

# BOOK REVIEW

## Biomedical Photonics Handbook

Tuan Vo-Dinh, Editor-in-Chief, 1864 pages, ISBN 0-8493-1116-0, CRC Press, Boca Raton, Florida (2003), \$199.95 hardcover.

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The application of spectroscopy to medicine has a long and innovative history. In the late 1800s Charles Alexander MacMunn investigated the spectra of heme proteins in different states of oxygenation. He summarized his spectroscopic findings in two important books: *The Spectroscope in Medicine* (1880), and *Spectrum Analysis Applied to Biology and Medicine* (1914). These early investigations were extended by David Keilin from 1925 to 1960, during which he used optical spectroscopy to study the respiratory chain and cytochromes common to plants, yeasts, and higher animals. In 1950, Torbjorn O. Caspersson of the Karolinska Institute, Sweden, published a book *Cell Growth and Cell Function, a Cytochemical Study*, which summarized his 20 years of research on microspectrophotometry of cell organelles, nucleotides, and proteins during the cell cycle, growth, and differentiation. There is a direct link between the work of Keilin on respiratory proteins and the prolific work of Caspersson on cellular microspectrophotometry and the innovative studies of Britton Chance on the application of spectroscopic techniques to cellular respiration.

The last 15 years have been a period of rapid development in the field of biomedical photonics. Participants of the SPIE conferences on bio-optics may recall the 1989 conference in San Diego on "New Methods in Microscopy and Low Light Imaging." That conference, chaired by John Wampler, covered papers on the following subjects: three-dimensional reconstruction of microscopic images, advances in CCD technology, low-level luminescence imaging, computer-aided microscopy, scanning confocal microscopy, and new developments in ophthalmic imaging. In the period following that seminal conference we have seen the rapid growth of SPIE conferences on medical imaging, biomedical optics, and diagnostics. What was contained in one conference proceedings is now contained in several thick proceedings. The SPIE Press also deserves credit for their books on biomedical optics and related technologies. The SPIE Milestone Series of books containing selected printed papers on microscopy, lasers, three-dimensional imaging, and tissue optics also contributed to the growth of the field. The *Journal of Biomedical Optics*, published by SPIE, is a growing forum for theoretical and experimental papers in biomedical optics.

The *Biomedical Photonics Handbook* was organized by the Editor-in-Chief Tuan Vo-Dinh in consultation with a prestigious advisory board comprised of leaders in their fields. The editor selected a group of contributors who are well-known, active researchers and clinicians in the field of biomedical optics. The handbook provides a comprehensive survey of optical instrumentation and techniques that are in various stages of development and clinical testing for both diagnostics and treatment.

The sample varies from molecules to organisms: the detection of pathogens in biological fluids, to the spectroscopic monitoring of cells and tissues, to spectroscopy and imaging of cells, tissues, and organs in vivo for the detection of pathology. Two other broad areas of interest contribute to the coverage of the handbook: a survey of optical techniques for the treatment of diseases in many fields of medicine, and a survey of optical techniques for genomics, proteomics, and medicine.

The handbook is divided into several major sections: photonics and tissue optics, photonic devices, photonic detection and imaging, biomedical diagnostics, optical biopsy, therapeutic and interventional techniques, and techniques for molecular medicine. Most of the chapters in the handbook are well organized, well illustrated, and contain a balance between theoretical principles, instrumentation, and applications. The chapters that present the theory of light-tissue interactions, optical properties of tissue, functional imaging with diffusing light, theoretical models and algorithms in optical diffusion tomography, photon migration spectroscopy in the frequency domain, and near-infrared fluorescence imaging and spectroscopy in random media and tissues form a category that would be useful for those researchers involved with mathematical modeling. The handbook contains chapters that describe the design, construction, and operation of biomedical instruments; these chapters would benefit those researchers that are involved in constructing biomedical instruments. The chapters describe various techniques in biomedical photonics such as photon migration, functional imaging with diffusing light, and near-infrared fluorescence imaging and spectroscopy, and biochips and microarrays. These techniques are still in the early stages of technological development. There are other, more mature techniques, such as photodynamic therapy (PDT), confocal microscopy, multiphoton excitation microscopy, optical coherence tomography (OCT) imaging, and lasers in clinical medicine that are emerging into commercial products and clinical trials.

Some of these emerging diagnostic techniques have widespread applications in many fields of clinical medicine. For example, the chapter on optical coherence tomography imaging discusses applications to clinical medicine in these areas: surgical guidance and intervention, ophthalmology, gastroenterology, laryngology, and minimally invasive surgery. A wide range of imaging devices that are based on OCT principles have been developed: microscopes, ophthalmoscopes, laparoscopes, and miniature, flexible catheters and endoscopes.

