Aglow in the Dark

The Revolutionary Science of Biofluorescence

By Vincent Pieribone and David F. Gruber, Harvard University Press, 2006, 263 pages, ISBN 0674019210, Hardcover, $24.95 US

REVIEWED BY MIKHAIL V. MATZ

Pieribone and Gruber's book is not as much about science itself as about careers in science and the way discoveries are made. One-third of the book (the first four of the twelve chapters) is devoted to discoveries in bioluminescence. The next six chapters (five to ten) discuss fluorescence (in particular, fluorescence determined by proteins related to the Green Fluorescent Protein [GFP]). The last two chapters are about neuroscience and the ways GFP-derived fluorescence can help it.

The first chapter tells about early records and research in bioluminescence, from Aristotle to Dubois, and also talks about bioluminescence in nature, mostly from perspective of its impact on human activities. The next chapter is devoted to the career of Edmund Newton Harvey—one of the classics in bioluminescence research. The third chapter is a dramatic story of Osamu Shimomura's life and work in Japan, where he managed to isolate pure *Cypridina* luciferin ("fuel" for the bioluminescent reaction of the sea firefly) and witnessed the bombing of Nagasaki. Shimomura features in the next chapter as well, this time in a discussion about his work in United States on isolation of bioluminescent protein from the jellyfish *Aequorea* and his historical first notion of the GFP from the same animal.

From this point onward, the focus of the book shifts towards fluorescence. Chapter five describes life and works of the discoverer of fluorescence, George Gabriel Stokes. This chapter also explains the physical basis of fluorescence and the earlier applications of fluorescence as a way to label, detect, and visualize things. We learn about forensic techniques that use fluorescent dyes and Albert Coons' work on fluorescence-tagged antibodies for pathogen detection. Top-notch imaging technologies such as confocal and multiphoton microscopy are explained. Chapter six lays out the foundations of molecular biology and methods required to isolate and study a new gene. It then describes the work of Prasher and Cormier on cloning of the bioluminescent protein aequorin from the jellyfish *Aequorea* (Shimomura's subject), as well as biochemistry studies of Morin, Hastings, and Ward on GFPs from the same jellyfish, the hydroid *Obelia*, and the sea pansy *Renilla*. The following chapter tells about the rise of minuscule nematode worm *Caenorhabditis elegans* to the status of a major genomic model and about the seminal work of Martin Chalfie on making the GFP gene from jellyfish (newly isolated by Prasher) work in the worm. Chapter eight is dedicated to arguably the most prominent figure of the current research in fluorescence-based labeling and detection technologies—Roger Y. Tsien—and his works on using and modifying the GFP for biomedical needs. Authors also describe the principles of sophisticated fluorescent methodologies that allow detection of ion concentrations and protein interactions in real time, and ponder the ethics of creating transgenic fluorescent animals for artistic purposes. Chapter nine tells the story of unexpected success of Sergey Lukyanov's laboratory in cloning the variety of colorful GFP-like proteins from reef organisms, which proved that GFP-related fluorescence in nature can be completely de-coupled from bioluminescence capabilities. Chapter ten talks about the beauty of coral reefs, authors' observations of fluorescent corals, and possible biological functions of coral fluorescence. The chapter concludes with the discussion of general value of biodiversity for biomedical research.

Chapter eleven moves into brain science. It tells about the life and work of the father of the neuronal theory of the brain, Santiago Felipe Ramon y Cajal, and gives examples of extremely successful uses of GFP-encoded fluorescence to visualize individual neurons in studies of the smell perception. Chapter twelve describes impressive but ethically controversial works of Jose Manuel Rodriguez Delgado on the external electrical control of brain functions, then talks about the opposite side of the same medal—possibility of deciphering brain electrical signals to control external machines such as prosthetic limbs. In the end of the chapter we are presented with the idea of using voltage-sensing GFP variants as markers of neuronal activity instead of electrodes for such purposes.

