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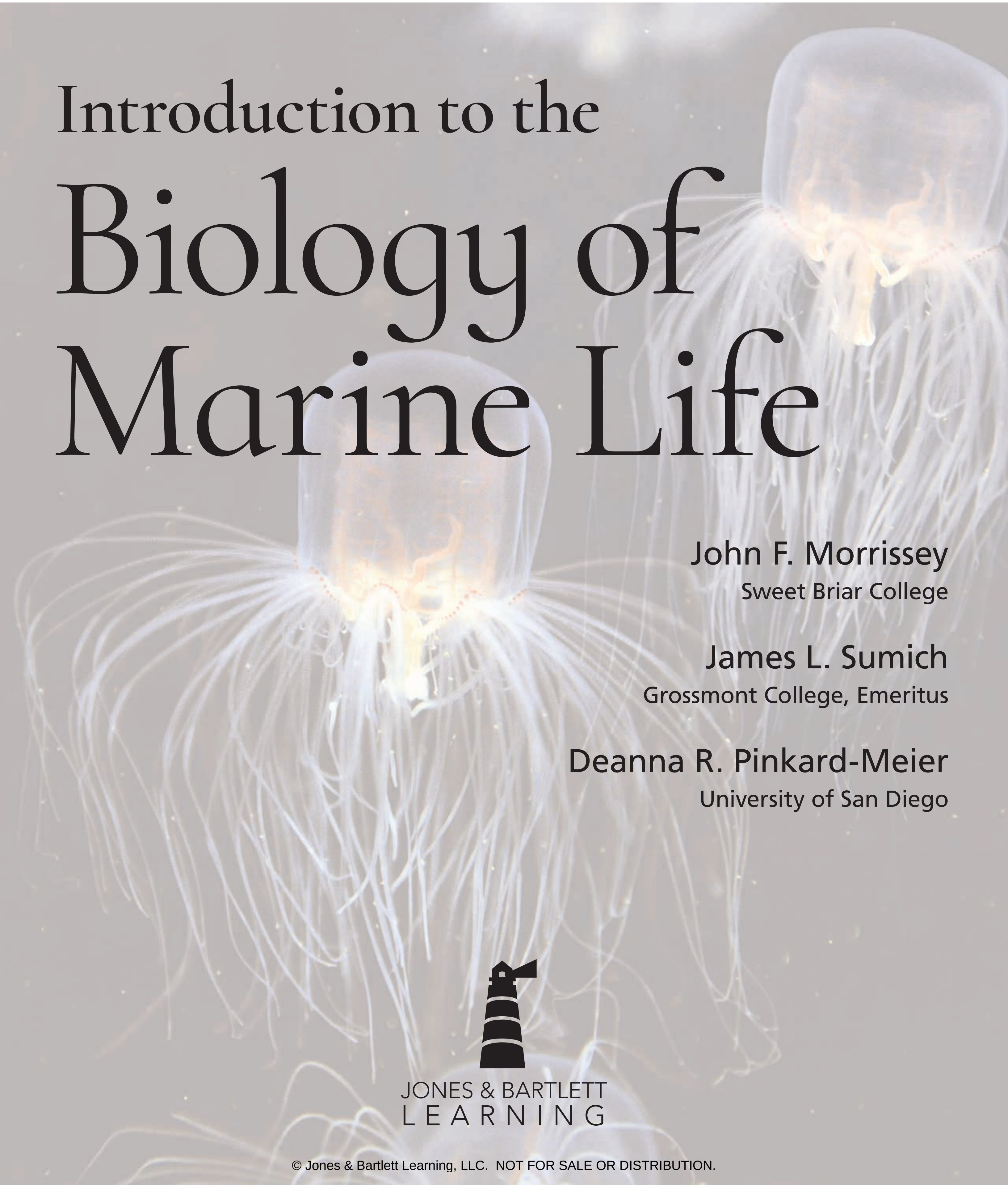

Introduction to the Biology of Marine Life

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Dedication

I dedicate my efforts on this book to my late mother, Diane Sue Pinkard, who taught me to appreciate the ocean from an early age, and who supported me through all of my endeavors. Her love for all things ocean related made a lasting impression on me as I pursued a career in the marine sciences.

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Brief Contents

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Preface

As this new edition is being prepared, the longest global coral bleaching and die-off event in recorded history is occurring, and there is evidence that the oceans have become more acidic due to increased carbon dioxide emissions. As scientists worldwide attempt to deal with new marine environmental problems arising and old problems persisting, continued understanding of the sea and its inhabitants is absolutely necessary. For nonscientists, if there is a desire to preserve our world ocean, which provides so many services to us, and to continue to enjoy having fun in the sea and eating seafood, we must expand our knowledge of the sea and how our daily activities affect its health. Familiarity with the effects of a changing climate will help one understand the complexities of rising sea temperatures and sea levels. An understanding of the biology of corals and other animals will enable scientists to predict the magnitude of impacts to these organisms when the water is too warm or the chemistry changes too much. Knowledge of the chemistry of seawater will provide one with the ability to understand the many changes to the water column that are being observed as ocean acidification becomes more widespread. Perhaps most important, a study of the biology of marine life will help one appreciate the reasons why so many organisms are harmed due to these changes to our world ocean, such as corals, which support entire ecosystems. All of this insight and much more is contained within this eleventh edition.

Audience

We have written *Introduction to the Biology of Marine Life* to engage introductory, college-level students in the excitement and challenge of understanding marine organisms, the environments in which they live, and the challenges they face as the marine environment changes. We assume no previous knowledge of marine biology; however, some exposure to the basic concepts of biology is helpful. This book uses selected groups of marine organisms to develop an understanding of biological principles and processes that are basic to all forms of life in the sea. To build on these basics, we present information dealing with several aspects of taxonomy, evolution, ecology, behavior, and physiology of these selected groups. We hope that a student's venture into this exciting field provides some flavor of the mix of disciplines that constitutes modern biological science. Moreover, we hope that this text cultivates an appreciation for the need to understand marine geology (the seafloor), marine physics (waves, tides, and currents), and marine chemistry (the composition of seawater) before a complete understanding of marine biology can be achieved.

Organization

Although we intend the sequence of topics to be flexible, we have presented our material in four sections.

We begin with an introduction to the sea as a habitat (Chapter 1), highlighting the many ways that the ocean realm differs tremendously from more familiar terrestrial environments, especially in terms of the chemistry of seawater and the geology of the seafloor. We have added an entire chapter on motion within the sea (Chapter 2), highlighting the mechanisms behind ocean movements and how ocean movements affect marine life. Then we provide a brief summary of basic chemical and biological principles that are not unique to the ocean for the beginning student (Chapter 3). The next portion of the book summarizes all life in the sea, with two chapters dedicated to autotrophic producers, large and small, and marine bacteria and viruses (Chapters 4 and 5); one chapter for microbial and invertebrate consumers (Chapter 6); and two chapters covering marine vertebrates (fish, amphibians, and reptiles in Chapter 7; birds and mammals in Chapter 8). We have organized the third section of this new edition around the major marine habitats: estuaries (Chapter 9), coastal seas (Chapter 10), coral reefs (Chapter 11), the open ocean (Chapter 12), and the deep sea (Chapter 13). Chapter 14 includes descriptions of the polar seas and their

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inhabitants, as well as a discussion of global climate change, including suggestions for lowering one's ecological footprint. Finally, we describe the history and current status of marine fisheries and aquaculture in Chapter 15.

