



p r e f a c e

The popularity of marine biology and related courses is firmly established not only in two- and four-year colleges and universities, but in many advanced high school programs. This interest in marine life arises in part from a growing awareness of the ocean's importance to humanity in providing resources and regulating climate. Many excellent documentary films and photo essays on various aspects of marine biology and the growing popularity of scuba diving, recreational fishing, and aquarium keeping have also raised awareness of the sea's beauty, mystery, and vast scale.

College marine biology courses attract a broad spectrum of students with varied backgrounds. *Marine Biology*, second edition, was written primarily for the largest group of students: non-science majors, many of whom will take no other college science course. A growing number of students enroll in marine biology not only for personal interest, but to fulfill a general science requirement. In writing this book we made a special effort to provide the solid basic science content required for a general education course, including fundamental principles of biology, the physical sciences, and the scientific method. Our general aim was to integrate this basic science content with a stimulating, up-to-date overview of marine biology. This approach demonstrates the relevance of the physical sciences and, hopefully, makes the study of all sciences less intimidating.

At the same time, we recognize that marine biology does not satisfy general education requirements at all institutions. This text is designed to give instructors flexibility in the amount of basic science coverage, in the order in which topics are covered, and in overall emphasis and approach. The book seeks to meet the needs and expectations of a wide range of students, from the political science major interested in fisheries policy, to the engineering major interested in ocean technology. We hope that even biology students find it useful.

Another feature of *Marine Biology* is its global, non-regional approach. That the world's oceans and seas function as a vast integrated system is among the most important messages of our book. Understanding this requires a new way of thinking for many students. One aspect of our global approach is the deliberate inclusion of examples from many different regions and ecosystems so

that as many students as possible will find something relevant to their local area. We hope this will stimulate them to think about the many relationships between their own shores and the one world ocean that so greatly influences our lives.

CHANGES IN THE SECOND EDITION

The most widespread criticism of the first edition was its lack of color and the small size of the photographs. We hope users of the second edition share our delight in the greatly improved art design. We made some minor rearrangements in the text, the most significant of which was to move the coverage of protozoans from chapter 6 to chapter 5, so that protists are all covered together. Chapter 6 contains a new table summarizing the most important characteristics of invertebrate groups. We updated the entire text to reflect new research, and of course we corrected errors that were kindly pointed out by reviewers and users of the first edition, who also suggested topics for several new boxed essays. Finally, we made every effort to improve the index, which in the first edition had many errors.

ORGANIZATION

Marine Biology is organized into four parts. The first section (chapters 1 to 3) introduces students to marine biology and related fields of science. Chapter 1 describes the history of marine biology. It also covers the fundamentals of the scientific method, which are essential in understanding the workings of science. This feature, found in no other marine biology text, presents science as a process, an ongoing human endeavor. We feel it is important that students realize that science does have limitations, and there is still much to be learned. Chapters 2 and 3 present geological, physical, and chemical oceanography as they relate to marine biology. This link among the marine sciences is a central theme that is repeated throughout the book. *Marine Biology* presents more information on the geology, chemistry, and physics of the marine environment than

other texts, but we kept chapters 2 and 3 as short and basic as possible. Many physical aspects of the marine environment are discussed where they are biologically relevant. Wave refraction, for example, is covered in conjunction with intertidal communities (chapter 10), and upwelling is covered with the epipelagic zone (chapter 14). Like the rest of the book, chapters 2 and 3 include original world maps that were drawn using the Robinson projection to minimize distortion.

