficult topic for students to grasp, has been clarified in Chapter 38 (How Animals Capture Oxygen). The discussion of cross-current exchange has also benefited from rewriting. A discussion of the control of breath-

ing has been added, and the discussion of carbon dioxide transport has been expanded.

*Chapter 39 (Circulation) features a new box on high blood pressure and a new discussion of the clotting mechanism.

*Chapter 40 (How the Body Defends Itself) received much attention in the revision process. The chapter has been completely reorganized to provide a step-by-step description of this complex system. Appropriate introductory material, such as descriptions of the cells of the immune system, and an overview of specific and nonspecific defenses have been placed at the beginning of the chapter to acquaint the student with the overall process of the system before launching into the details. Spectacular full-color paintings of the humoral and cell-mediated responses are featured in this chapter, as well as a flowchart that outlines the entire immune response, from the invasion of an antigen to the proliferation of memory cells. James Smith, Ph.D. of California State University-Fullerton, should be acknowledged for his very detailed criticisms regarding the first edition chapter.

*New information on ADH, temperature regulation, and dialysis has been added to Chapter 41 (The Control of Water Balance).

*Chapter 42 (Sex and Reproduction) gives more attention to the role of hormones in the reproduction cycles of both males and females. Updated material on birth control and AIDS appears in this chapter. In addition, the chapter was reorganized to place the structure of the male and female reproduction system before the function of the systems.

*Chapter 43 (Development) is a completely new chapter that covers comparative vertebrate embryology; the focus turns to human development in the second half of the chapter.

*Chapter 44 (Animal Behavior) has been extensively revised to include information on proximate and ultimate factors; the genetic and neural bases of behavior; learning; behavioral rhythms; animal communication; ecology and behavior; sociobiology; and insect and vertebrate societies.

HELP FOR THE STUDENT

In our text we are highly sensitive to the fact that many of the students reading this book are novices to the subject of biology. To help the student master the material, we have included numerous teaching aids that are specifically designed to foster applications of key concepts instead of rote memorization.

1. An *Overview* prefaces each chapter. This overview briefly summarizes the content of the chapter for the student.

2. The *For Review* section, placed at the beginning of each chapter, lists terms that the student has encountered in previous chapters. The *For Review* list alerts students to terms that should be understood before proceeding further. The chapter in which each term appears is given for easy reference.

3. *Concept Summaries* are capsule summaries that appear throughout each chapter. These summaries provide a spot review of key concepts featured in each chapter.

4. The *Chapter Summary* at the end of each chapter provides additional reinforcement of key concepts.

5. *Review Questions* at the end of each chapter test student knowledge of the chapter content in a fill-in-the-blank format. The *Self Quiz* questions quiz students in a multiple choice format. *Thought Questions* ask students to apply the chapter's key

concepts to new and interesting situations not encountered in the chapter. Chapters 11 and 12 also include genetics problems. Answers to the Review and Self Quiz Questions are given in Appendix B. Extensive answers to the genetics problems are also given in Appendix B.

6. *Boxed essays* present interesting topics of social, medical, or environmental concern from a biological perspective. The research into new crops to feed a starving world (p. 553) and the health risks associated with smoking (pp. 334-335) are but two of the topics addressed in the boxed essays.

7. *Miniglossaries* are found in chapters that are particularly dense with vocabulary (such as Chapters 13 and 15). The miniglossaries list key vocabulary terms and their definitions within the chapter to provide the student with easy reference. Turn to pp. 325 and 373 for examples of miniglossaries.

8. The comprehensive glossary defines the bold-faced terms in the text and provides the derivation of each term.

SUPPLEMENTS

We have developed a complete package of ancillaries to accompany the second edition of UNDERSTANDING BIOLOGY. These ancillaries will aid both student and instructor in managing what must sometimes seem an immense amount of material.

For the Student

UNDERSTANDING BIOLOGY Study Guide, second edition, written by Ann Vernon of St. Charles Community College. This illustrated study guide is keyed directly to the text and provides students with significant additional study aids, including chapter overviews; chapter outlines; key terms exercises that reinforce vocabulary retention and understanding; "concept check" exercises that use a variety of techniques to enhance understanding of chapter topics; and mastery tests. Flash cards help students to conveniently review important concepts. Answers to all questions, including thought questions in the text, are included.

UNDERSTANDING BIOLOGY Laboratory Manual is a new addition to the ancillary package. This lab manual has been written specifically for this edition of UNDERSTANDING BIOLOGY by Randall C. Moore of Wright State University and Darrell Vodopich of Baylor University. The 30 laboratory exercises in the manual, all class tested by the authors, take an investigative approach, and each exercise ends with a challenge to the student to apply what has been learned to new and different problems. Numerous illustrations, including many created specifically for the manual, provide extensive visual support.

