

LIFE

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**THE SCIENCE  
OF BIOLOGY**

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SECOND EDITION

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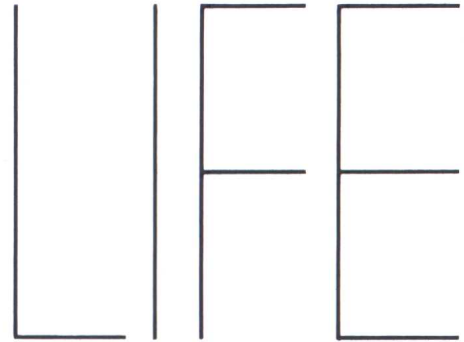
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**THE SCIENCE OF BIOLOGY**

SECOND EDITION

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## To Jean and Betty

### LIFE: THE SCIENCE OF BIOLOGY Second Edition

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#### THE COVER

Black-necked stilts (*Himantopus mexicanus*): A painting by J. F. Lansdowne, which appears as Plate 25 in his book *Birds of the West Coast:2* (© 1980 by M. F. Feheley Artists Company Ltd. All rights reserved).

The black-necked stilt breeds on shallow, alkaline lakes and ponds in arid and coastal regions in western North America, from Washington state south through Central America and on into temperate South America. Its unusually long legs allow it to wade far out into ponds to capture the aquatic insects and crustaceans upon which it feeds. The simple nest in which the female lays four large eggs is constructed in short vegetation, in shallow water near the edge of a pond. The young are able to walk and feed themselves from birth and follow their parents to rich foraging grounds. Males and females look alike in this species, and share in incubation and guarding of the young. Northern populations are present on their high-latitude breeding grounds only in the spring and summer, returning to lower latitudes for the winter.

## PREFACE

An excellent textbook is more than a collection of accurate statements of fact, supplemented by good illustrations. The crucial attribute of a fine textbook is its ability to *explain* things so that students can understand and appreciate them. As authors, our overriding goal at all times has been to explain biological concepts and processes clearly and thoroughly—a goal that guides our classroom teaching as well.

We have been at great pains, throughout the book, to develop each topic until it has been explained or illustrated sufficiently to meet the needs of both the student who requires extra help and the student who aspires to a greater degree of understanding. At the same time, we have tried not to beat topics to death: Material that is inherently so clear that simple descriptions suffice is treated succinctly.

We have given particular attention to explaining and illustrating the most fundamental concepts at each level of biological organization. Among these are cellular energetics (especially basic thermodynamics, the chemiosmotic model, and photophosphorylation); cellular physiology (especially membrane receptors, second messengers, and the mechanisms of resting and action potentials and of muscle contraction); genetics, including both Mendelian and molecular genetics; the mechanisms of evolution; and the interactions among organisms that structure ecological communities.

Every instructor has a unique approach, a personal style, and a particular set of preferences of material to teach. Thus, a textbook must have more material than any one instructor is likely to use. Neither of us teaches in a course in which all of the topics presented here are taught at this level of detail. Nonetheless we offer a sufficient variety of material so that each instructor or team of instructors may select those topics that best suit their needs. There is no single best order of presenting topics in introductory courses; therefore, we have written this book in such a way that instructors may select a number of different sequences of chapters. However, within each of the major sections we have followed a logical progression of topic development.

It is sometimes said that certain important topics are “too difficult” or “too advanced” for students of introductory biology. This may simply mean that those topics require more careful explanation. With adequate presentation, many seemingly difficult topics become clear. Between us, we have been teaching for about fifty years, and we have taught students of widely differing aptitudes. Our experience supports our optimism about the ability of students to learn material if it is carefully explained and clearly illustrated. In the classroom and in this book we have not shied away from topics sometimes regarded as too advanced. We have introduced—and explained—such topics when they clarify other, “less difficult” concepts, or when they contribute to a more complete, more understandable story.

Some topics are more readily understood in the context of their historical development, or of the experimental background of our current knowledge. Space limitations make it impossible to introduce all or even most topics in this way, but we have used this approach where it seems most appropriate. The historical approach is particularly evident in Chapter 13 (Molecular Genetics of

Prokaryotes). Heavy emphasis on experimental evidence occurs widely throughout the book, but see especially Chapter 9 (Photosynthesis), Chapter 12 (Nucleic Acids as the Genetic Material), Chapter 14 (Gene Expression in Eukaryotes), Chapter 15 (Animal Development), Chapter 18 (Plant Development), and Chapter 32 (Origins).

In preparing a second edition of our book, we have taken advantage of the feedback we received from the many users of the first edition—incorporating many of their suggestions, profiting from their (and our) experience in teaching from the book, and correcting the errors (of both commission and omission) that inevitably found their way into the first edition. We also have included some of the most recent findings in molecular and cellular biology and in mechanisms of learning, and we have included, throughout the book, the relevant material discovered by application of recombinant DNA technology. This is reflected in particular by changes in the chapters on endocrinology, neurobiology, eukaryotic molecular genetics, origins of life, taxonomy and phylogeny, and macroevolution. Several chapters are now linked by new emphases on second messengers, on gated channels in membranes, and on membrane receptors. In our new organization of some of the material, developmental biology became one of the major section topics (it now forms the fourth of eight sections). We continue to introduce the special biology of plants by way of their development, but the basics of plant structure are now treated at the beginning of that chapter, as they should have been in the first edition. Also, each of the five kingdoms now has its own chapter in the section on the diversity of life. We have revised and expanded the introductory chapter (now two chapters) to orient the student more effectively for what follows, and to provide a more thorough discussion of scientific methods.

We have significantly increased our coverage of human genetics, of plant adaptations, of eukaryotic molecular genetics (now a full chapter), of homeostasis and thermoregulation (also a full chapter), of human evolution, of taxonomic methods, and of ecological succession. Some of these additions were in response to users' requests; others represent changes in the state of the art; still others represent our own changed assessment of certain fields. Additions necessitated complementary deletions, if the book was not to grow beyond all reason. Rather than eliminating topics, we have attempted to tighten the discussions in certain areas, and to eliminate instances in which unnecessary detail (for an introductory course) had appeared in the first edition. Several diagrams that were difficult for some students of the first edition have been redesigned. We hope that the great majority of our readers will find these changes helpful.

As with the first edition, many of our colleagues (listed at the end of this Preface) have reviewed chapters in manuscript. All their contributions are much appreciated, and the book is far better for their willingness to help. We particularly thank Ron Calabrese, Rob Colwell, Arthur Forer, Larry Gold, Bertil Hille, Merrill Hille, Richard McIntosh, and Bruce Walsh. They stand out among an outstanding group of reviewers because they provided explicit recommendations for extensive improvements. We are also especially indebted to those reviewers who have been users of the first edition and whose warmth and loyalty to the book have brightened the many, long months of the revision process. We will appreciate any suggestions and criticisms that you may choose to offer as you use this edition.

We continue to be obligated to the authors of the earlier textbook *Life on Earth* (Sinauer Associates). In writing the first edition of *Life* we had unlimited access to figures and text from that book; some of that material is still present in the second edition of *Life*. Carl May, whose contributions to the entire illustration program in the first edition were crucial to its success, directed the photography program for this edition. Andy Sinauer continues to be the amiable but firm

publisher that he has always been, and his contributions to this edition have been too many and varied to enumerate here. The entire staff of Sinauer Associates has conspired to make our task more enjoyable than it would otherwise have been, but we are still pleased to be through writing for a while.

November, 1986

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