New to the Eleventh Edition

The tenth edition of this text was well received by a wide audience, and this was very encouraging while preparing the eleventh edition. Many wonderful suggestions were made by reviewers and readers of earlier editions, and it was these suggestions, along with creative ideas suggested by the editors at Jones & Bartlett Learning, that led to a textbook that has been greatly improved and updated. This eleventh edition represents our continuing efforts to meet the needs of our readers more completely, and to adapt to changing educational platforms. We are certain that students and instructors alike will be pleased to see the many ways that the book has been augmented with new information, new features, and refreshed dialogue.

Chapter 1 has been updated and improved by making the material more concise and moving information on ocean chemistry and oceanography to the new Chapter 2, "Physical and Chemical Oceanography." The new Chapter 2 includes examples of the linkages between ocean water movement and the fate of marine organisms and additional information on El Niño. Chapter 3 now includes a clarified discussion of photosynthesis and a new section that introduces evolution by natural selection. Chapter 4 has been expanded to cover marine bacteria, Archaea, and viruses and includes updated photosynthesis terminology and an introduction to phylogenetics. Chapter 5 now contains the latest hypotheses on the phylogenetic relationships of marine algae. Chapter 6 includes a discussion of the abandonment of the term "protista" and more detailed information on invertebrate phyla, including new discussions of the phylum Tardigrada and meiofauna. Chapter 7 includes more detailed information on fish physiology, a discussion of *Hox* genes, and a new example of hermaphroditism in fish. Chapter 8 now includes information on echolocation; additional information on manatees, dolphins, porpoises, and sperm whales; and updated information on population statuses of several groups of marine mammals. Chapter 9 has been augmented with expanded coverage of nutrient pollution, the biology of mangroves, and suggestions for improving the health of estuaries. Chapter 10, which covers the biology of coastal seas, offers coverage on hot topics in marine science such as connectivity. Chapter 11 has been updated with a large amount of recent research examples, new hypotheses on coral spawning strategies, the effects of ocean acidification on coral, and new information on Marine Protected Areas. Chapter 12 now includes more information on the orientation of organisms in the open sea, including zooplankton behavior. An updated Chapter 13 includes new information about technological advancements in deep-sea research and new discoveries in the deep sea. Chapter 14 is a new chapter on the polar seas. It contains information moved from other chapters on animals that inhabit polar climates, new information on climate change and sea ice research, and suggestions for reducing our greenhouse gas emissions. Chapter 15 highlights the latest trends in fisheries science, updated fisheries statistics, the recent increase in aquaculture, and concludes the book with suggestions for becoming a steward of the ocean.

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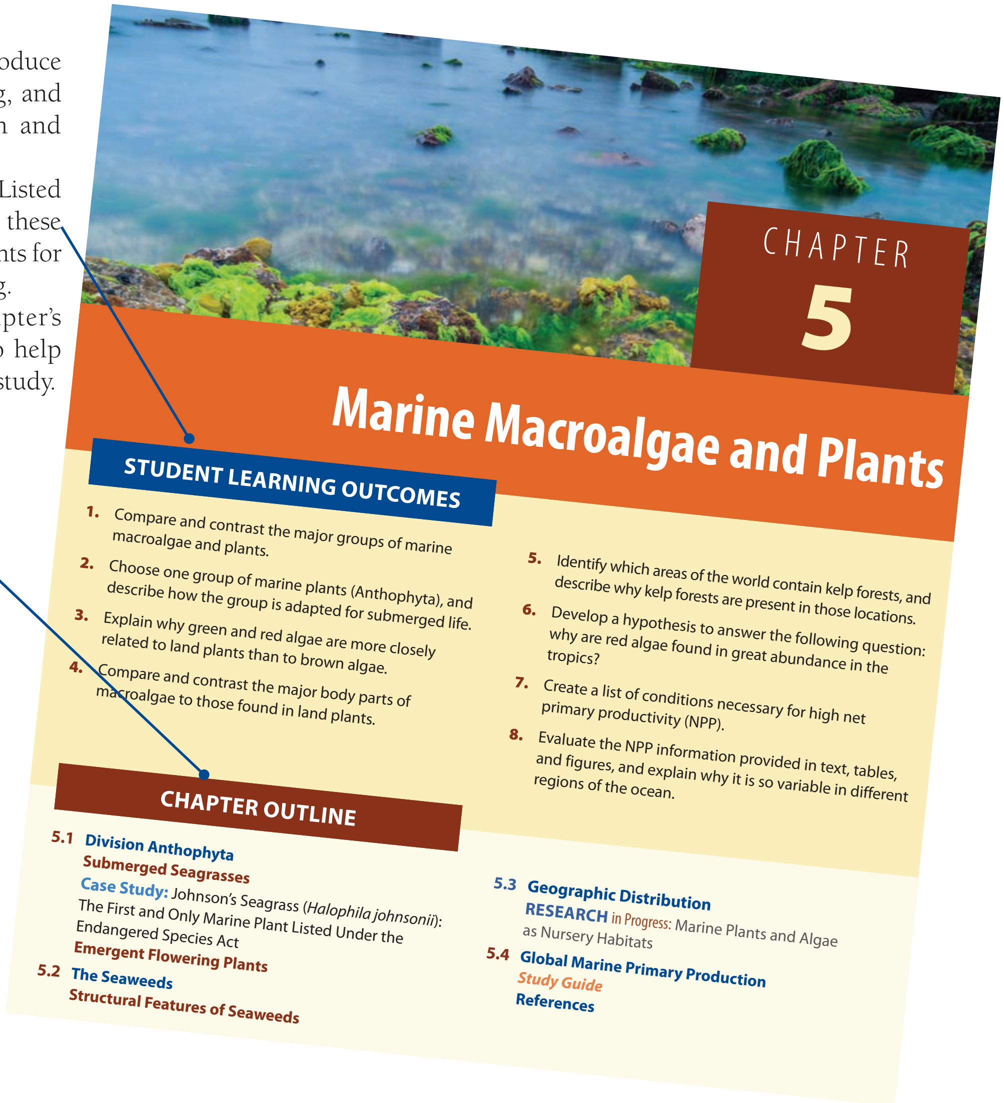
The Student Experience

Each of the chapters is designed to introduce key concepts, reinforce understanding, and encourage independent investigation and education.

- **Student Learning Outcomes**—Listed at the beginning of every chapter, these learning objectives prepare students for the material they will be learning.
- **Chapter Outlines**—The chapter's framework is clearly laid out to help students plan their reading and study.