The exciting nature of life in the sea is the subject of part two (chapters 4 to 8). Chapter 4, "The Business of Life," is a brief introduction to the basic principles of biology. As with the fundamentals of geological, physical, and chemical oceanography, basic biological concepts are reviewed throughout the book in short Review Boxes. Because the most important material is reviewed in these boxes, chapter 4 may be omitted if introductory biology is a prerequisite for the course. The major groups of marine organisms are surveyed in chapters 5 to 8. As in the first part of the book, we provide introductory information that is reviewed and expanded upon in future chapters. In discussing the various groups, we emphasize functional morphology, outstanding ecological and physiological adaptations, and economic importance or significance to humanity. Classification and phylogeny are not stressed. However, a classification scheme for the major groups is given at the end of each of the four chapters in part two. Terminology has been limited to the bare essentials. Here and throughout the book we selected organisms from around the world for illustration in photographs, line drawings, and color paintings, but those organisms inhabiting the coasts of North America are emphasized. Organisms are referred to by their most widely accepted common names; one or two common or important genera are listed in parentheses the first time a group is mentioned in a chapter. Nomenclature follows the FAO Species Catalog and Species Identification Guides for groups covered by these references.

The third and most extensive part (chapters 9 to 15) constitutes the heart of the book. The first chapter of this section (chapter 9) introduces the fundamental principles of ecology. As in chapter 4, important concepts presented here are reviewed elsewhere in Review

Boxes. In the remaining six chapters of part three, we present the major environments of the world ocean, proceeding from nearshore to offshore and from shallow to deep water. The chapters are designed so that they can be covered in any sequence according to the instructors's preference and needs. The basic themes are adaptation to the physical constraints of the environment and the interaction of organisms within the environment. The chapters incorporate some of the most recent and exciting discoveries, as in the case of coral reefs and deep water.

The final part of the book looks at the many ways that humans interact with the world ocean: the use of resources, our impact on the marine environment, and the influence of the ocean on culture and the human experience. These chapters present an up-to-date, comprehensive view of issues and concerns shared by many students. The chapter on resource utilization (chapter 16) looks not only at traditional uses such as fisheries and mariculture, but at more modern aspects such as the pharmacological use of marine natural products and the application of genetic engineering to mariculture. In chapter 17, a discussion of marine pollution is followed by an examination of the conservation and enhancement of the marine environment. The book closes with an essay about the impact of the ocean on human affairs (chapter 18), one that we hope will stimulate students to reflect on the past and future significance of the world ocean.

TEACHING AND LEARNING AIDS

Because courses vary in content and sequence, *Marine Biology* was designed to be a flexible and efficient teaching aid. Chapters are written as short, readily absorbed units to increase instructors' flexibility in selecting topics. It is not assumed that instructors will follow the order in which material is presented in the book. For this reason, we provide **Review Boxes** that briefly explain key terms and concepts from other chapters. Some are illustrated by line drawings. Each box refers to the chapter and page where the concept is explained if more detailed information is needed. We hope this feature reduces the distraction of searching the index for unfamiliar terms.

A **Chapter Outline** is provided at the beginning of each chapter. **Key Concept Summaries**, printed in italics, highlight the most important terms and ideas presented in preceding paragraphs. The text is accompanied by a superb collection of photographs and illustrations that were carefully designed and selected to complement and reinforce

the text. Some of their captions contain questions that seek to further stimulate the student. There are many maps specifically created for *Marine Biology* to our specifications. The extensive **Glossary** provides complete definitions, and often refers to illustrations or other key terms in the glossary that help explain the concept.

All chapters contain short **Boxed Essays** that present interesting supplementary information—material as varied as experimental setups, John Steinbeck, intelligence in dolphins, and marine archaeology.

Each chapter concludes with an enumerated **Do-It-Yourself Summary** that allows students to test their comprehension and retention of the most relevant information. Key terms are omitted and the answers are provided in appendix A. The **Thought Questions** at the end of each chapter challenge students and stimulate class discussion. Many of these have no "right" answer—that is often the point. A short annotated list of recent references, **For Further Reading**, is also provided in each chapter. These list general articles of an appropriate level to students with limited backgrounds in science. We relied heavily on richly illustrated articles in such accessible publications as *Scientific American*, *National Geographic*, *Natural History*, *Oceanus*, and *Smithsonian*.

SUPPLEMENTARY MATERIALS

Instructor's Manual/Test Item File

Prepared by Peter Castro, this helpful ancillary provides Chapter Outlines and Summaries, a listing of Audio-Visual Materials and Software that complement each chapter, and answers to the "Thought Questions" in the text. Instructors will also find suggestions on how to present concepts to students and organize materials for class presentation. The Test Item File includes 15–30 multiple-choice questions per chapter and an answer key in the back of the book. The Instructor's Manual and Test Item File are available free-of-charge to instructors using the textbook.

