

Preface

The ocean fascinates people all over the world, including, of course, students enrolled in undergraduate marine biology courses. For many students, taking marine biology is the natural expression of an interest in marine life that began by visiting the shore, scuba diving, recreational fishing, aquarium keeping, or viewing one of the many television documentaries about the ocean. Many students are also concerned about the increasing impacts of humans on the marine environment. **Marine Biology, tenth edition**, was written to reinforce and enhance our readers' enchantment with marine life while providing a rigorous introduction to marine biology as a science.

Marine Biology is used by undergraduate, graduate, high school, and adult-education students, as well as by interested laypersons not enrolled in formal courses. We are gratified that many professional marine biologists use the book. The book is used in many countries outside the United States, and has been or is being translated into six other languages. While keeping this range of users in mind, the text is primarily written to meet the needs of lower-division, non-science majors at colleges and universities. For many of these students, marine biology will be their only tertiary science course, often taken to satisfy a general education requirement. We have therefore been careful to provide solid basic science coverage, including principles of the scientific method, the physical sciences, and basic biology. Our aim has been to integrate this basic science content with a stimulating, up-to-date overview of marine biology. We hope this approach demonstrates the relevance of the physical sciences to biology and makes all sciences less intimidating. To this end, we use an informal writing style that emphasizes an understanding of concepts over rigorous detail and terminology.

Not all marine biology courses, of course, are intended to fulfill a basic science requirement, and in many the students already have a science background. To balance the needs of instructors teaching courses with and without prerequisites in biology or other sciences, we have designed the book to provide as much flexibility as possible in the use of the basic science material, the order in which topics are presented, and overall emphasis and approach. We have tried to meet the needs and expectations of a wide variety of students, from the scuba-diving philosophy major to the biology major considering a marine science career. We hope a variety of readers other than university students also find the book useful and enjoyable.

Four major themes run through **Marine Biology**. One is the above mentioned coverage of basic science applied to the marine environment. Another is an emphasis on the organisms themselves, and their vast diversity not only in taxonomic terms but also in structure, function, and ecology. A third theme is an ecosystem approach that integrates this organismal diversity with the challenges imposed by the surrounding environment, both physical

and biological. A final theme that, unfortunately, becomes more relevant with each passing year is the impact of humans on the marine environment.

Marine Biology, tenth edition, adopts a global perspective to emphasize that the world's oceans and seas are an integrated system that cannot be understood by looking in any one person's own backyard. For many students this is a new perspective. 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, not just in North America but around the world, will find something relevant to their local areas or places they have visited. 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 all our lives.

CHANGES IN THE TENTH EDITION

As in every edition, we have made extensive revisions to incorporate new information and improve readability, and in response to comments by reviewers, whose suggestions we greatly appreciate. We have added a large number of new photographs to all chapters and the *Special Report: Our Changing Planet*. We have also revised or added new illustrations to practically all chapters and the *Spécial Report*, all expertly prepared by Bill Ober and Claire Garrison. We have also updated the end-of-chapter references for all chapters and the *Special Report*. Much of the data presented in the tenth edition—among others, for the frequency of shark attacks, the conservation status of threatened species, global temperatures, the extension of the Gulf of Mexico's hypoxic zone, the status of some invasive species, whaling, sea otter transplantations, fisheries catches, aquaculture production, and seafood demand and consumption around the world—has been updated to the latest information available at the time of writing. The researches highlighted in the "Eye on Science" boxes, which have proven to be very popular among students and instructors alike, have been updated. Two "Eye on Science" boxes have been added, one on a cat parasite that has become more prevalent in marine mammals (Chapter 13) and another on the effects of climate change on Arctic peoples (Chapter 18). There are too many other topics for which we have updated or added new information to list in full here, but examples include the following:

- Modified Table 5.1 on the metabolism of marine prokaryotes to make it more reader-friendly
- Updated the classification of protozoans
- Expanded information on marine fungi
- Added a new section on chlorophyll and accessory pigments in marine primary producers

- Added information on the biology of marine angiosperms and particularly expanded coverage of their reproduction, including a new diagram contrasting the life histories of angiosperms with the four basic patterns of seaweeds
- Added many new photos of seaweeds, marine flowering plants, invertebrates, fishes, sea turtles, seabirds, and marine mammals
- Expanded Table 6.1 on the groups of marine autotrophs
- Updated, to follow more current views, the position of chaetognaths as protostomes and echiurans as annelids
- Added characters to cladograms in Figs. 7.1 (invertebrates) and 8.1 (vertebrates) and revised to follow latest interpretations on the phylogeny of invertebrate taxa
- Updated species counts for all invertebrate and vertebrate groups
- Expanded Table 7.1 on the groups of invertebrates
- Modified box on sharks to emphasize threats to their existence
- Added information to the box on coelacanth
- Significantly expanded section on the biology of marine mammals, adding a great deal of information (swimming, diving, migrations, behavior, and reproduction) on non-cetaceans (pinnipeds, the walrus, sea otter, polar bear, and sirenians)
- Expanded illustration of filter feeding in whales
- Updated status of great whales and dolphins
- Updated some of the graphs in the *Special Report*
- Added information on the biology (physiology, ecology) of mangroves and seagrasses, including new photos
- Added information on bioturbation, fjord communities, and deep-water reefs
- Greatly expanded the box on Antarctic subtidal communities, now including the Arctic and the effects of human intrusion in both
- Added information on species composition, biodiversity, and biogeography of soft-bottom subtidal communities
- Added recent information, including a new figure, on a tropic cascade involving sea otters and the recovery of seagrass meadows
- Expanded section on the human impact on seagrasses
- Redesigned figures on the rete mirabile of epipelagic fishes, adaptations for fast swimming in tunas, and the krill photophore
- Added new information on aquaculture and the use of methane hydrates as a source of energy
- Added new figure on ocean thermal energy conversion (OTEC)
- Expanded and updated information on marine protected areas
- Added new figure on the Gulf of Mexico hypoxic, or "dead," zone