CHAPTER 5

Marine Macroalgae and Plants

STUDENT LEARNING OUTCOMES

1. Compare and contrast the major groups of marine macroalgae and plants.
2. Choose one group of marine plants (Anthophyta), and describe how the group is adapted for submerged life.
3. Explain why green and red algae are more closely related to land plants than to brown algae.
4. Compare and contrast the major body parts of macroalgae to those found in land plants.
5. Identify which areas of the world contain kelp forests, and describe why kelp forests are present in those locations.
6. Develop a hypothesis to answer the following question: why are red algae found in great abundance in the tropics?
7. Create a list of conditions necessary for high net primary productivity (NPP).
8. Evaluate the NPP information provided in text, tables, and figures, and explain why it is so variable in different regions of the ocean.

CHAPTER OUTLINE

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- **High-Quality, Carefully Rendered Illustrations and Figures**—More than 340 NEW and revised photos and illustrations are included in this edition to help support visual learners, clarify key concepts, and enhance the students' reading experience.

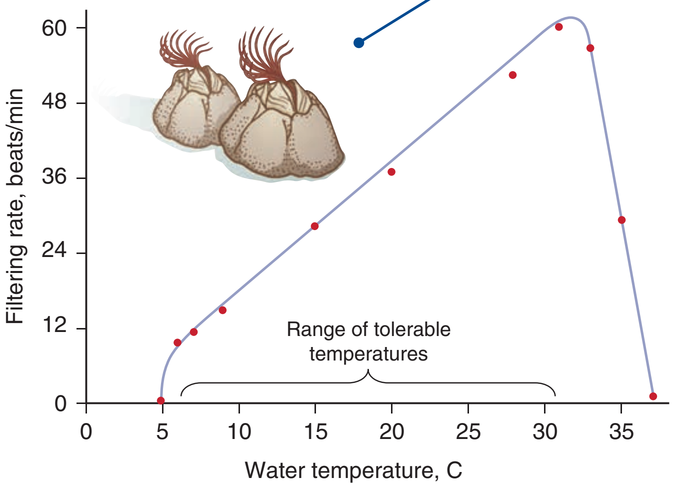

Figure 2.38 Graph depicting the filtering rate of a marine barnacle as a function of water temperature. The filtering rate drops dramatically as the barnacle is placed outside the range of tolerable temperatures.
Modified from Southward, A. J., *Helgol. wiss. Meersuntersuch* 10 (1964):391–401.

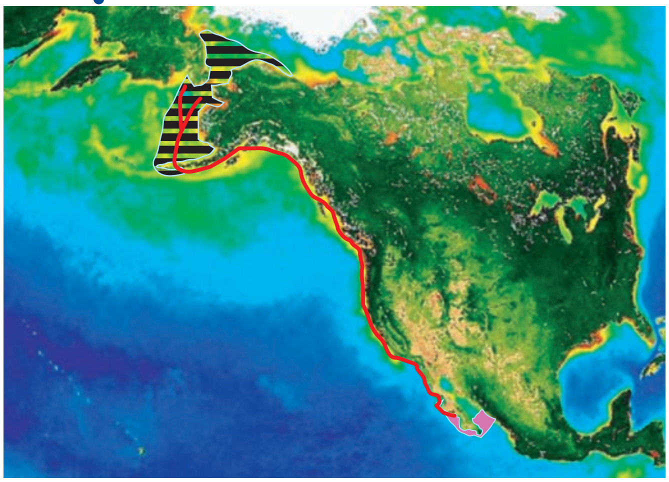

Figure 8.32 Migratory route (blue [?] line) of the North Pacific gray whale, with summer feeding (red hatching) and winter breeding areas (pink) indicated. Primary productivity i indicated by water color, with green representing the highest chlorophyll content and dark blue the lowest.
Courtesv of NASA.

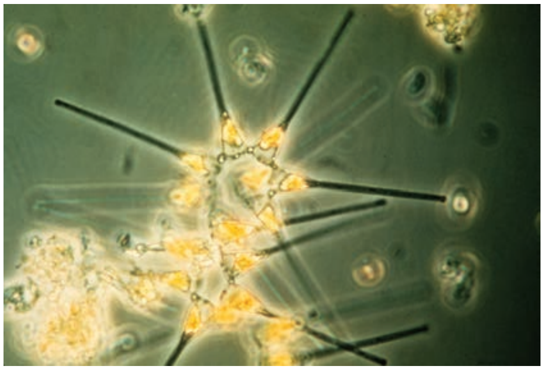

Figure 4.7 A common marine silicoflagellate slightly smaller than the coccolithophores shown in Figure 4.6.
NOAA Photo Library.

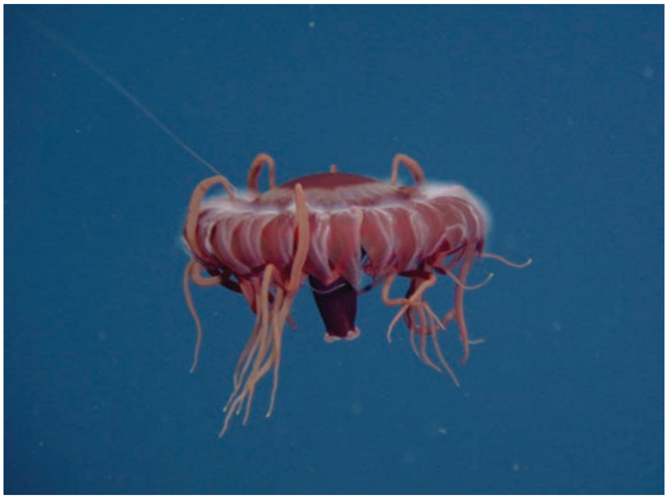

Figure 13.8 A crown jellyfish, *Atolla*

Figure 8.22 A manatee floating, surrounded by snappers in Crystal River, Florida.
Keith Ramos/USFWS.

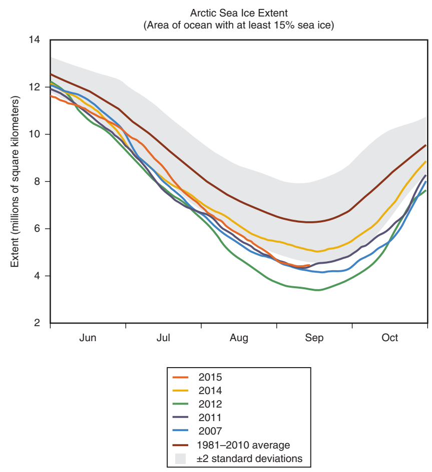

Figure 14.22 Average Arctic sea ice extent for 1981 to 2010 compared to the five lowest ice measurements recorded. Data are provided by the National Snow and Ice Data Center.
Courtesy of National Snow and Ice Data Center.