For the Instructor

Mechanisms of Life: Stability and Change Videodisc is an all-new, state of the art instructional medium for UNDERSTANDING BIOLOGY, second edition. The instructional value of this new videodisc stems from its versatility, compactness and ease of use. This customized resource combines high-resolution artwork from the text with film clips on biological processes to provide visual reinforcement for classroom presentation. Other outstanding features include the ability to quickly search and display images or animated sequences and extensive use of full motion along with still images. The videodisc is accompanied by

the Instructor's Manual contains all bar codes for player, as well as complete instructions.

Instructor's Resource Guide, written by Florence Ricciuti, of Albertus Magnus College, provides text adopters with substantial support in preparing for and teaching introductory biology with this text. The manual contains suggested course outlines, extensive sources of supplementary materials, and additional resources such as lists of audiovisuals and computer software; 100 overhead transparency masters; suggested learning objectives for each chapter; and chapter-by-chapter notes. Also included is a chapter for novice instructors, with down to earth suggestions for surviving the teaching experience.

Overhead Transparency Acetates of 102 of the text's most important four-color illustrations are available to instructors for use as teaching aids. The transparencies were selected with the assistance of a number of instructors of introductory biology. With this edition of acetates, we have greatly increased the size and boldness of the labels. The increased size and boldness of the acetate labels should make the acetates legible for the students sitting in the back of a large lecture hall.

A printed *Test Bank*, written and revised by Richard Van Norman of the University of Utah, provides an extensive battery of 2000 objective test items that may be used by instructors as a powerful instructional tool. Each chapter has between 40 and 50 questions, including multiple choice, short answer, and classification formats. For each question, in addition to the answer, we have identified the subject tested, given an approximate difficulty rating, and indicated the type of question (factual or conceptual) and the text page on which the question's information appears. New to this edition of the test bank are questions based on over 40 of the overhead transparency masters that appear in the *Instructor's Resource Guide*. These masters of important structures and diagrams are unlabeled for use with the test bank, or with questions developed by the instructor. Also new to the test bank is "*Proctor Practice*," a separate bank of 1500 questions intended for use as practice exams.

A computerized version of the test bank, *Diploma II* is available in IBM and Apple versions. Diploma's EXAM allows instructors to add, edit, and delete questions and to print randomly—or manually—selected tests. GRADEBOOK records students grades, provides reports on individual or class performance, and graphically displays important information. PROC-TOR (used with the separate "*Proctor Practice*") disks included in the *Diploma II* package, allows instructors to provide students with practice exams based on a separate bank of test questions written by the author of the test bank. Scores on the *Proctor Practice* exams can be transferred to GRADEBOOK if desired.

LXR Macintosh Computerized Test Bank contains the same content as the printed and *Diploma II* test banks, but has different capabilities. This computerized test bank allows the instructor to select, edit, and delete questions to create custom tests and answer keys. Graphic images may be placed with the test questions, difficulty level and type of question can be controlled with a pop-up menu, and question information window allows simultaneous reference questions to the instructor's notes.

ACKNOWLEDGMENTS

Anyone who has ever been involved with writing a text knows that the real authors are the reviewers and editors who shape the book. The hundreds of teachers who used the first edition and told us what they thought made a contribution to this edition as great as any author. We cannot name them all here, but we hope that they will recognize the improvements they initiated and appreciate the gratitude we feel. A few were particularly avid in detecting errors and inconsistencies, like Stephen Hedman of the University of Minnesota-Duluth and Clyde Bottrell of Tarrant County Junior College. The art benefited from the careful scrutiny of Steve Dina of St. Louis University and Ed Joern of the University of Missouri-St. Louis. Two teachers became even more deeply involved in our revision, offering criticisms and critiques so detailed that they totally reshaped particular segments of the text: Charles Schauf of the School of Science at Indianapolis put the entire eleven chapters of the animal biology section under a microscope, critically evaluating every statement and suggesting many improvements; and James Traniello of Boston University took the behavior chapter apart in a similar fashion, molding and changing it in many ways. We are deeply grateful for their interest and commitment to our text, which they greatly improved.