The obvious good of this book is the diversity of the described careers and paths to discovery. Authors put significant effort into meeting and interviewing the people about whom they were going to write, and that is what makes the book truly unique. Stories from the book promote a lot of thought about the nature of scientific breakthrough and the roles of such factors as long-term vision and perseverance versus flashing ideas and luck, collaboration and exchange of thoughts versus the ivory-tower attitude, and last but not least, the role of ethics and aesthetics in scientific progress. Students puzzling over career options should find these stories informative and inspiring.

Molecular biology, neuroscience, and fluorescence technology issues are very well explained, owing to the primary expertise of one of the authors (Pieribone) in molecular neuroscience. Even such complicated things as multiphoton microscopy, protein molecular structure, and the interplay of molecular interactions to generate fluorescence resonant energy transfer (FRET) are made very clear. It is very helpful that the book includes a list of references to all the relevant original publications.

Unfortunately, from the point of view of biological oceanography, this book leaves a lot to wish for. I was disappointed not to find even a brief overview of known bioluminescent systems and their biological functions—in particular, it would be great to see how much is currently considered known versus how much still remains open to speculation. Likewise, there is no mention of other ecologically and technologically relevant bio-fluorescence except the GFP-related one (fluorescent plumages of parrots and chlorophyll fluorescence as indicator of stress in plants spring to mind). The biological examples given in the text tend to be trivial, such as anglerfish as an example of a bioluminescent sea creature (with its peculiar reproductive biology described and illustrated—again…), rabbits in Australia as an example of invasive species, or "Finding Nemo" as an illustration of reef's biodiversity. The view on the origin of coral reef biodiversity advocated by the authors—that it is a consequence of intense competition—has been strongly challenged in recent years by alternative neutralist explanations, and the discussion is still hot. I wish the authors did not pass up opportunities such as this one to make the book sound fresher.

And, finally, the ugly. Fluorescence is not "glow in the dark." It cannot happen in the dark because it is essentially a transformation of light of one color into light of another color—it needs incoming light to work. The real "glow in the dark" is luminescence—production of light as a result of chemical reaction, and it is a totally different physico-chemical process. So what's up with the title of the book, "Aglow in the Dark: The Revolutionary Science of Biofluorescence"? To my frustration, instead of clearing up the confusion, the book actually cultivates a feeling that luminescence and fluorescence are both genuine "glow-in-the-dark" phenomena and there maybe just a minor difference in detail between them. Fortunately, the title is the only place where this idea is communicated in a flat-out erroneous statement. The rest of the book simply tries to never draw a line between luminescence and fluorescence. The first (and as far as I could find, the only) explanation of the difference between them is on page 72—roughly a third into the book, hidden in the middle of the paragraph. I think the main reason for keeping the reader confused was to fully exploit the magic contained in the phrase "glow in the dark," and also to justify putting the actually unrelated stories about bioluminescence as a sort of prologue to the GFP research. Interestingly, the foreword helps the authors by using the word "bioluminescence" to refer to all matters addressed in the book—apparently the authors of the foreword were confused as well.

In short, I would not recommend this book to those looking for comprehensive information about bioluminescence and biofluorescence. Instead, it can be a great source of inspiration for science students and researchers early in their careers, especially for those attracted to biotechnology and/or neuroscience.

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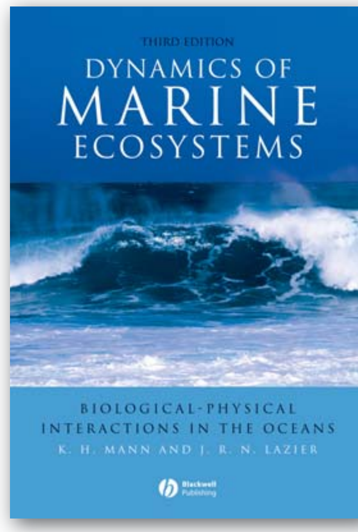
Dynamics of Marine Ecosystems