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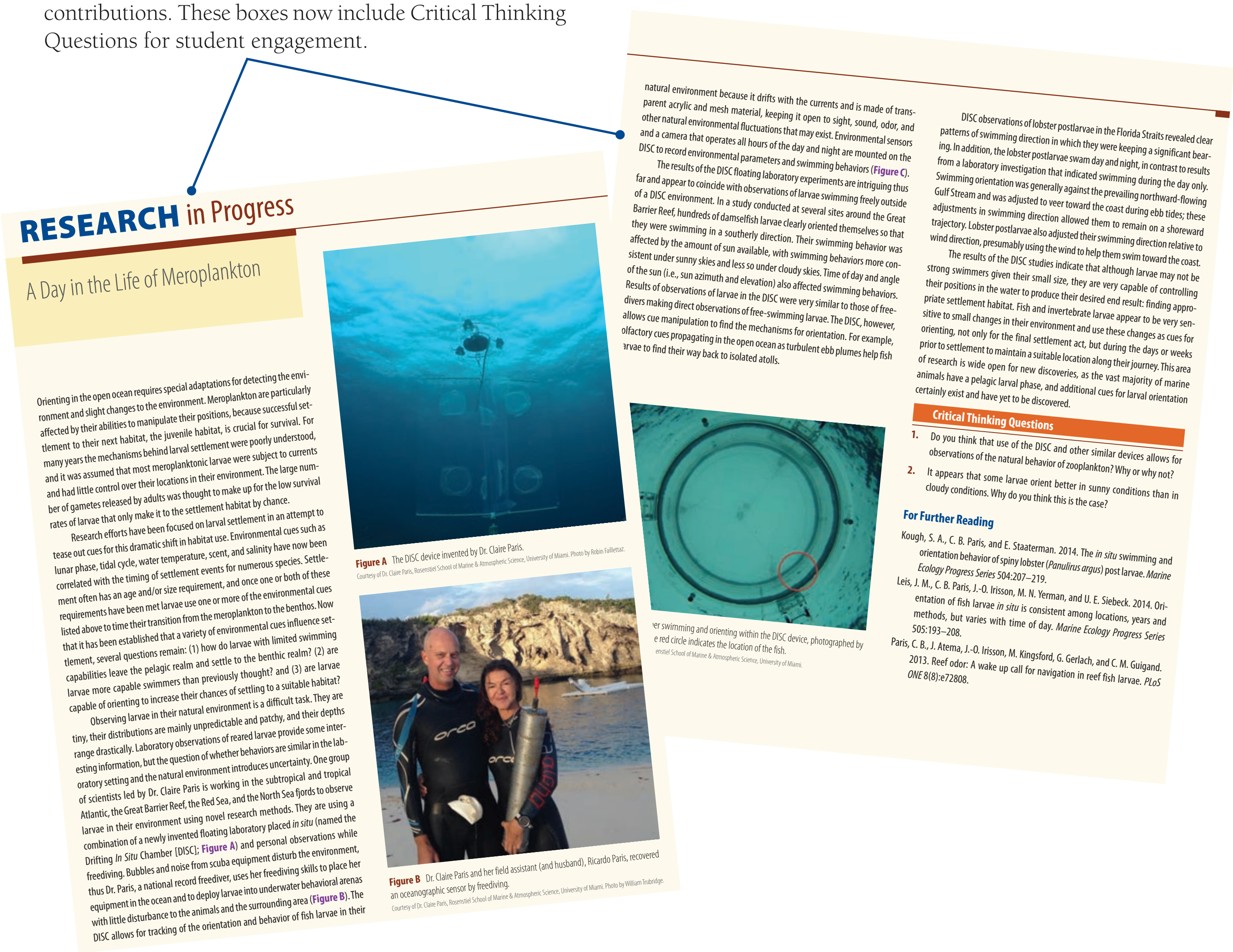
- **Did You Know?**—These NEW boxes are scattered throughout each chapter, providing interesting marine biology material for students and generating curiosity about the marine world.

DID YOU KNOW?

Hagfish slime is unique among animal mucus because it contains protein threads that help it expand dramatically when it contacts seawater. The sticky, expanding mucus is what was thought to deter predators, and in 2011 this behavior was finally caught on video for observation by researchers. Because the slime expands, it basically chokes fish that are trying to eat the hagfish by clogging their gills. Video from 2011 also caught hagfish preying on other fish, a previously unknown behavior for this fish that was considered a scavenger, feeding on dead and decaying matter, and sometimes on small living invertebrates. These unique features are likely several of the characteristics that have allowed hagfish to persist for so long with success.

- **Research in Progress**—One of our primary objectives is to show students that marine biology, like all sciences, is a dynamic and active field. Each year, recent discoveries about the sea are published in thousands of new scientific papers. A popular feature in previous editions, these boxes have been fully updated to reflect current ongoing research that will encourage students to learn more about real work being done in the field of marine biology. Through these boxes we hope to show the process of science, as well as to suggest to our readers that marine biology is a vibrant field of study, ready for their future contributions. These boxes now include Critical Thinking Questions for student engagement.



RESEARCH in Progress

A Day in the Life of Meroplankton

Orienting in the open ocean requires special adaptations for detecting the environment and slight changes to the environment. Meroplankton are particularly affected by their abilities to manipulate their positions, because successful settlement to their next habitat, the juvenile habitat, is crucial for survival. For many years the mechanisms behind larval settlement were poorly understood, and it was assumed that most meroplanktonic larvae were subject to currents and had little control over their locations in their environment. The large number of gametes released by adults was thought to make up for the low survival rates of larvae that only make it to the settlement habitat by chance.

Research efforts have been focused on larval settlement in an attempt to tease out cues for this dramatic shift in habitat use. Environmental cues such as lunar phase, tidal cycle, water temperature, scent, and salinity have now been correlated with the timing of settlement events for numerous species. Settlement often has an age and/or size requirement, and once one or both of these requirements have been met larvae use one or more of the environmental cues listed above to time their transition from the meroplankton to the benthos. Now that it has been established that a variety of environmental cues influence settlement, several questions remain: (1) how do larvae with limited swimming capabilities leave the pelagic realm and settle to the benthic realm? (2) are larvae more capable swimmers than previously thought? and (3) are larvae capable of orienting to increase their chances of settling to a suitable habitat?

Observing larvae in their natural environment is a difficult task. They are tiny, their distributions are mainly unpredictable and patchy, and their depths range drastically. Laboratory observations of reared larvae provide some interesting information, but the question of whether behaviors are similar in the laboratory setting and the natural environment introduces uncertainty. One group of scientists led by Dr. Claire Paris is working in the subtropical and tropical Atlantic, the Great Barrier Reef, the Red Sea, and the North Sea fjords to observe larvae in their environment using novel research methods. They are using a combination of a newly invented floating laboratory placed *in situ* (named the Drifting *In Situ* Chamber [DISC]; **Figure A**) and personal observations while freediving. Bubbles and noise from scuba equipment disturb the environment, thus Dr. Paris, a national record freediver, uses her freediving skills to place her equipment in the ocean and to deploy larvae into underwater behavioral arenas with little disturbance to the animals and the surrounding area (**Figure B**). The DISC allows for tracking of the orientation and behavior of fish larvae in their

Figure A The DISC device invented by Dr. Claire Paris.
Courtesy of Dr. Claire Paris, Rosenstiel School of Marine & Atmospheric Science, University of Miami. Photo by Robin Faillettaz.

