UNDERSTANDING BIOLOGY

RAVEN & JOHNSON

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PREFACE

Most teachers who lecture to introductory biology classes have been tempted at one time or another to begin by reading to the class the "Science" section of the daily newspaper. Today's paper, for example, reports the identification of the gene that causes cystic fibrosis, a fatal genetic disorder that affects more than 30,000 people in the United States today. For years scientists have been searching for the gene, which is carried silently by an estimated 1 in every 20 Caucasians; studying it may provide clues that will eventually lead to a cure. This discovery is of great interest to every student in a freshman biology class; to premeds and English majors and students majoring in dance. They all want to know about cystic fibrosis, and also about AIDS and cancer and genetic engineering, because these issues affect their lives. They want to learn enough biology to understand the newspapers and magazines they read.

This is not how introductory biology is usually taught to prospective biology majors. What about worms and the parts of a flower and dissecting frogs? Prospective biology majors are traditionally introduced to the subject by exposure to a large body of information, much of it process-oriented, about animals and plants. This information, the nuts and bolts of the subject of biology, is not composed of attention-grabbing stories such as one reads in the newspapers, but rather of a set of principles that explain why biological processes work the way they do—why brothers and sisters look alike, why you become dehydrated when you drink too much alcohol, why people grow old. Biology as a science is not so much a body of information as it is a set of working rules, principles that we understand only imperfectly. In training our next generation of doctors, veterinarians, and biologists, we try to impart a clear view of this framework as we now understand it, both so that they can do their jobs and also so that some of them can in turn further improve the clarity of our understanding.

Both kinds of biology need to be taught to freshmen, many of whom will take only one biology course. The "trendy" biology gets into the newspapers for a reason that we should not ignore: because it affects many people in important ways. In 1987 voters faced ballot initiatives concerning the barring of students afflicted with AIDS from classrooms, the imposition of mandatory testing for the AIDS virus, and alternative proposals concerning the protection of the confidentiality of those who test AIDS-positive. Of the many thousands of voters casting ballots, few have had the biology necessary to understand the issues. We need to teach all of our students the sort of biology that will give them the tools to be informed citizens and to live in a world where biological issues are of increasing importance. Few instructors of potential biology majors would disagree. The problem is one of limited time in a freshman class. To teach the more traditional "classical" material to potential majors usually requires two full semesters. Why not trim the traditional material a little, to squeeze in a little of the new? Because it takes time for students to assimilate the basic principles that constitute the core of biology. Students learn Mendelian genetics only by tracing in detail the results of genetic crosses, by puzzling through problems and considering unusual results. It is not possible for even the best of students to learn all of this at one sitting; the cleverest of words cannot substitute for student involvement.

So it is a case of apples and oranges: two different approaches, both valid and necessary. Many schools respond to this problem by offering two sorts of introductory biology courses: a "trendy" course for nonmajors and a "principles" course for majors. In our opinion, this is not the best solution to the problem. A "trendy" course without a foundation of basic principles gives a student no tools with which to make decisions five years later, when the stories in the newspapers are different; the course simply replaces the newspaper as a source of current information. Nor are the potential majors well served by two courses. Current issues add both excitement and perspective, and students are not being properly introduced to biology unless they are exposed to these issues.

The different approaches employed in teaching in-

troductory biology to prospective majors and to nonmajors comes into sharp focus in courses intended for both majors and nonmajors—the so-called "mixed-majors" courses that are becoming increasingly popular around the country. How ought one to teach such a course? Over the last five years we have been involved in preparing introductory biology texts. We were originally induced to leave our labs for this task by what we perceived as a need for a new sort of introductory biology text, one in which the central biological principle of evolution is integrated into every chapter, rather than being relegated to a few brief pages. In 1986 we published *Biology*, a comprehensive text organized around an evolutionary theme, intended for use by prospective biology majors. Since then, we have addressed ourselves to the preparation of a short text for a one-semester course—the text you now hold in your hands. Writing this text, we have had to address directly the issue of balancing the need to teach principles with the need to be current in a rapidly changing science. Here is what we chose to do:

Rearrange traditional material. Much of the beginning of the text is devoted to general principles, with detailed consideration of the anatomy and physiology of animals and plants delayed to the end of the course. The student is introduced to cell biology, metabolism, genetics, evolution, and ecology, the principles of which apply to all organisms, before focusing on the biology of any particular organism. This both ensures that the key material gets taught, and, interestingly, provides a better framework for consideration of recent developments. Teaching why smoking leads to lung cancer uses a knowledge of genetics—of how mutations alter a cell's DNA—rather than a knowledge of descriptive information about human lungs.

Limit paradigms. To make room for teaching new developments, while at the same time preserving a detailed treatment of basic principles, we limit ourselves to examining only those principles that are absolutely essential. The student is given a detailed treatment of Darwinian evolution, Mendelian genetics, and the role of DNA as the genetic material, but is not treated to a similarly detailed presentation of all areas of biology that are well understood. This is a key distinction between this book's approach and that of our more comprehensive text for majors. Choosing the proper material to present in depth is the essence of a successful one-term introductory biology course.

Stress evolution. It has often been said that biology only makes sense in the context of evolution, and it is certainly true that learning the principles of biology is much easier if the material is presented to the student within an evolutionary context. With this in mind, we have maintained the evolutionary emphasis of our majors text. The student is provided with a detailed treatment of Darwin in the introductory chapters, and even the chemistry is presented within an evolutionary framework.

The section of the text devoted specifically to evolution begins with a chapter explicitly presenting the evidence that Darwin was right—if the principle of evolution is central to biology, then we ought to be able to convince our students of its validity. They will be voting in a society where many voters support "scientific creationism" (even the Supreme Court was not unanimous in rejecting it), and we have attempted to give them the training to evaluate those views.

Focus on current material. In the necessary tradeoff between classical material and recent developments, we have leaned far toward the new. We incorporate detailed discussions of the mechanisms leading to cancer and AIDS, progress in genetic engineering, accounts of current ecological issues such as destruction of the tropical rain forests and acid rain, and other topics of current interest.

Integrate new developments with basic principles. Each new development is introduced as an extension of basic principles, rather than nakedly, so that students can truly understand what is going on, rather than simply garnering more information. Such integration of recent developments with general principles is critical to successful teaching because, in most cases, it is not possible to simply tack on new developments as a linear extension of what we already teach. Why not? Because fast-moving areas in biology tend to coalesce. As we learn more, we often come to view areas traditionally considered distinct as different facets of the same phenomenon. Only by coupling advances to basic principles can instructors of introductory biology convey how advances relate to one another, and so convey some of the excitement and potential gripping biological scientists today.

Present biology in an engaging way. The most important quality of any text is that it be written clearly. In teaching a broad spectrum of students,

a second important quality of a successful text is that the writing style be relaxed and enjoyable to read, as students' motivation and background will vary widely. Our goal in preparing this text has been to write each chapter so that a history or art major, as well as a potential biology major, will be interested enough to want to keep on reading. While an attractive illustration program can help win student interest, there is no substitute for writing at the proper level.

Increase pedagogy. As students are exposed to more and more modern information, they find it progressively harder to see the structure of the course. Almost all of what they are learning is new to them, and they have no perspective to appreciate what is most important, what less so. Learning aids are thus much more important than they used to be. Spot summaries spaced throughout the text of each chapter, for example, can help guide a student's learning. These sorts of aids have not been used often in introductory nonmajors texts in the past, because space in an introductory text is at a premium. Yet, such aids are essential. The text is a teaching *tool,* and should be crafted as such. Believing this, we have made extensive use of pedagogical aids in this text.

We thus attempt to balance the need to teach principles to all students with the desire to be current in a rapidly changing science by first limiting the number of principles we attempt to teach, and then by carefully developing the connection of new developments to these principles, so that what is going on now becomes for the student a natural extension, a further development. Our goal is both to promote a fuller understanding by the student of what is happening now, and to present the student with a dynamic picture of how science works, with ideas constantly in a state of flux—a hazy picture becoming clearer.