Biological-Physical Interactions in the Oceans (3rd Edition)



By K.H. Mann and J.R.N. Lazier, Blackwell Publishing, 2006, 496 pages, ISBN 1405111186, Paperback, $74.95 US

REVIEWED BY ANDREW J. PERSHING

In 1991, Kenneth Mann and John Lazier published the first edition of *Dynamics of Marine Ecosystems* (DME). Subtitled "Biological-Physical Interactions in the Oceans," DME was an ambitious attempt to describe how physical processes in the ocean structure biological communities. The newly released third edition contains significant updates to several sections. Although the book has grown somewhat, the additional material makes for a more comprehensive treatment of the field, and perhaps surprisingly, a more cohesive book.

In the interest of full disclosure, I must inform you that I am not an unbiased reviewer. At my Ph.D. institution (where I am currently employed), cows outnumber oceanographers by more than ten to one. In lieu of a formal course on biological oceanography, a small band of us, led by my major professor, worked our way through Mann and Lazier's first edition. As Mann and Lazier state in the preface to the first edition, DME presents the essentials of physical oceanography in the context of how it influences the biology. Biology is presented in more detail, and the authors try to outline areas of current research. DME served me very well in this regard, and my well-worn copy provided a jumping off point for my dissertation research. DME is now required reading for my students, and whichever one has my book, please return it.

Now that the legal stuff is out of the way, let's get to the review. The main theme of the book is that biological processes in the ocean are intimately connected with physical processes. Mostly, this theme is considered from the point of view of how a physical process such as vertical mixing influences a biological process like primary productivity; however, the latest version has expanded its consideration of how biological processes feed back to the physics. This discussion includes carbon cycling and climate changes as well as absorption of heat and light by phytoplankton pigments. The interdisciplinary approach serves two functions. On a pedagogical level, it provides a coherent treatment of two major subdisciplines of oceanography. On a practical level, presenting the physics and biology together is consistent with how most modern oceanographic research is conducted.

The book is organized by scales, starting from the smallest to the largest. The authors begin by considering life at low Reynolds numbers, focusing on nutrient uptake by single phytoplankton cells and the influence of turbulence on predator-prey interactions. I must admit that, as a graduate student, I found this section rather boring. However, my interest in low-Reynolds-numbers phenomena increased after seeing video footage of copepods feeding. This point brings up perhaps the biggest weakness of this book: the paucity of photographs. While one could argue that a graduate-level text shouldn't need fancy pictures, I think it a shame to devote so much text (and time reading) to the intricacies of flagellar swimming and copepod feeding without actually showing the reader what a dinoflagellate or a copepod looks like.

DME then moves up to scales of 1 km and focuses on mixed-layer dynamics. On the physical end, the authors consider the processes that lead to the shoaling or deepening of the mixed layer. DME does an excellent job synthesizing thermodynamics, including light penetration and heat flux. The level of detail of the physics is sufficient to give the reader a good qualitative and even intuitive understanding of these processes, which sets up their discussion of phytoplankton dynamics. In particular, the section on Sverdrup's critical depth theory is one of the best I've seen. The new edition also contains a good review of iron limitation, a much needed improvement to the book.

The next section considers scales of 1–1000 km, including coastal upwelling and fronts of various kinds. This section begins with a very readable description of the development of Ekman spirals and then moves on to Ekman drift and Rossby deformation scales. Then, the authors discuss the impact of coastal upwelling on ecosystems in the context of five major upwelling regions. The next chapter presents fronts of various kinds and discusses research on why frontal systems are often associated with high concentrations of plankton and fish. Finally, the section concludes with a discussion of tides and internal waves. Their description of equilibrium tidal theory and Kelvin waves is one of the most intuitive I've encountered, as is their description of internal waves.