Figure B Dr. Claire Paris and her field assistant (and husband), Ricardo Paris, recovered an oceanographic sensor by freediving.
Courtesy of Dr. Claire Paris, Rosenstiel School of Marine & Atmospheric Science, University of Miami. Photo by William Trobridge.

natural environment because it drifts with the currents and is made of transparent acrylic and mesh material, keeping it open to sight, sound, odor, and other natural environmental fluctuations that may exist. Environmental sensors and a camera that operates all hours of the day and night are mounted on the DISC to record environmental parameters and swimming behaviors (**Figure C**).

The results of the DISC floating laboratory experiments are intriguing thus far and appear to coincide with observations of larvae swimming freely outside of a DISC environment. In a study conducted at several sites around the Great Barrier Reef, hundreds of damselfish larvae clearly oriented themselves so that they were swimming in a southerly direction. Their swimming behavior was affected by the amount of sun available, with swimming behaviors more consistent under sunny skies and less so under cloudy skies. Time of day and angle of the sun (i.e., sun azimuth and elevation) also affected swimming behaviors. Results of observations of larvae in the DISC were very similar to those of free-divers making direct observations of free-swimming larvae. The DISC, however, allows cue manipulation to find the mechanisms for orientation. For example, olfactory cues propagating in the open ocean as turbulent ebb plumes help fish larvae to find their way back to isolated atolls.

…er swimming and orienting within the DISC device, photographed by … e red circle indicates the location of the fish.
…enstiel School of Marine & Atmospheric Science, University of Miami.

DISC observations of lobster postlarvae in the Florida Straits revealed clear patterns of swimming direction in which they were keeping a significant bearing. In addition, the lobster postlarvae swam day and night, in contrast to results from a laboratory investigation that indicated swimming during the day only. Swimming orientation was generally against the prevailing northward-flowing Gulf Stream and was adjusted to veer toward the coast during ebb tides; these adjustments in swimming direction allowed them to remain on a shoreward trajectory. Lobster postlarvae also adjusted their swimming direction relative to wind direction, presumably using the wind to help them swim toward the coast.

The results of the DISC studies indicate that although larvae may not be strong swimmers given their small size, they are very capable of controlling their positions in the water to produce their desired end result: finding appropriate settlement habitat. Fish and invertebrate larvae appear to be very sensitive to small changes in their environment and use these changes as cues for orienting, not only for the final settlement act, but during the days or weeks prior to settlement to maintain a suitable location along their journey. This area of research is wide open for new discoveries, as the vast majority of marine animals have a pelagic larval phase, and additional cues for larval orientation certainly exist and have yet to be discovered.

Critical Thinking Questions

1. Do you think that use of the DISC and other similar devices allows for observations of the natural behavior of zooplankton? Why or why not?
2. It appears that some larvae orient better in sunny conditions than in cloudy conditions. Why do you think this is the case?

For Further Reading

Kough, S. A., C. B. Paris, and E. Staaterman. 2014. The *in situ* swimming and orientation behavior of spiny lobster (*Panulirus argus*) post larvae. *Marine Ecology Progress Series* 504:207–219.

Leis, J. M., C. B. Paris, J.-O. Irisson, M. N. Yerman, and U. E. Siebeck. 2014. Orientation of fish larvae *in situ* is consistent among locations, years and methods, but varies with time of day. *Marine Ecology Progress Series* 505:193–208.

Paris, C. B., J. Atema, J.-O. Irisson, M. Kingsford, G. Gerlach, and C. M. Guigand. 2013. Reef odor: A wake up call for navigation in reef fish larvae. *PLoS ONE* 8(8):e72808.

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- **Case Studies**—A NEW Case Study box has been added to each chapter, taking a closer look at a particular organism. Each Case Study also includes Critical Thinking Questions.

Case Study

The Great Pacific Garbage Patch

Currents and gyres not only transport living organisms but also anything that is present in the water and light enough to be moved along within a water mass. The large gyres pictured in Figure 2.15 have been a topic of interest for researchers for decades, and just recently the North Pacific Gyre has been in the spotlight. Located within the North Pacific Gyre are several areas known as "garbage patches" (**Figure A**). Human garbage dumped into the sea from land or boats accumulates in regions of the ocean to form these patches. Most of the garbage is made of plastic.

The locations of garbage patches are somewhat predictable, because on a large scale the locations of major currents and gyres are predictable. The actual composition of the garbage patches changes daily, though, because currents change with changing weather patterns, and the water is constantly mixing up the contents of the patches. The North Pacific Gyre has gained attention in recent years, but garbage patches are found in many other areas of Earth's oceans. Floating debris accumulates within any moving water mass, and gyres are particularly good current patterns for this accumulation of junk.

An erroneous assumption that is often made concerning the garbage patches is that large pieces of trash are found floating around; however, most of it is actually small. Scientists studying these areas describe the trash as a peppery soup with larger garbage floating through it. The larger garbage may be derelict fishing gear, abandoned boating equipment, and a variety of plastic items. Birds and fish often eat the plastic items, mistaking them for food (**Figure B**). Over time, garbage made of plastic breaks down into smaller pieces, some microscopic, and floats around with the currents. Some of the worst areas of accumulated garbage are not even visible to the common person sailing right through the area, unless he or she is looking closely for plastic peppery soup.

The question now is the following: how do we clean up the oceans and get rid of these garbage patches? Cleaning up the ocean is a difficult task. Because the plastics are mostly very small, there is no feasible method to remove them. The best thing we can do now that we are aware of these garbage patches is to prevent the future addition of more debris. Until we stop adding more garbage to the ocean, all of the cleanup efforts possible will not make any difference to remedy the problem. We can do many things in our everyday lives to ensure that our trash does not make it into the ocean. Reuse or recycle whenever possible. Never, ever, pollute. It sounds simple, but many well-intentioned beachgoers accidentally leave beach toys, water bottles, suntan lotion bottles, and a variety of other trash behind. Last, avoid buying plastics when there is an alternative product available. This includes limiting (or omitting altogether) purchases of plastic disposable items. Plastic never goes away but eventually breaks down into tiny potentially harmful substances that fish and other marine organisms ingest. It really is up to us to stop adding to the garbage patches that exist in our world ocean.

Figure B A deceased albatross full of plastic trash.
NOAA Marine Debris Program.

