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Malini Olivo · U. S. Dinish
Editors

Frontiers in Biophotonics for Translational Medicine

In the Celebration of Year of Light (2015)

Springer

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Foreword I

The UN proclaimed 2015 as the International Year of Light and Light-based Technologies, emphasizing achievements in the optical sciences and their importance to humankind. Light in the ultraviolet, visible, and infrared spectral region is a fundamental tool of human inquiry. This miniscule region of the vast electromagnetic spectrum is the only one that provides molecular information directly. Because molecules are the building blocks of life, the importance of light in the life sciences and medicine cannot be overemphasized.

Man-made high-resolution optical imaging dates to 350 years ago, when planar optical microscopy enabled visualization of subcellular structures, the basis of histology. However, light scattering in biological tissue presents a multitude of challenges to optical penetration. Wavefront aberration limits planar microscopy to tens of microns of penetration. Three centuries later, the advent of the laser and other new light sources enabled a host of new microscopic technologies. Tomographic optical microscopy—such as confocal microscopy, two-photon microscopy, and optical coherence tomography—beats the wavefront aberration limit by suppressing multi-scattered signals, but is still limited by diffusion to ~ 1 mm of penetration. Three-dimensional photoacoustic microscopy and photoacoustic computed tomography have conquered the diffusion limit by combining diffuse-light excitation and unscattered ultrasonic wave detection and advanced the penetration limit by nearly two orders of magnitude. Currently, penetration is confined only by dissipation. Wavefront engineering with internal guide stars, a nascent innovation, promises to shatter the dissipation limit and approach the absorption limit for whole-body penetration in human tissue.

This timely book highlights selected advances in biomedical optical technologies made toward translational biomedicine. The chapters are contributed by thought leaders responsible for cutting-edge developments in their areas of research. The technologies that have been commercialized for clinical or preclinical applications include optical coherence tomography, fluorescence lifetime microscopy, photoacoustic microscopy, and photoacoustic computed tomography.

Upcoming technologies with excellent translation potential include Raman spectroscopy, plasmonic sensing, nanoparticle-enhanced endoscopy, in situ gas spectroscopy, and diffuse optics. Also important is the chapter from a leading medical instrumentation company, highlighting their view of optical imaging in clinical laparoscopic surgery.

While the twentieth century was revolutionized by physical sciences, this century will belong to engineering and life sciences. As an interface between these disciplines, biomedical optics is particularly exciting. Our field will undoubtedly see even greater fruition by leveraging the previous century's invention—such as large-scale semiconductors, computers, lasers, nanotechnology, and ultrafast detectors. Let us join hands and use light to eradicate the most challenging diseases and make the world a healthier place to live.

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Foreword II

Optical imaging is not an emerging technology anymore in the world of molecular imaging. This book is a perfect testament of the advent of a new era in optical bioimaging and biosensing development which has already shown its impact in preclinical research, cancer detection, drug development, prognosis and diagnosis, image-guided therapies at the bedside, and many other areas of biomedicine. The potential of optical imaging remains considerable. Modern personalized medicine calls for noninvasive and nonionizing high performance imaging methods, to preserve cell integrity and allow harmless repeated explorations over time. Optical imaging meets increasingly those requirements with the rapid advances in biophotonics which provide cost-effective methods allowing deeper penetration into tissues and organs and ever-increasing specificity and resolution. These methods offer other significant competitive advantages: they are amenable to combination with other imaging modalities such as MRI and they can be used label-free or in conjunction with versatile intrinsic and extrinsic metabolic/chemical probes, dyes, conjugates, and contrast media to document in a targeted manner, cell physiology and function, molecular mechanisms, and gene expression.

In this context, this book is particularly timely, especially when its publication occurs in 2015, the International Year of Light and Light-based Technologies. It has been assembled by two world leading specialists in biophotonics, Professor Olivo and Dr. Dinish in Singapore, who have been successful in gathering contributions from the best international experts in the field of advanced optical imaging. The 11 chapters cover selected hot topics illustrating the high translational potential of biophotonics together with several actual transfers from bench to bedside. No doubt this opus will be of utmost interest for scientists and clinicians, both specialists and newcomers in this exciting field of modern optical bioimaging methods and their applications to medicine.

Prof. Patrick J. Cozzone
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About the Editors

Prof. Malini Olivo is currently the head of Bio-Optical Imaging Group, Singapore Bioimaging Consortium, A*STAR, Singapore, e-mail: malini_olivo@sbic.a-star.edu.sg; malini.olivo@nuigalway.ie. She holds a Stokes Professorship at the National University of Ireland and Royal College of Surgeons, Dublin, Ireland. She obtained a Ph.D. in Bio-Medical Physics in 1990 and did her postdoctoral training between 1991 and 1995 in University College London, UK, McMaster University and University of Toronto, Canada.

Since 1995 she has been very active in pioneering biophotonics research in Singapore. In 2015 she was awarded the OSA Fellowship for her pioneering contribution to photomedicine in the area of clinical biophotonics for diagnostics and therapeutics of cancer. The International Society for Photonics and Optics conferred an award for her contribution as a woman in photonics. She has won numerous awards in recognition of her contribution to biophotonics in Singapore, Ireland, and United States. She has published over 300 peer reviewed scientific papers, 12 book chapters, one book, and 23 patents. She has secured >US$20 million in research grants over the years and serves in the editorial board of photonics journals. Malini Olivo is well recognized internationally in her field and serves in numerous scientific advisory boards in the area of Photonics in Medicine.

Dr. U. S. Dinish is a biophysicist working as Research Scientist at Bio-Optical Imaging Group, Singapore Bioimaging Consortium, under Agency for Science Technology and Research (A*STAR), Singapore, e-mail: dinish@sbic.a-star.edu.sg. He obtained his Ph.D. in bio-optics and imaging in 2005 from Nanyang Technological University (NTU), Singapore. His current research interests include Nano-biophotonics and its applications in translational medicine and biomedical optical instrumentation and spectroscopy. He holds nine patents/patent applications and has published over 80 international journal papers and conference proceedings/presentations. He also authored four book chapters and won young investigator and best paper awards in international conferences in 2006 and 2012.

Dinish organized and chaired special sessions on bio-optical imaging and sensing in international photonics conferences. He is serving as reviewer for 14 leading journals in the field of optics, bio-optics, nanotechnology, and nanomaterials and won the certificate of appreciation for excellent review service (2012, 2013, and 2014) from the chief editor of Journal of Biomedical Optics (JBO), SPIE, USA. Currently, he is serving as the editorial board member of the journal 'Scientific Reports' (Nature Publishing Group) in biological physics category since 2014. Dinish was also nominated as consulting editor for the 'International Journal of Nanomedicine' (Dove press) since 2015.