The third section considers processes on the scale of ocean basins. DME presents a straightforward qualitative description of wind-driven circulation, beginning with global wind systems and ending with western boundary currents and their rings and eddies. When the authors turn to the influence of basin-scale circulation on biology, the chapter really comes alive. Although the physical processes that generate rings and eddies are largely ignored, Mann and Lazier's synthesis of the role that mesoscale eddies play in the primary productivity of the subtropical ocean is quite exciting, and certainly cleared up a lot of my personal confusion on this subject.

The next chapter discusses the impact of changes in ocean circulation on marine ecosystems, notably, on fisheries. My trusty copy of DME was the first place I encountered the ideas of basin-scale variability, notably for me, the North Atlantic Oscillation (NAO). The discussion of this phenomenon serves as a good example of one of the key strengths of DME, and also one of its key weaknesses. Mann and Lazier walk a fine line between presenting established concepts like critical depth theory alongside emerging research ideas that are still under development. The biology sections that conclude most of their chapters are equivalent to review papers, and the authors should be commended for their attempts to synthesize current results into something fresh and new. This approach makes the text exciting and serves their goal of introducing emerging scientists to emerging ideas. However, it is often hard to distinguish when Mann and Lazier are pushing the envelope. For example, the NAO section in their original edition contained several misstatements, including a summary figure that was patently wrong. Thankfully, the new edition corrects these errors, at least in the NAO section, but I can't help wondering what else is lurking out there. However, if I had to choose between a book that occasionally pushed the boundaries and one that stuck with established fact, I'd take the former. The new ideas in the book make it much more interesting to read and should be excellent fodder for class discussion and, likely, the genesis of a few dissertations. My hope is that future editions will maintain the adventurous spirit but provide some sign posts when they're leading us on a new trail.

In the final chapter, Mann and Lazier discuss four big-picture "questions for the future." It's easy for scientists to get caught in the details of their particular research area, and I found it refreshing to read a consideration of very broad questions. Of the four questions they present, the one that resonates the most (at least with this reviewer), is the issue of whether we can develop models that span the enormous range of scales of time, space, and body size, inherent in marine ecosystems. Essentially, Mann and Lazier are asking whether we can merge the ideas and models developed by some of the major research programs of the 1990s (e.g., JGOFS and GLOBEC). This section does an incredible job tying together many of the ideas presented in the earlier chapters, and the authors clearly had a lot of fun writing it.

In their opening chapter, Mann and Lazier declare that marine ecology "may be said to have come of age." When I first read their declaration that marine ecology has come of age, I found it hard to figure out what Mann and Lazier really meant. I mean, what does it really mean for a field to come of age? Can marine ecology stay out past midnight? Can I buy it a beer? Seriously, though, I've given this some thought. Coming of age implies a sense of self, of definition, of who you are and where you want to go. In this sense, I think Mann and Lazier were right on. Marine ecology has definitely come of age, although perhaps it's still a bit gawky. Similarly, I think that DME could be said to have come of age as well. In the first edition, Mann and Lazier boldly presented the physics along with the biology and emphasized the interdisciplinary nature of marine research. As the field progressed in the intervening years, the value of interdisciplinary research has grown. In their third version, Mann and Lazier have done an incredible job of integrating these new developments into their text. The result is a more coherent and more confident presentation of the field.

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Atmosphere-Ocean Interactions (Volume 2) edited by W. Perrie, WIT Press, 240 pages

Chemical Oceanography (3rd Edition) by Frank J. Millero, CRC Press, 496 pages

HYDRO to NAVOCEANO: 175 Years of Ocean Survey and Prediction by the U.S. Navy by Charles C. Bates, Corn Field Press, 329 pages

Introduction to the Physics and Techniques of Remote Sensing (2nd Edition) by Charles Elachi and Jakob van Zyl, Wiley, 552 pages

The Turbulent Ocean by Steve A. Thorpe, Cambridge University Press, 439 pages

Oceans: An Illustrated Reference by Dorrik Stow, University of Chicago Press, 256 pages