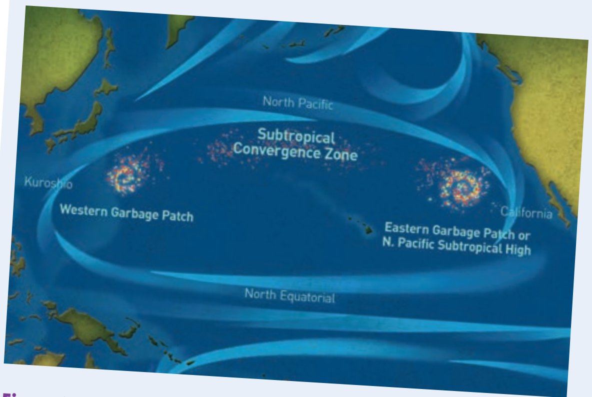

Figure A The locations of large accumulations of trash in the North Pacific Gyre.
NOAA Marine Debris Program.

Critical Thinking Questions

1. Make a list of all the products you use in one day, including items used for food and drink storage (e.g., water bottle) and those used for entertainment (e.g., cell phone). Circle the products you use that are made of any kind of plastic, and add a star next to those that are single-use plastic items. Propose alternative products that can be used in place of all of the plastic in your life.
2. Propose a possible solution for reducing plastic in the sea, and describe how your idea can be implemented.

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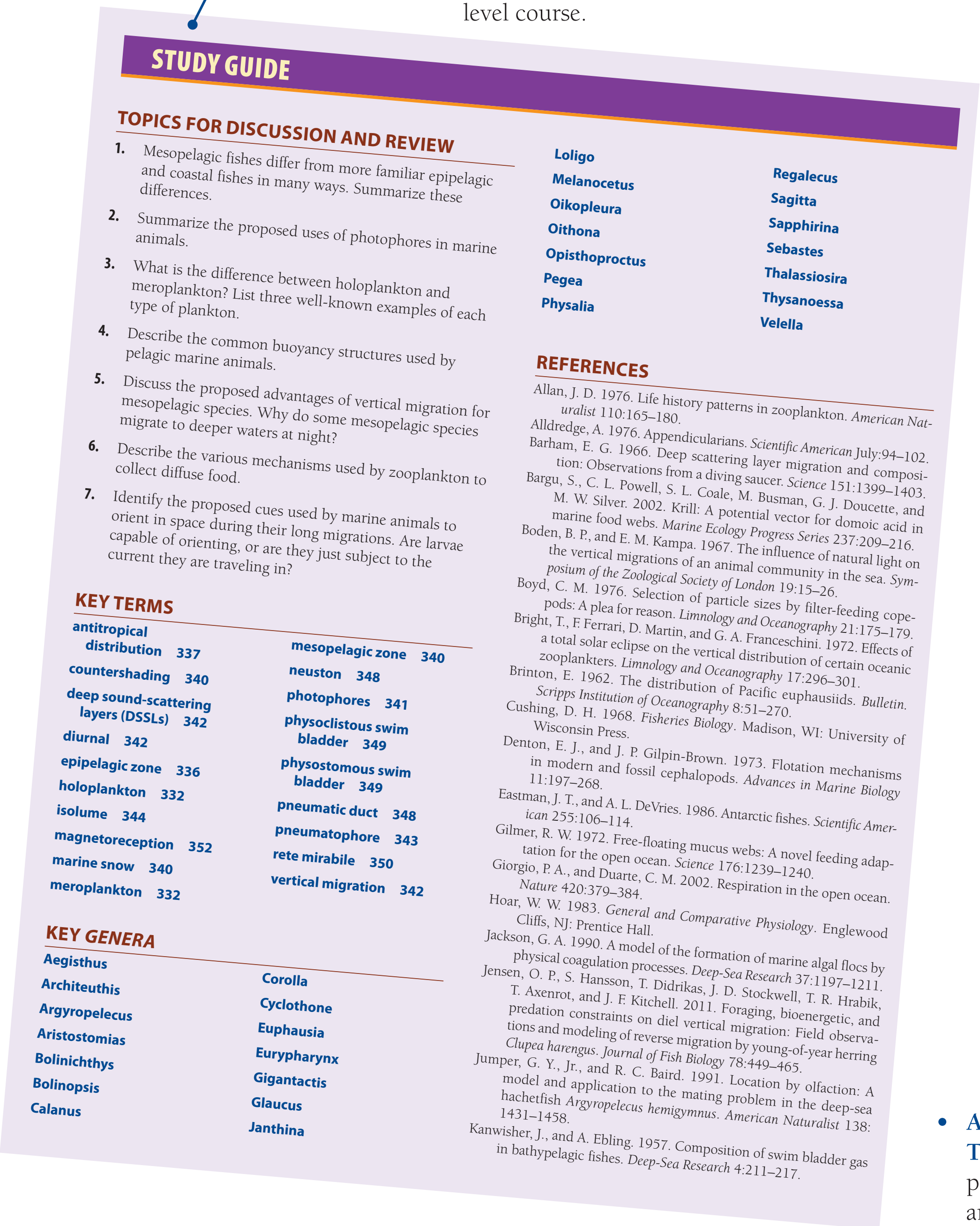
- **Study Guide**—Each chapter closes with a Study Guide section containing useful study tools for instructors and students:
  - **Topics for Discussion and Review**—These questions encourage further in-depth exploration of covered topics and have been evaluated and revised, updated, or replaced as needed from the previous edition.
  - **Key Terms**—A Key Terms list, including page numbers for all terms, is included to help students learn new marine biology vocabulary.
  - **Key *Genera***—A list of Key *Genera* discussed in each chapter is a helpful study tool for students learning about new organisms.
  - **References**—Although this text includes more material than might be covered in one semester, instructors can select and mold the material to match their teaching styles and time limitations. With judicious use of outside supplementary readings, such as those suggested in the References section of the Study Guide, this text can easily provide the structure for a two-semester or upper-level course.



STUDY GUIDE

TOPICS FOR DISCUSSION AND REVIEW

1. Mesopelagic fishes differ from more familiar epipelagic and coastal fishes in many ways. Summarize these differences.
2. Summarize the proposed uses of photophores in marine animals.
3. What is the difference between holoplankton and meroplankton? List three well-known examples of each type of plankton.
4. Describe the common buoyancy structures used by pelagic marine animals.
5. Discuss the proposed advantages of vertical migration for mesopelagic species. Why do some mesopelagic species migrate to deeper waters at night?
6. Describe the various mechanisms used by zooplankton to collect diffuse food.
7. Identify the proposed cues used by marine animals to orient in space during their long migrations. Are larvae capable of orienting, or are they just subject to the current they are traveling in?

KEY TERMS

antitropical distribution 337
countershading 340
deep sound-scattering layers (DSSLs) 342
diurnal 342
epipelagic zone 336
holoplankton 332
isolume 344
magnetoreception 352
marine snow 340
meroplankton 332
mesopelagic zone 340
neuston 348
photophores 341
physoclistous swim bladder 349
physostomous swim bladder 349
pneumatic duct 348
pneumatophore 343
rete mirabile 350
vertical migration 342

KEY GENERA

Aegisthus
Architeuthis
Argyropelecus
Aristostomias
Bolinichthys
Bolinopsis
Calanus
Corolla
Cyclothone
Euphausia
Eurypharynx
Gigantactis
Glaucus
Janthina
Loligo
Melanocetus
Oikopleura
Oithona
Opisthoproctus
Pegea
Physalia
Regalecus
Sagitta
Sapphirina
Sebastes
Thalassiosira
Thysanoessa
Velella

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Teaching Tools

A variety of teaching tools are available via digital download and multiple other formats to assist instructors with preparing for and teaching their courses.

