Introduction to the Issue on Biophotonics

THE RAPIDLY developing field of biophotonics integrates the descriptive and analytical aspects of the life sciences and photonics to register unprecedented achievements in the detection, imaging, identification, kinetics, and manipulation of biological materials. Biophotonics is used in biology to probe for molecular mechanisms, function, and structure. In medicine, biophotonics is used to study tissue and blood at the macro- and micro-organism level to detect, diagnose, and treat diseases in ways that are noninvasive or minimally invasive to the body. Applications of biophotonics include using light to image or selectively treat tumors, sequence DNA, and identify single biomolecules within cells.

Against this backdrop of science and technology, this issue of the IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS (JSTQE) on *Biophotonics* features articles covering a range of disciplines that describe advances and revolutionary developments in the field. Manuscripts on the latest research and developments in photonics-driven areas such as: bioimaging, biosensors/assays, contrast agents, multicolor probes, biomolecular mechanisms and function, biomolecular structure, advanced medical devices, biocomputers, optical limiters, and biophotonic and biocompatible materials were solicited for this JSTQE issue. The papers published in this JSTQE volume represent the impact of biophotonics on new understanding of fundamental biological processes, innovative approaches to major health issues such as novel methods for medical diagnosis and treatment, and new techniques and technologies to satisfy biorelated national security needs such as the detection of toxic agents and pathogens, and associated countermeasures.

This issue's title changed from the prior "Lasers in Medicine and Biology" to the forward-looking "Biophotonics" and is deemed necessary to more properly characterize the rapid and numerous developments that are taking place at the intersection of the life sciences and photonics. The new name subsumes the previous topical areas of the old designation.

ACKNOWLEDGMENT

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RALPH R. JACOBS, *Primary Guest Editor*
Lawrence Livermore National Laboratory
The NSF Center for Biophotonics Science and Technology (CBST)
Livermore, CA 94551 USA

R. ROX ANDERSON, *Guest Editor*
Massachusetts General Hospital
Wellman Laboratories of Photomedicine
Boston, MA 02114 USA

ARTHUR CHIOU, *Guest Editor*
National Yang-Ming University
School of Medical Technology and Engineering
Shi-Pei, Taipei, Taiwan, R.O.C.

LEON ESTEROWITZ, *Guest Editor*
National Science Foundation
Biomedical Engineering Research to Aid Persons with Disabilities
Arlington, VA 22230 USA

JOSEPH A. IZATT, *Guest Editor*
Duke University
Biomedical Engineering Department
Durham, NC 27708-0281 USA

DENNIS L. MATTHEWS, *Guest Editor*
University of California, Davis
The NSF Center for Biophotonics Science and Technology (CBST)
Sacramento, CA 95817 USA

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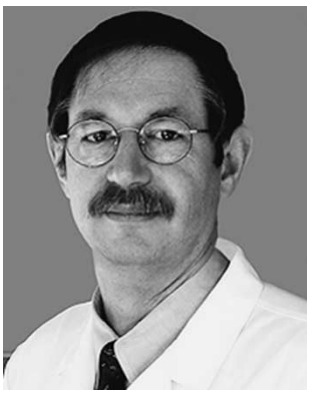
Ralph R. Jacobs (SM'85–F'91) received the B.S. degree (*cum laude*) in physics from New York University in 1964 and the M.S., Ph.M., and Ph.D. degrees, all in physics, from Yale University, New Haven, CT, in 1965, 1967, and 1969, respectively.

He is the Director of New Technology Initiatives in the Physics and Advanced Technologies Directorate at the Lawrence Livermore National Laboratory (LLNL), Livermore, CA. During 1982–1983, he helped found SDL, Inc. as Corporate Manager for Research and Advanced Development at Spectra-Physics. From 1969 to 1972, he served as a Member of the Technical Staff at the GTE Laboratories. From 1972 to 1980, he held the positions of Senior Physicist and Project Manager in the laser program at the LLNL. From 1980 to 1990, he held positions of increasing and related responsibility at Spectra-Physics, including Engineering Manager in the Laser Products Division, culminating as Director of Corporate Technical Development. In 1990, he assumed his current position at LLNL. He has published over 50 articles and received six patents in laser-related investigations.

Dr. Jacobs also is a Fellow of the American Physical Society and the Optical Society of America. In May 2000, he received the Award for Excellence in Technology Transfer from the Federal laboratory Consortium for Technology Transfer. He has served as Vice President for Conferences and Member of the Board of Governors for the IEEE Lasers and Electro-Optics Society.



R. Rox Anderson graduated from the Massachusetts Institute of Technology (MIT), Cambridge, then received the M.D. degree *magna cum laude* from the joint MIT-Harvard medical program, Health Sciences and Technology.