DEVELOPMENT OF THIS TEXT

No successful text is written in isolation. In writing this one, we have had the benefit of literally hundreds of reviews and comments, both by reviewers commissioned by the publisher and by scientific acquaintances. This input not only ensures the accuracy of what is said, but also helps to mold the text's presentation to better suit its teaching purpose.

It is unlikely that we could have agreed to undertake this project—we have learned from preparing our majors text that writing a text takes an enormous chunk out of our lives—except for one significant advantage: the majors text that we had just finished provided us with an invaluable resource from which to garner material. Used by more than 70,000 students in its first year, *Biology* has been gone over more carefully than any manuscript can be, and input by hundreds of instructors all over the country from Harvard and Stanford to Forest Park Community College has cleaned our majors text of all the glitches, errors, and misstatements that any first edition is prone to contain. We had an extraordinarily clean base from which to prepare this text.

Because *Understanding Biology* was not to be simply a cut-down version of *Biology,* but rather a differently organized book aimed at a far broader audience, the project was launched with a qualifying review of our detailed book plan and proposed table of contents by several instructors chosen to help us refine the proposed contents and organization. In a focus group session, eight of the reviewers met with us and the editors for two days to advise us in detail on our plans and approach. The first draft was reviewed by 15 instructors, representing a broad array of institutions. From their extensive comments we developed a second draft, which was in turn reviewed by a second panel of 15 reviewers. The comments from these reviews were used to hone and refine the final draft. To ensure that no errors had been inadvertently introduced, the final draft was reviewed yet one more time by 10 additional technical reviewers who read the manuscript with but one mission: catch errors and suggest corrections for any misstatements or ambiguous passages. It has been our goal that *Understanding Biology* be as free of errors, typos, misprints, and other glitches as a *second* edition would be.

TEACHING AND LEARNING AIDS

Getting the science correct and up to date is only one phase of developing a biology text. To be an effective teaching tool, the text must present the science in a way that can be clearly taught and easily learned. With this in mind, we have included a variety of different teaching and learning aids.

General Approach

Readability. A text is only as easy to use as it is easy to read. This text has a "discovery" approach and a lively writing style intended to engage the interest of students. Simple analogies are used extensively as an aid to understanding. The level of difficulty has been carefully controlled to correspond to the actual abilities of today's undergraduates.

Vocabulary. The large number of terms encountered in studying biology is a real stumbling block for many students. This book lessens the problem by addressing and reinforcing a student's vocabulary development at three levels. First, no term is used without first being clearly defined. A student does not have to be familiar with the terminology of biology to use this book. Second, terms that are particularly important are printed in **boldface** at the point they are first used and defined. Finally, a complete and up-to-date glossary of terms is included at the end of the book.

Illustration. Because illustrations are so critical to a student's learning and enjoyment of biology, we have used full-color photographs throughout the text. All line art in *Understanding Biology* was done under the direct supervision of the authors, and planned to illustrate and reinforce specific points in the text. Consequently, every illustration is directly related to the text narrative and specifically cited in the text when the illustrated point is discussed. Great care has been taken in page make-up to place illustrations as close as possible to the text discussion. All illustrations and captions have been independently and carefully reviewed for accuracy and clarity.

Individual Chapter Elements

Chapter Overviews. Each chapter is introduced by a brief paragraph that tells the student what the chapter is about and why the subject is important. Not a summary, the overview allows students to place the chapter in perspective as they begin it.

For Review. As students progress through the text, they acquire an increasing vocabulary of terms and concepts, many of which play an important role in later chapters. To aid students in reviewing particularly important concepts, we have included a unique pedagogical device: each chapter is preceded by a short list of terms and concepts from earlier chapters that will be critical to understanding the present chapter, with an indication of where students should look to review any terms or concepts that are unfamiliar.