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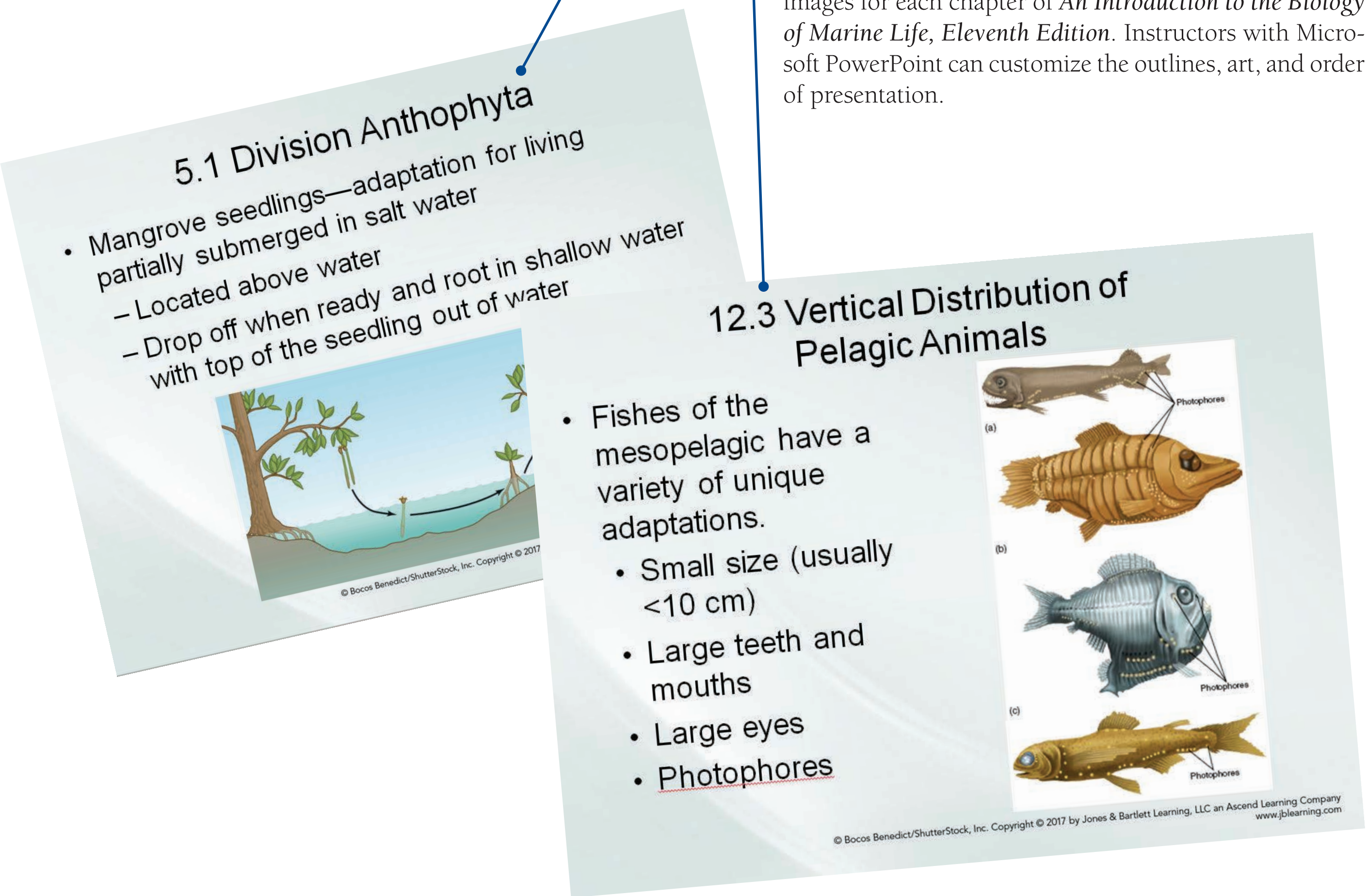

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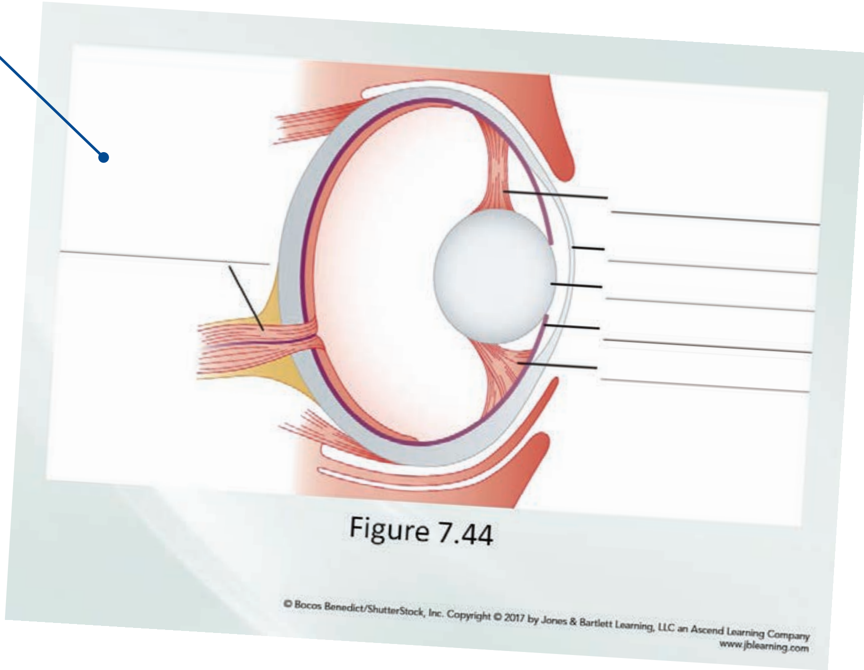

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- **Transition Guide**—The publisher has prepared a Transition Guide to assist instructors who have used previous editions of the text with conversion to this new edition.