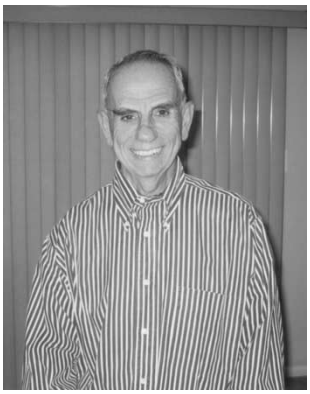
After completing residency in dermatology and research fellowships at Harvard, he joined the faculty there, where he is presently Associate Professor in Dermatology, leads a research group at the Wellman Laboratories of Photomedicine, and is Director of the MGH Laser Center. He conceived and developed many of the nonscarring laser treatments now widely used in dermatology. These include selective photothermolysis for birthmarks, microvascular and pigmented lesions, tattoo and permanent hair removal. He also contributed to laser lithotripsy, laser angioplasty, photodynamic therapy, and optical diagnostics. The highest-resolution imaging device approved for human use, an infrared confocal microscope, recently came from his laboratory. He has contributed to basic knowledge of human photobiology, drug photosensitization mechanisms, tissue optics, and laser-tissue interactions. He has authored or coauthored 170 research papers, and 35 issued patents.

Arthur Chiou received the Ph.D. degree in applied physics from California Institute of Technology, Pasadena.

He had been an Engineer at the Jet Propulsion Lab. (JPL), Pasadena, NASA, a Post-Doctoral Research Fellow at IBM San Jose Research Lab., a Principal Investigator, a Senior Scientist and a Program Manager at Rockwell Science Center in the U.S., and a Professor of the Electrical Engineering Department and the Dean of the College of Science and Engineering at the National Dong Hwa University, Hualien, Taiwan, R.O.C. He is currently a Professor of the Institute of Biophotonics Engineering and the Dean of the School of Medical Technology and Engineering at the National Yang-Ming University, Taipei, Taiwan. His recent research interest has been in the field of optical manipulation and sensing, and spectroscopic laser microscopy for biomedical applications. He has more than 180 publications and presentations, and holds two U.S. patents.

Dr. Chiou is a Fellow of the Optical Society of America (OSA), a Fellow of the SPIE, and a Fellow of the Photonics Society of Chinese-Americans (PSC). He was the President (1993) and the Chairman of the Board (1994) of PSC. He is a Member of the Board of Director (BoD) of SPIE (2000, 2002–2004), a

Member of the Board of Directors of the Physical Society of the R.O.C. (2001–2003), the President of the OSA, Taiwan Chapter (2002–2003), and a recipient of the SPIE 1989 Rudolph Kingslake Award and Medal.



Leon Esterowitz (SM'85–F'01) received the B.S. degree from Yeshiva University, New York, and the Ph.D. degree from New York University, both in physics, in 1956 and 1963, respectively. This was followed by a Postdoctoral Fellowship at Yale University, New Haven, CT, on high power gas lasers.

From 1965 to 1969, he was Group Leader of the Quantum Electronics Group at the Night Vision Lab. at Fort Belvoir, performing research on infrared to visible imaging technology. In 1969, he cofounded CEA Industries, Inc., and directed the design of components for state-of-the-art infrared detection and imaging systems. From 1971 to 1999, he served as Section Head, Branch Head, and Chief Scientist in the Optical Sciences Division at the Naval Research Laboratory. He pioneered the development of compact, low-cost, diode-pumped, solid-state lasers at wavelengths required for biomedical applications, and developed new methods of generating highly efficient flashlamp-pumped two micron solid state lasers. He currently is Program Director of Biomedical Engineering in the Engineering Directorate at the National Science Foundation. He has authored 330 papers, and has been awarded 33 patents.

Dr. Esterowitzs' service activities include the following.

- LEOS Program Committee Member and Chair for Solid State Lasers (1992–1997).
- CLEO Technical Program Committee Chair for Solid State Lasers (1997–1998).
- Committee Chair for LEOS Symposium on Lasers in Medicine (1995–2000).
- Committee Member for LEOS Symposium on Lasers in Medicine (2001–2002).
- CLEO Steering Committee Member for IEEE/LEOS (1999–2001).
- Guest Editor for inaugural issue of IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS (*Tunable Solid State Lasers*, vol. 1, no. 1, Apr. 1995).
- Associate Editor for the IEEE JOURNAL OF QUANTUM ELECTRONICS (1995–2001).
- Guest Editor for Feature Section on *Biomedical Photonics*, IEEE JOURNAL OF QUANTUM ELECTRONICS, vol. 38, no. 2, Feb. 2002.
- Editor-in-Chief for the IEEE JOURNAL OF QUANTUM ELECTRONICS (2002–2006).