Concept Summaries. Another unique learning element that we have employed in each chapter is brief concept summaries. Throughout the text, important discussions and key points are succinctly summarized, with the summaries set off from the text and in boldface for emphasis. These concept summaries recap concisely the essential points that a student should learn.

Boxed Essays. To engage the student's interest and make the learning more exciting and fun, most chapters contain boxed essays on topics of special interest. Only a few paragraphs long, these essays provide an opportunity to briefly examine specialized topics for which there would otherwise be no space in the text.

Chapter Summaries. At the end of each chapter, a numbered summary provides a quick review of key concepts in the chapter.

Review and Self-Quiz Questions. A list of objective questions follows each chapter, intended to spot-check key information in the chapter. These questions can be used by students to test the degree to which they have read the chapter with sufficient attention and retention. The answers are in an appendix at the back of the book, so that students may check their performance.

Thought Questions. A brief list of thought-provoking questions and problems follows each chapter. These questions are not simply review, but rather are intended to challenge the student to think about the lessons of the chapter. Where chapters treat material such as genetics, in which solving problems plays an important role in learning, more problems are presented. The answers to these questions appear in the Instructor's Manual.

For Further Reading. Each chapter is followed by a short annotated list of books and articles, to which interested students can refer for additional information. Many of the articles are from *Scientific American* or other sources at a level appropriate to students with a limited science background.

SUPPLEMENTS

Few introductory courses attempt to cover the enormous amount of material that biology texts typically address. In the range of topics covered, introductory biology is almost unique. For this reason, we have provided a complete package of supplements for use with this text, to aid both student and instructor in dealing with what must sometimes seem an immense amount of material.

For the Student

Understanding Biology Study Guide, written by Susan M. Feldkamp and David Whitenberg, both of Southwest Texas State University. A direct companion to the text, the study guide provides students with significant additional study aids, including expanded chapter overviews, learning objectives, capsule summaries of key points, vocabulary reviews, additional self-study review questions, and other features intended to support motivated self-study of the textual materials.

Biology Laboratory Manual, written by Darrell Vodopich and Randall Moore of Baylor University to accompany Raven/Johnson, *Biology,* and equally useful as an accompaniment to *Understanding Biology*. The 35 laboratory exercises in the manual illustrate basic concepts and focus on experiments that will actually work when attempted. The emphasis in the laboratory manual is on manageability of equipment and content, with extensive visual support through numerous illustrations.

For the Instructor

Instructor's Manual, prepared by Ronald S. Daniel of California Polytechnic University at Pomona and Sharon Callaway Daniel of Orange Coast Community 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 film and computer software, 108 overhead transparency masters to supplement the acetates available with the text; suggested learning objectives for each chapter; and chapter-by-chapter notes.

Overhead Transparency Acetates of 100 of the text's most important four-color illustrations are available to instructors from the publisher for use as teaching aids. These transparencies were selected with the assistance of a number of teachers of introductory biology, to provide the maximum utility to the instructor. The instructor's manual contains suggestions for the use of these transparencies.

A printed *Test Bank,* prepared by Richard Van Norman, University of Utah, provides an extensive battery of more than 1800 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.

Microtest II, a computerized version of the complete test bank, is available to instructors from the publisher on disks compatible with the IBM-PC or the Apple IIc and IIe. It also provides instructors with the opportunity to add questions of their own as well as to modify or delete questions already on file.

A FEW WORDS OF THANKS

This is the second book that we have written together, and we have been fortunate to have had continued excellent support within our publishing company, with editors who put in hours as long as ours and production staff who care deeply how the book looks. The art was again in the sensitive and gifted hands of Bill Ober. Again, our wives and families have tolerated neglect so that the book could be finished in a timely manner. At every stage, excellent and dedicated reviewers suggested countless improvements. We are especially grateful to those individuals who participated in our Focus Group; the names of the reviewers and the Focus Group members follow. Without the help of all these people, we could not have written this book, and we thank them sincerely.