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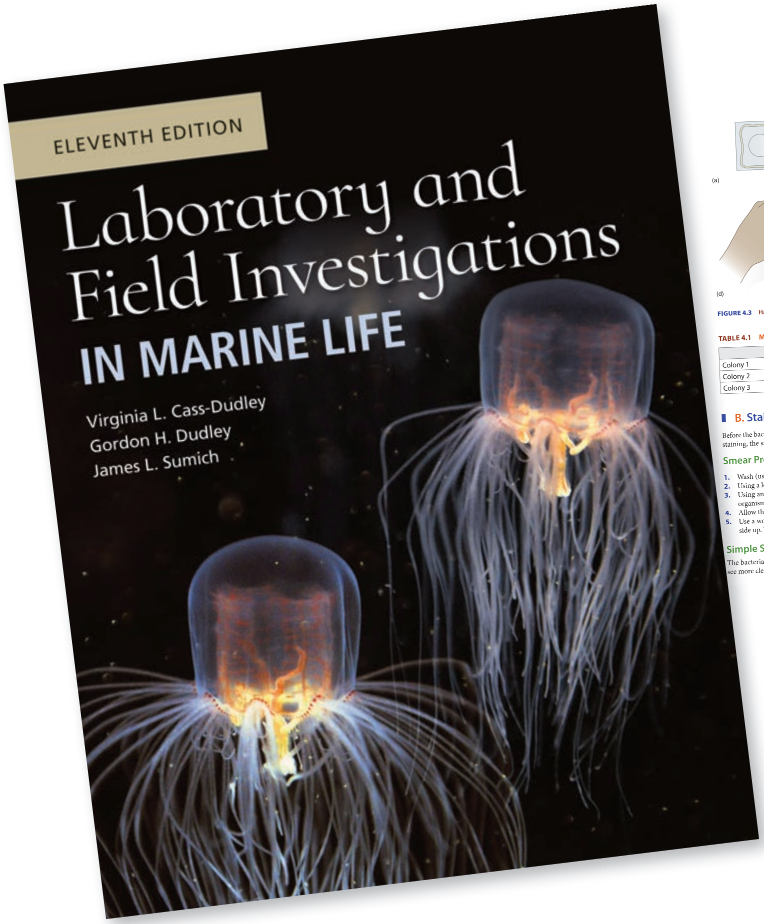
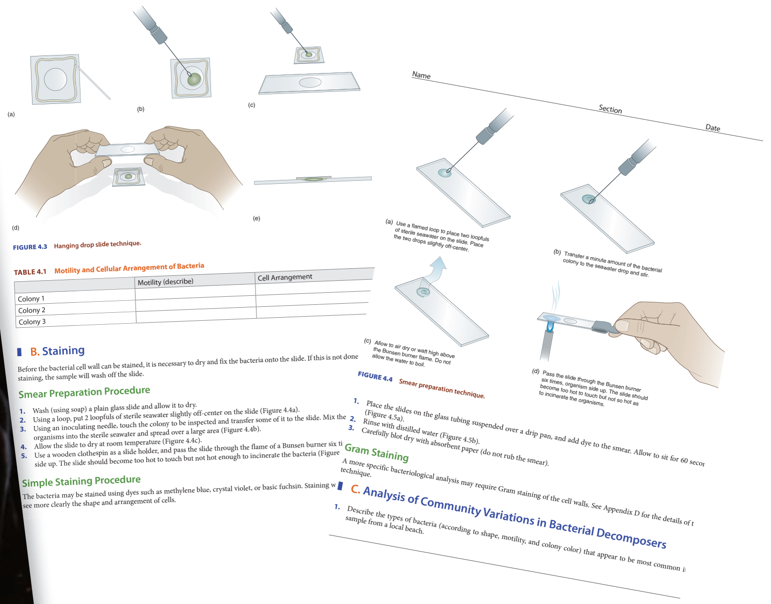
Lab Manual





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In closing, we encourage you, students and instructors alike, to immerse yourself in this material as much as possible and in as many ways as you can invent. Spend time at the seashore just wading about.

Walk along a beach after high tide and examine the biological treasures that the sea left behind. Sit on the edge of a rocky tide pool and watch the action before you. If you can, swim, snorkel or dive for a closer look. If you don't swim, learn. Watch how young children observe things, and mimic their enthusiasm.

Pick up the less fragile organisms for a closer look.

Take a day trip on a fishing boat. Volunteer at a local aquarium even if you think you don't yet know enough to contribute; you'll learn. Mostly, it is a matter of investing time—time in the field and time in the classroom. You will get to experience the fun stuff only if you put in the time.

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About the Authors

John F. Morrissey earned his B.A. and M.A. degrees in Biology from Hofstra University. After teaching marine biology and coral reef ecology in Jamaica for 1 year, he then earned his Ph.D. in Marine Biology and Fisheries from the University of Miami's Rosenstiel School of Marine and Atmospheric Science. His dissertation research concerned the movement patterns, diel activity, and habitat selection of lemon sharks in Bimini, Bahamas. Since then, Dr. Morrissey has studied the biology of sharks, skates, and rays all over the world, including Jamaica, Japan, the Azores, and the Canaries. He has been on the board of directors of the American Elasmobranch Society since 1996.

For 16 years he taught marine biology, a field course in tropical marine biology, and comparative anatomy at Hofstra University, where he won the Distinguished Teacher of the Year Award in 2006. In 2007, Dr. Morrissey moved to Sweet Briar College in central Virginia, along with his egg-laying colony of 100+ chain catsharks, to teach marine biology, comparative vertebrate anatomy, and animal physiology. He won their Excellence in Teaching Award in 2010. He lives on a dirt road in the woods with his wife (who is also his research partner) and their four spoiled cats.

James L. Sumich received his M.S. in Biological Oceanography at Oregon State University, joined the biology faculty at Grossmont College, and then returned to Oregon State for a Ph.D. For his Ph.D. thesis, he studied the interactions between newborn gray whale calves and their mothers and the way each budgets its energy expenditures during the period of calf nursing.

He has taught marine mammal biology classes for graduates and undergraduates at San Diego State University, University of San Diego, and Oregon State University, where he continues to teach, as the requirements of retirement permit. His retirement activities include continued research and writing on gray whale behavior and energetics. He recently marked the publication of the second edition revision of a textbook on the evolutionary biology of marine mammals, coauthored with Dr. Annalisa Berta and Dr. Kit Kovacs. He lives in a home he has built with his wife, Caren, in the woods near Corvallis, Oregon.

Deanna R. Pinkard-Meier earned her B.S. degree in Aquatic Biology from the University of California Santa Barbara and her M.S. degree in Marine Biology from the Florida Institute of Technology. Her early research efforts were concentrated on marine invertebrates near the California Channel Islands. She then moved her research focus and home to the tropics, studying the behavior, reproduction, and recruitment of tropical marine fishes, specifically snappers, damselfish, and wrasses. After 5 very productive years in the warm waters of the Caribbean and Florida, she ventured back home to California where she worked as a research fisheries biologist for the National Oceanic and Atmospheric Administration (NOAA), studying the endangered white abalone and declining rockfish populations with a remotely operated vehicle.

For the past decade Deanna has taught many biology courses at a variety of universities and community colleges in San Diego, while still publishing research with hardworking former colleagues at NOAA. She especially enjoys teaching marine biology, organismal biology, and evolution and introducing students to field survey techniques used in the intertidal or from a boat. She resides in Cardiff-by-the-Sea, California, with her husband and two sons, where they can often be found jumping in the ocean for a surf session or snorkel. She is active in her local community where she participates in Surfrider Foundation events and volunteers as a visiting scientist at local schools.

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