Computerized Testing Software

This user-friendly computerized software is available at no charge to instructors for testing and grading. It can be ordered in either IBM (DOS or Windows) or MacIntosh version.

Transparencies

A set of 75 full-color overhead transparencies of key illustrations from the text is available to instructors at no cost.

Case Studies in Marine Biology

Supplement your instruction with this series of engaging essays written about current topics and issues in marine biology. Chosen with the intent to spark student interest, these essays offer opportunities for class discussion and additional projects.

Invertebrate Zoology Videodisc

This exciting ancillary provides a taxonomic sequence of 800 photos of invertebrates, 1,000 microscope slides, and video clips of key organisms demonstrating mobility, habits, and habitats—all easily accessed by bar code references.

Optilearn CD-ROM: Ocean Pollution

This new CD-ROM features more than 100 vivid photographs—each accompanied by a separate, descriptive caption explaining the significance of the image—that will help your students understand the environmental issues pertaining to the earth's largest biome. Also included is a free, easy-to-use presentation program, so you can create your own multimedia presentation.

Oceans Online

Oceans Online © is a new internet service that serves the "marine community" and provides access to peer groups within a large number of professions, databases, online teleconferencing, libraries for marine-related software, Internet and Usenet access, customer support services, and more. The Oceans Online system has been established to service professionals in oceanography, marine biology, geophysics, geology, engineering, manufacturing, the Navy, the Coast Guard, civil maritime, maritime law and insurance, state and federal maritime professionals, and university, collegiate and secondary schools. Oceans Online currently provides a LISTSERVE function for basic information on the system and will shortly be adding LISTSERVS for the major discussion areas. For an automated reply of topic listings send mail to: OCEANS@VBS.COM

In the subject line type: INDEX

ACKNOWLEDGMENTS

The many contributors of photographs that add so much to the book are acknowledged in the credits section, but we extend special thanks to A. Charles Arneson, who provided many excellent photos. We are also grateful for the outstanding artwork of Bill Ober and Claire Garrison.

We also thank the exceptional staff at Wm. C. Brown Publishers, particularly Kathy Loewenberg, Developmental Editor, and Marla Irion, Production Editor, for their patience in dealing with us while we worked in our separate corners of the world, and for their efficiency in managing an enormous amount of detail.

Finally, we thank the students, friends, colleagues, former teachers, and reviewers who answered questions, pointed out errors, and made suggestions that greatly improved the book. We take full credit, however, for any errors or shortcomings that remain.

REVIEWERS

David B. Campbell,
Rider University

Claudia A. Freitas,
Long Beach City College

Javier Gago,
*Los Angeles County Museum
of Natural History*

Marie McGee,
Arizona Western College

James E. T. Maragos,
East-West Center Program on Environment

William J. Minkel,
Santa Clara University

Ray Stross,
State University of New York-Albany

Mel Zucker,
Skyline College

We also remain grateful to the following reviewers of the first edition whose helpful suggestions have been carried forward to this text.

Keith E. Arnold,
*California State Polytechnic University,
Pomona*

Hans Bertsch,
*National University and El Camino
Community College*

Anthony L. Brundage,
*California State Polytechnic University,
Pomona*

Susan M. Cormier,
University of Louisville

Harold Hirth,
University of Utah

Ralph A. Lewin,
Scripps Institution of Oceanography

David A. McKee,
Corpus Christi State University

Edward K. Mercer,
*California State Polytechnic University,
Pomona*

Thomas M. Niesen,
San Francisco State University

John S. Pearce,
University of California, Santa Cruz

John E. Randall,
Bernice P. Bishop Museum, Honolulu

Roger A. Rulifson,
East Carolina University

Leslie J. Snider,
Mira Costa College

Patrick J. Walsh,
*Rosenstiel School of Marine and
Atmospheric Science, University of Miami*

A. Quinton White,
Jacksonville University