

A large crab is perched on a coral reef. The coral is a vibrant orange-red color, and the water is a deep, clear blue. The crab is brown and has its legs spread out. The background is slightly blurred, focusing attention on the crab and the coral.

# 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 superb television documentaries about the ocean. Many students are also concerned about the increasing impacts of humans on marine ecosystems. *Marine Biology, ninth 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 high school, undergraduate, graduate, 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 abovementioned 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 phys-

ical 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, ninth 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 NINTH 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. In the ninth edition we have introduced new sections on the biology of cubozoans, and reorganized the coverage of marine reptiles and seabirds into new sections that emphasize adaptations for swimming, diving, and reproduction. The cladograms in the book have been enhanced by adding key characteristics that distinguish groups, and have been redrawn to aid student comprehension and retention. We have reflected taxonomic revisions for bluefin tunas, several whales and dolphins, and the mesopelagic shrimp *Gnathophausia*. Information has been added on the effects of humans on oyster reefs and mangrove forests, as well as new sections on human impacts on seagrass and coral reef communities. Much of the data presented in the ninth edition—among others, for the frequency of shark attacks, the conservation status of threatened species, global temperatures, atmospheric carbon dioxide levels, and fisheries catches—has been updated to the latest information available at the time of writing. We have added coverage of two disasters that captured global headlines, the Kagoshima tsunami and the *Deepwater Horizon* oil spill. There are too many topics for which we have updated or added new information to list in full here, but examples include:

- Updated information on ocean observing systems
- New information on the life history of seaweeds
- Updated and revised coverage of several groups of invertebrates, including cnidarians, crinoids, and hemichordates
- Revision of the section on shark reproduction

- New information on whale vocalization and behavior
- A new figure in *Special Report: Our Changing Planet* showing that the current atmospheric concentration of carbon dioxide is higher than at any time in the last 400,000 years
- Recent findings about how seasonal cycles affect the balance of competition and predation in the rocky intertidal
- New information on the marine otter and on the population size and parasitic diseases of sea otters
- New research on increases in sponge abundance on Caribbean coral reefs above past levels, apparently as a result of anthropogenic impacts on corals
- Discussion of how overfishing of coral reef sharks can result in a trophic cascade that affects the entire coral reef community
- Recent findings of close associations between cyanobacteria and heterotrophic bacteria in the epipelagic, in relation to energy flow through the “microbial loop”
- Recent findings of flexible camouflage behavior in mesopelagic cephalopods
- Updated information on obtaining energy from the sea, including a new Figure 17.18 showing methodology for oil and gas drilling in deep water and a new Figure 17.20 showing technology for generating electricity from waves

We continue to receive positive feedback from instructors and reviewers on our “Eye on Science” boxes—brief vignettes of major research programs or individual research projects. We have added 13 new boxes to the ninth edition:

- “Carbonate Experiments on the Reef” (to emphasize that scientists conduct experiments in the field as well as in the laboratory)
- “Life Below the Sea Floor” (marine biology extends deep into the earth)
- “Larval Transport Near Hydrothermal Vents” (biologists need physical oceanography too!)
- “A Fourth Domain of the Tree of Life?”
- “Marine Algae as Biofuels” (will oils from marine phytoplankton help power our cars?)
- “The Octopus’ Complex Brain” (they’re smarter than you think)
- “Great White Shark Migrations”
- “Feeding in the Blue Whale”
- “Restoration of Salt Marshes”
- “Biological Nutrient Pumps” (from shrimp to whales, marine animals may play surprising roles in pelagic nutrient cycles)
- “*Alvin* Reborn” (rumors of this oceanographic icon’s demise were premature)

- “The Aquaculture of Bluefin Tunas” (recent developments in aquaculture research)
- “Human Impact on the Arctic” (consequences of a reduction in sea ice)

We have also made a number of revisions to illustrations and selected new photographs to make the artwork clearer and more visually appealing.

## ORGANIZATION

*Marine Biology* is organized into four parts. **Part 1** (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 cover 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 2** (Chapters 5 through 9) surveys the diversity of marine life from the perspective of organismal biology. As in Part 1, 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 3** 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 3 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 3 also contains the *Special Report: Our Changing Planet*, a feature on anthropogenic global change that was introduced in the seventh edition.

Finally, **Part 4** 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. The book closes with an essay on the interactions between the ocean and the human culture (Chapter 19) that we hope will stimulate students to reflect on the past and future significance of the world ocean to all our lives.

## ACKNOWLEDGMENTS

Bill Ober and Claire Garrison have again done a great job of bringing new life to the illustrations. We also thank the many contributors of photographs that add so much to the book,

especially A. Charles Arneson, who has provided many excellent photos, and appreciate the diligent efforts of LouAnn Wilson in locating new photos. We are grateful to the editorial and production staff, particularly Janice Roerig-Blong, Executive Editor, Wendy Langerud, Developmental Editor, and Lisa Bruffodt and Shyam Ramasubramony, Project Managers, 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.

We also give special thanks to the following researchers who provided information, photographs, and other assistance in the preparation of the “Eye on Science” boxes:

Dr. Sepehr Eskandari, *California State Polytechnic University, Pomona*

Michael C. Scholl, *White Shark Trust*

Dr. Lenard R. Troncale, *California State Polytechnic University, Pomona*

## REVIEWERS

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

Sabine Alshuth, *Indian River State College, Florida*

Lesley P. Baggett, *University of South Florida*

Erin J. Burge, *Coastal Carolina University, South Carolina*

Melissa Gibbs, *Stetson University, Florida*

Gwen Goodmanlowe, *California State University, Long Beach*

Sherri Hitz, *Florida Keys Community College*

Robert McDowell, *American Public University, West Virginia*

Noel Rizzuto, *Keiser University – Lakeland, Florida*

Ryan Tanish, *Johnson & Wales University, Florida*