- Added new information on endangered marine species, including updating of our unique table on Red List and CITES lists for marine species
- Expanded data on plastic pollutants and artificial reefs
- Added new section on prospects for the future of the marine environment and the role of marine biology

ORGANIZATION

Marine Biology is organized into four parts. **Part one** (*Chapters 1 through 4*) introduces students to marine biology and the basic sciences that underpin it. *Chapter 1* describes the history of marine biology. It also explains the fundamentals of the scientific method. This feature emphasizes that science is a process, an ongoing human endeavor. We think it is critical that students understand how and why science works, that science has limitations, and that there is still much to be learned. *Chapters 2 and 3* are a basic introduction to marine geology, physics, and chemistry. *Marine Biology* includes more information on these subjects, and places greater stress on their importance to understanding marine ecosystems, than other texts but we have kept *Chapters 2 and 3* as short as possible and have covered many abiotic aspects of the marine environment in the chapters where they are most relevant to the biology. Wave refraction, for example, is described in conjunction with intertidal communities (*Chapter 11*) and estuarine circulation is discussed as part of the ecology of estuaries (*Chapter 12*). This approach emphasizes the importance of the physical and chemical environment to the organisms of the sea throughout the book. At the same time, it provides flexibility for instructors to make best use of the material in light of general education requirements, course prerequisites, and students' backgrounds. *Chapter 4*, "Fundamentals of Biology," briefly reviews some essential biological concepts. In covering basic biology we have tried to balance the needs of a spectrum of students ranging from those with no prior university-level instruction to those who have taken a number of biology courses. Depending on the level of their students, instructors may choose to cover *Chapter 4* in class, assign it as review reading, or omit it and rely on the in-text glossary entries in later chapters to remind students of the definitions of key terms.

Part Two (*Chapters 5 through 9*) surveys the diversity of marine life from the perspective of organismal biology. As in Part One, we provide introductory information that is reviewed and expanded upon in later chapters. In discussing the various taxa we emphasize functional morphology, ecological and physiological adaptations, and economic importance or other significance to humanity. Classification and phylogeny are not stressed, though we do present cladograms illustrating widely accepted phylogenetic schemes for invertebrates and vertebrates. As in the rest of the book we have selected organisms from around the world for photographs, line drawings, and color paintings, but organisms from 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 noted in parentheses the first time a group is mentioned in a chapter, but we have not attempted to provide comprehensive lists of genera.

Part Three of the book (*Chapters 10 through 16*) presents an ecological tour of the major environments of the world ocean, commencing with an introduction to some fundamental principles of marine ecology in *Chapter 10*. As in *Chapter 4*, important concepts presented here are reviewed elsewhere in the in-text glossary boxes. The remaining six chapters of Part Three proceed from nearshore to offshore and from shallow to deep water, describing the physical characteristics of each environment and the adaptations and interactions of the organisms that live there. This admittedly arbitrary sequence follows the teaching sequence of the greatest number of our reviewers, but the chapters are designed so that they can be covered in any sequence according to instructors' preferences and needs. Most chapters include generalized food webs with standardized color coding to indicate the nature of the trophic relationships. Part Three also contains the *Special Report: Our Changing Planet*, a feature on anthropogenic global change that was introduced in the seventh edition.

Finally, **Part Four** looks at the many ways in which humans interact with the world ocean: our use of and impact on the marine environment and the influence of the ocean on the human experience. The section presents an up-to-date, comprehensive view of issues and concerns shared by many students. The chapter on resource utilization (*Chapter 17*) looks not only at traditional uses, such as fisheries, aquaculture, and oil and gas extraction, but also at more modern aspects, such as the emerging technologies to generate energy from the sea, the pharmacological use of marine natural products, and the application of genetic engineering and other technologies in aquaculture. *Chapter 18* discusses human-induced degradation of the marine environment, balanced by an examination of marine conservation and habitat restoration.

ACKNOWLEDGMENTS

Bill Ober and Claire Garrison have again done a superb job of bringing new life to the illustrations, including new ones. We also thank the many contributors of photographs that add so much to the book, and appreciate the expert and diligent efforts of LouAnn Wilson in locating new photos and information about them. We are grateful to the editorial and production staff, particularly Rebecca Olson, Fran Simon, Patrick Reidy, and Lisa Bruflo, for their patience, support, and efficiency in managing an enormous amount of detail. Most of all we thank the students, friends, colleagues, former teachers, and reviewers who answered questions, pointed out errors, and made suggestions that have greatly improved the book. We take full credit, however, for any errors or shortcomings that remain.

REVIEWERS

The following people reviewed the ninth edition and have provided useful commentary for preparation of the tenth edition:

Dr. Chantale Bégin, *University of South Florida*

Paul Detwiler, *San Diego Mesa College*

Dr. Michelle L. Hardee, *University of South Carolina*

Dr. Rob McDowell, *American Public University*

Dr. Christopher Osovitz, *University of South Florida*

Dr. Christina L. Richards, *University of South Florida*