We are also indebted to an unusually creative editorial team. The authors write a book, but others create it. The beauty of this edition's art program, its lovely design and layout, the depth and clarity of its within-chapter topic reorganization, the innovative ancillaries—all these things are important aspects of the new edition, and they reflect the hard work of four people: a delightful chief artist and art coordinator, Nadine Sokol (who fit having a baby into a killer production schedule); a flexible book designer and page layout wiz, Liz Rudder, who never lost track of the fact that the text is a teaching tool; a perceptive, thorough, and incredibly hard-working developmental editor, Kathleen Scogna, who was fearless in her efforts to keep the authors focused on her vision of the book, but willing to accommodate ours; and a creative, risk-taking publisher, Ed Murphy, who shares with us a common vision of what an effective text ought to be. Many others helped too, more than we can name here. They will know what they did, and how grateful we are to each of them.

A particularly interesting contribution to this edition was made by the marketing staff, particularly the marketing manager Leslie Tinsley. It was Leslie who suggested that we might be willing to contribute to the international conservation efforts of the World Wildlife Fund, and Leslie who communicated to the sales staff what it was we were about.

This is the third text edition we have published together, and as in all the others we are deeply in debt to our families for their understanding of the demanding schedules we have had to keep, and forgiveness for the neglect that has often resulted. Loss of family time is one of the greatest hidden costs of text writing, and only the strong support of our wives Tamra and Barbara has made it possible to complete this revision.

Finally, a special word of thanks to Kathleen Scogna, for this edition is her creation as much as ours. This is her first book as a developmental editor. Look at it, and you will see why we suspect it will not be her last.

Thanks, all of you.

A FINAL NOTE

Our commitment to educating citizens of the 1990s in important biological issues is deeply felt. It has shaped our personal and professional lives and forms the philosophical basis from which we teach. In keeping with our belief that students share our concern for the future of the earth and as a token of our commitment to education and conservation, we are contributing to the World Wildlife Fund one dollar from our royalties for every copy of the second edition sold. Buying this book may not save an elephant, but we hope it will help.

If you would like to make an individual contribution to the World Wildlife Fund, please write:

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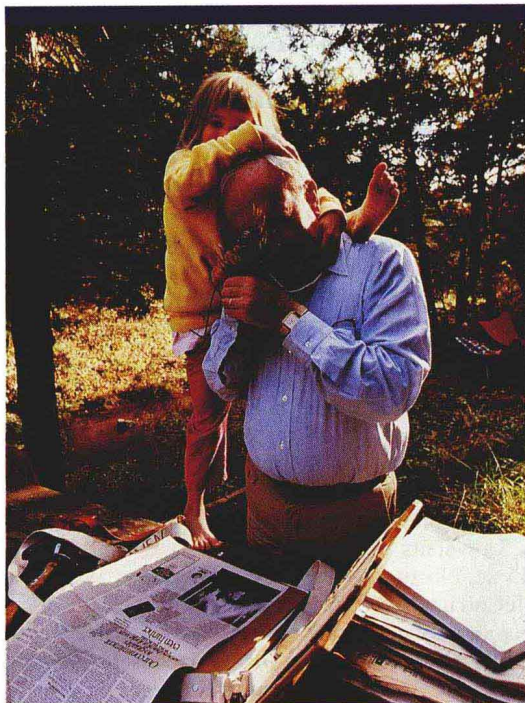
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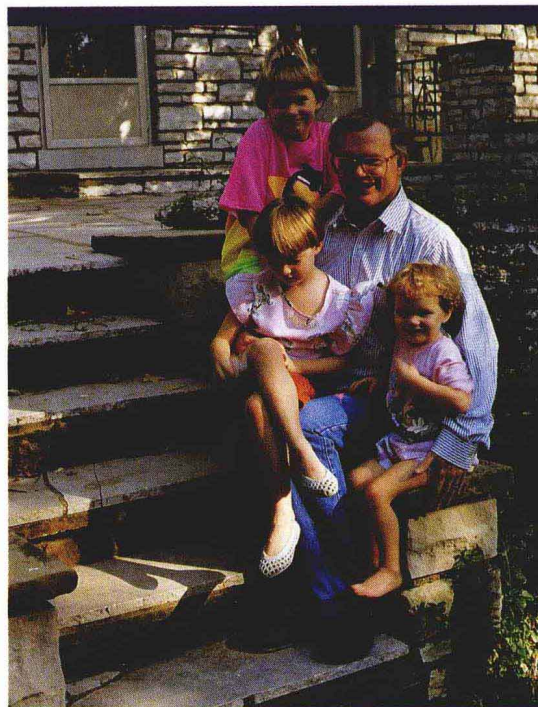
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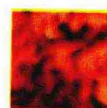
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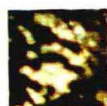
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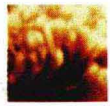


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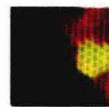
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