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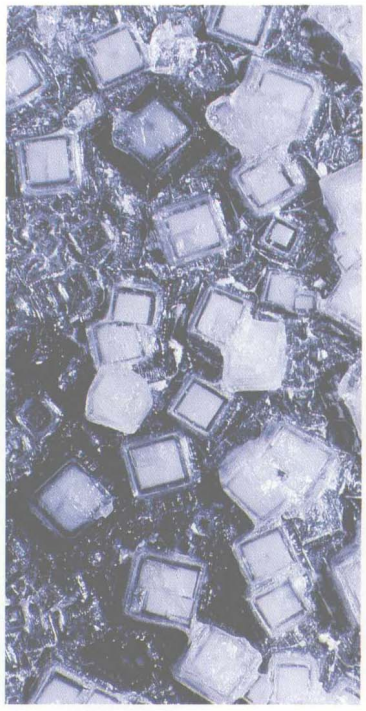

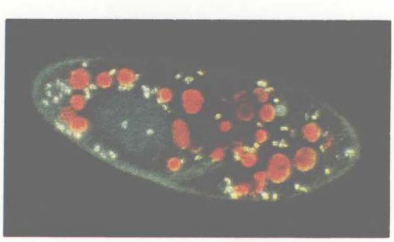

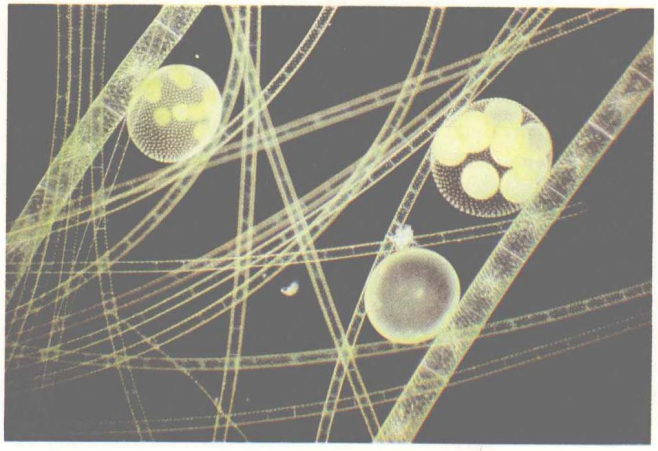

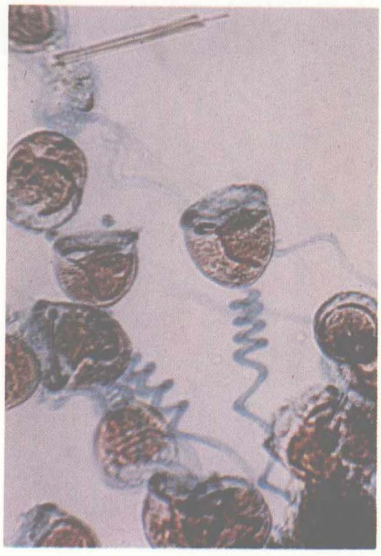

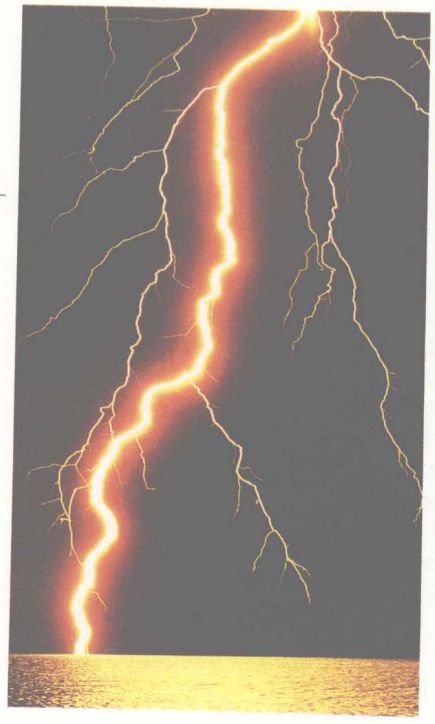

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