Joseph A. Izatt received the S.B. degree in physics in 1986, and the S.M and Ph.D. degrees in nuclear engineering in 1988 and 1991, respectively, from Massachusetts Institute of Technology, Cambridge.

He is an Associate Professor of Biomedical Engineering, Associate Professor of Ophthalmology, and holds appointments in both the Department of Biomedical Engineering and the Department of Opthalmology at Duke University, Durham, SC. He is also the Director of the Laboratory for Biophotonics in the Fitzpatrick Center for Photonics and Communications. His research interest include biomedical optics, spectroscopy, and imaging; laser-tissue interactions; optical and ultrasonic signal processing; novel methods for high-resolution, and minimally invasive medical imaging and tissue characterization. Biophotonics is concerned with the application of cutting-edge optoelectronic technologies to problems in the biomedical sciences. His research centers on the application of optical technologies for noninvasive, high-resolution imaging and sensing in living biological tissues. The technologies used in the laboratory include acoustooptic and integrated-optic devices, femtosecond lasers, and ultrabroadband fiber optic telecommunications equipment. The applications of the systems that are built include noninvasive medical diagnostics, *in vivo* tomographic microscopes, and high-throughput three-dimensional small animal imaging systems for genomics studies. His work involves multiple collaborations with engineers, biologists, and physicians at Duke University and elsewhere.

Dennis L. Matthews received the Ph.D. degree in physics from the University of Texas, Austin, in 1974. His thesis work dealt with the understanding the radiative and collisional ionization properties of energetic heavy ions moving through gases and solids.

He is an expert on the radiative properties of ions in plasmas as well as in the conversion of laser light into X-rays. He is also an expert in developing optically based biosensors and medical devices. He holds several joint appointments: University of California Davis College of Engineering and the School of Medicine Director, NSF Center for Biophotonics and Associate Director, University of California Davis NCI-Designated Cancer Center and Lawrence Livemore National Laboratory, Livermore, CA, Director of the Center for Biotechnology, Biophysical Sciences and Bioengineering.

He is responsible for the development of industrial and medical applications of Lawrence Livermore National Laboratory technology, especially for the prevention, screening, diagnosis, and treatment of diseases such as diabetes, stroke, brain trauma, chronic pain, and cardiovascular disease. He is also responsible for founding a biomedical technology stem of research and teaching curriculum within the Department of Applied Science. He leads a multidirectorate Center within Livermore whose mission is to develop medical devices in collaboration with industry. Current projects and those already successfully transferred to industry include: an opto-acoustic recanalization device for treating ischemic stroke; a miniature X-ray source which is mounted on a microcatheter and used to treat coronary artery restenosis; micropower impulse radar for numerous medical diagnostics including differentiating hemorrhagic versus ischemic stroke; an implantable, continuous glucose monitor and ultra-short-pulse laser microsurgery devices. He is a co-Principal Investigator on a Department of Energy funded Center of Excellence for Application of Lasers to Medicine and on a NIH Unconventional Innovations Program Grant to Develop Compact Light Sources for Mammography and Radiotherapy. He is Principal Investigator and Director of the University of California Davis National Science Foundation's Center for Biophotonics Science and Technology. He is also the Associate Director and Biomedical Technology Program Leader of the University of California Davis/LLNL Cancer Center that received NCI designation in 2002. He has also worked for short periods at the Hahn Meitner Institut in Germany, Rutherford-Appleton Laboratories in Great Britain, the University of Paris-Orsay, and the Centre d'Etudes de Limeil-Valenton in France. He has lectured at numerous universities and research centers in the United States, Europe, and Japan. He is widely acknowledged to have invented and developed the X-ray wavelength lasers. Among many other applications of that technology, he continues to collaborate with biologists in order to use X-ray lasers to generate X-ray images of living subcellular material, and with materials scientists to develop new methods of studying materials properties and defects. He is extremely active in commercializing technologies developed at the national laboratories. He specializes in helping investors or small companies obtain the technologies needed to capture profitable new markets. He has already helped investors put together several startup companies based on Livermore and other national lab technologies. He has broad scientific management and marketing skills, having managed programs as large as $30 M/yr while at Livermore and having successfully garnered project funding from both government and private sources. He has written over 190 publications in the scientific literature and holds numerous patents, especially for medical devices and commercial applications of lasers.

Dr. Mathews is a Fellow of the American Physical Society and the Optical Society of America and is a corecipient of the 1990 Division of Plasma Physics Award for Excellence in Plasma Physics Research. He is also a member of the American Physical Society, Optical Society of America, and the Society of Photographical and Industrial Engineers.