The handbook contains many useful illustrations (some in full color) and a detailed index. An extensive appendix contains useful spectroscopic data on biologically and medically relevant molecules and samples. An extensive listing of references is given, but this would be more useful if the quality and the significance of the papers were discussed as in an annotated bibliography.

I think that the audience for the handbook would consist of graduate students in biomedical engineering programs, scientists and engineers who are interested in initiating research in biomedical optics, and clinicians who are interested in a single-volume source that presents the theory, instrumentation, and

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some selected studies of applications in biomedical photonics. The handbook is a good general source for individuals in diverse disciplines who share a common interest in biomedical optics. Clinicians in the fields of dermatology, ophthalmology, and minimally invasive surgery and diagnostics would find the handbook to be a useful guide.

The major strength of the handbook is its broad and integrated coverage of theory, devices, and techniques in a single volume. The editor and his scientific advisory board selected a broad range of topics that would not usually appear in a single volume. For example, there are a large number of comprehensive chapters on spectroscopic techniques, several chapters on imaging, three chapters on photodynamic therapy, and chapters on biochips, microarrays, DNA sequencers, and other techniques used by molecular biologists. Included in the section on biomedical diagnostics are two important diagnostic techniques: x-ray imaging and optical pumping in magnetic resonance imaging.

The first section of the handbook is devoted to photonics and tissue optics. It contains three well-organized chapters (optical properties of tissue, light-tissue interactions, and theoretical models and algorithms in optical diffusion tomography). These integrated chapters set the high standards of clarity coupled with physical rigor. The next sections on photonic devices and photonic detection and imaging techniques are characterized by an appropriate balance of theory and a detailed description of instrument design and construction.

About one-fourth of the handbook is devoted to intervention and treatment techniques. The important field of photodynamic therapy is well described in three comprehensive chapters, which is an indication of the maturity of this technique in clinical medicine. Today, almost all branches of clinical medicine benefit from the availability of clinical lasers, and this aspect of biomedical photonics is well covered in a series of chapters that describe the latest techniques in each clinical discipline. It is fair to state that lasers have revolutionized the fields of ophthalmology and dermatology.

The section on advanced biophotonics for genomics, proteomics, and medicine is a very exciting and new area of biophotonics. The topics discussed include: biochips, sensors on the nanoscale, probes, optical trapping techniques, and surface-enhanced Raman scattering. These are the techniques that will have major impacts on the field of molecular medicine. The advances of molecular biology interfaced with the rapid development of nanoscale devices will further accelerate the development of biomedical photonics.

The major theme that emerges from this volume is that biomedical photonics is having a great impact on both basic medical sciences and in clinical medicine in the areas of diagnostics, intervention, and treatment. The many advances in biomedical photonics that are described in the handbook succeeded because of the multidisciplinary research teams in the laboratory and in the clinic. It is the integration of theory, instrument design, signal processing, image processing, and clinical knowledge that is driving the advances in biomedical photonics.

In contrast to the overall high quality of the handbook there exists a lack of coordination between some of the chapters and insufficient editing. In a book that contains many chapters on diagnostic techniques there is little discussion and analysis of the sensitivity, specificity, and limitations of these techniques. The emphasis of the handbook is on new developments in technology: the theory, methods, and instrumentation. Nevertheless, the secondary theme of the volume is applications to medicine: medical diagnostics, optical biopsy, intervention, and treatment techniques. In order to critically evaluate the efficacy of these techniques a discussion of sensitivity, specificity, and limitations is required. Similarly, it would also be very useful to have some discussion of indications, contraindications, and complications for many of the intervention and treatment techniques that are described. Hopefully, by the time the next edition is published there will be some large-scale, randomized, clinical trials based on some of the exciting technological developments that have been described in the handbook.

The handbook does not cover several important areas: nonlinear microscopy such as second-harmonic generation imaging, third-harmonic generation imaging, coherent anti-Stokes Raman spectroscopy (CARS), and microscopy. On the clinical side, the handbook does not include the clinical scanning laser microscope and other clinical microscopes for diagnostics in dermatology. A discussion of clinical scanning slit microscopes for ophthalmology and laser scanning confocal microscopes with both eye tracking and adaptive optics for retinal diagnostics are also missing from the book. Hopefully, a future edition will be enhanced by the editor.

The stated goal of the handbook is to provide a comprehensive, integrated, interdisciplinary forum that would be of great interest and use to scientists, engineers, manufacturers, teachers, students, and clinicians. The editor and the 150 authors have succeeded in their goal; therefore, I recommend the handbook as a useful reference book.



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