

# BOOK REVIEWS

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## Introduction to Biophotonics

Paras N. Prasad, 616 pages, ISBN 0-471-28770-9, John Wiley & Sons, Hoboken, New Jersey (2003), \$105.00 hardcover.

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What is biophotonics?

In the preface of *Introduction to Biophotonics*, Paras N. Prasad provides a broad definition: "Biophotonics is...the fusion of photonics and biomedical sciences and deals with the interactions between light and biology." With such a vast scope, the term encompasses an interdisciplinary range of topics—photosynthesis, vision, photoinduced pathology, vitamin D synthesis, photodynamic therapy, laser diagnostics and laser surgery, photochemistry, optical biopsy, optical imaging of cells, tissues, and organs.

As the SUNY Distinguished Professor of Chemistry, Physics, Electrical Engineering, and Medicine, as well as the Executive Director of the Institute for Lasers, Photonics, and Biophotonics at the University of Buffalo, Prasad is well qualified to author this multidisciplinary book. He expands on his vision for interdisciplinary education and research in the preface and introduction of his textbook. Clearly, the words *interdisciplinary*, *multidisciplinary*, and *cross-cutting research* are an integral part of the new mantra in science. However, the concept's pertinence has a long history leading back to the Manhattan Project and the RadLab.

To understand the scope of Prasad's vision it is useful to look back and consider the role of multidisciplinary research in science and technology. It has long been the case that the publication of a book or the formation of a new interdisciplinary organization changes the direction of a scientific field. The result is a fertile period of intense development based on multidisciplinary collaboration and research. Case in point—Erwin Schrödinger's book *What is Life?*, based on his 1943 lectures at Trinity College, Dublin, and first published in 1944. After reading this collection, many physicists turned their attention to structural biochemistry, genetics, virology, and later molecular biology and medicine. The result was a string of cross-disciplinary discoveries and the awarding of numerous Nobel Prizes.

The multidisciplinary Neurosciences Research Program, led by Francis O. Schmitt, brought physicists, electrical and computer science engineers, and cell biologists together for the first time to explore memory and learning, neural plasticity and development, and various brain functions. More recently, the growth of journals such as the *Journal of Biomedical Optics*, *Applied Optics*, and the *Biophysical Journal* is thriving on the submission of papers from disparate disciplines and the proliferation of presentations from multidisciplinary meetings such as SPIE BIOS and the OSA optical

meetings. The philosophy behind *Introduction to Biophotonics* is consistent with this long-standing vision of interdisciplinary education and research.

Prasad set out to provide a unified synthesis of biophotonics that would serve as both a textbook and a reference book. His objective was "to provide a basic knowledge of a broad range of topics so that individuals in all disciplines can rapidly acquire the minimal necessary background for research and development." Prasad succeeded in these aims. He has authored an integrated textbook that is clear and concise, one that is bound to stimulate researchers and health care professionals to foster collaboration across an array of programs.

While the book is intended for a multidisciplinary readership, *Biophotonics* focuses on potential benefits to medicine, both in diagnostics and therapeutics. Written for researchers and educators, the book is crafted in a way that meets the needs of both audiences. It is coherent in both style and nomenclature. Though the author relied on several individuals to help write chapters, prepare illustrations, and critique the manuscript, Prasad is the sole author of the textbook.

Each chapter has an introduction, a listing of pertinent web sites, a clear and concise (some may claim too concise) exposition of the main concepts, definitions, and applications. Throughout the chapters there are clear schematics of the optical instruments. Then, there follows a summary of the highlights of the chapter, and finally a list of pertinent references. Prasad has made a careful selection of cited references; they are very useful and would add the missing details to a course based on his textbook. Half of the book is devoted to theory and principles: fundamentals of light and matter, basics of biology, light-matter interactions, lasers, nonlinear optics, photobiology, and the theory and applications of bioimaging. The latter half focuses on biophotonic devices: biosensors, microarray technology, flow cytometry, photodynamic therapy, optical tissue engineering, laser tweezers and scissors, nanotechnology, and biomaterials.

Beyond the book's general structure, the author has effectively inserted charts (to show complex relationships) and tables (to summarize data) into the text to improve its clarity. Prasad is at his best when he is explaining fine details, for example the photophysics of biophotonics; light-matter interactions, molecular spectroscopy, lasers, and photobiology. The depth and clarity of these discussions are exemplary.

*Biophotonics* provides a wonderfully well-rounded introduction to the theory and applications of bioimaging (itself a field that integrates many disciplines). The chapter on principles and techniques is given an equal number of pages to the chapter on applications. The text covers most types of optical imaging: bright-field fluorescence microscopy, phase contrast microscopy, differential interference contrast microscopy, confocal microscopy, multiphoton excitation microscopy, op-

tical coherence tomography (OCT), total internal reflection fluorescence microscopy, and near-field optical microscopy. In addition, the text covers spectral and time-resolved imaging, fluorescence resonance energy transfer (FRET), fluorescence lifetime imaging microscopy (FLIM), and nonlinear microscopy.

In view of the rapid advances in the field of OCT, it would be useful to include an expanded discussion of the following topics: time and frequency domain OCT, polarization OCT, high-resolution OCT, and ophthalmic applications of OCT. In addition, in the section entitled Future Directions of Optical Bioimaging (7.16), 4Pi imaging and its enhanced far-field resolution is poorly explained.

It is the last third of *Biophotonics*, covering devices and integrated systems, that differentiates this book from the mass of available biomedical imaging texts. The chapters are excellent introductions to biosensors, microarray devices, flow cytometry, photodynamic therapy, optical tissue engineering, laser trapping and cutting, nanotechnology, and photonic biomaterials. Prasad's presentation helps his readers appreciate the multidisciplinary nature of advances in optics, biology, nanotechnology, and image and signal processing. This is a very rich area for research and development and this text can provide new graduate students with a wealth of exciting research problems to investigate.

*Introduction to Biophotonics* is a quality book. The figures, some of which are in color, are well designed and integrated. I commend the author for his excellent use of figures and

tables to augment the text. One exception is Figure 5.2, which purports to illustrate transverse electromagnetic modes in a laser beam. It is both incorrect and misleading; circles are drawn as ovals, and white and black are reversed in the drawing and the accompanying text.

The text does contain a few errors that escaped detection and correction, for example the definition of  $k$  (Eq. 2.4) is "a propagation constant or wave number" and not "a propagation vector" as stated in the book. There are also some misspelled words; e.g., terms in Table 6.1 and the repeated misspelling of Köhler in the text. Prior to using this book in a course it would be helpful for the instructor to prepare a very brief erratum.

Instructors have long needed an introductory textbook on biophotonics that could be adopted for a one-semester course. *Introduction to Biophotonics* effectively fills that void. It could be used as a comprehensive textbook for an introductory course on biophotonics for graduate students or an advanced undergraduate class, though a comprehensive course in general chemistry is a suggested prerequisite.

Some authors may have needed the wisdom of Solomon to decide what topics to include in an interdisciplinary textbook of this magnitude. Calling on his own cross-disciplinary background and unique insight, Prasad has succeeded in creating a textbook that is clear and comprehensive, yet balanced and concise. *Introduction to Biophotonics* is very well written and is destined to become part of the canon of science books whose farreaching influences help make history.