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Joseph A. Izatt (1962–2024)

By Marinko V. Sarunic & Cynthia A. Toth

Joseph Izatt's work advanced the science of imaging in biophotonics and brought optical coherence tomography imaging to the eye care of infants and children and, as live feedback for the surgeon, to ophthalmic microsurgery.

Joseph Izatt, who passed away on 7 April 2024, was the Michael J. Fitzpatrick Professor of Engineering, Chair of Duke's Department of Biomedical Engineering in the Pratt School of Engineering, and Professor of Ophthalmology in the School of Medicine, Duke University.

Izatt inherited his love of science from his father, Jerald Izatt. He started working with lasers in high school, winning first place in the Quebec Science Expo. He pursued his undergraduate studies in physics at the Massachusetts Institute of Technology (MIT) to follow in his father's scientific footsteps, finding great intellectual fulfilment in his research at the George R. Harrison Spectroscopy Laboratory and in his work with Claude Shannon on his juggling machine. Izatt relished the opportunity to tinker and build, leading his undergraduate advisor Mildred Dresselhauss to suggest that he should pursue his advanced training in an engineering field. As a result, Izatt focused on applied optics for his graduate studies at MIT, first under the mentorship of Michael Feld and then under James Fujimoto for his postdoctoral work.

Izatt joined the Biomedical Engineering Faculty at Case Western Reserve University in Cleveland, Ohio upon the completion of his postdoctoral fellowship in 1994. He then moved to Duke University in 2001, where he was the inaugural Director of the Laboratory for Biophotonics in the Fitzpatrick Institute of Photonics, in the Pratt School of Engineering, and became Chair of Biomedical Engineering in 2022. His research was based in biomedical optics and optical spectroscopy for non-invasive and minimally invasive imaging of living cells and tissues, with real-world clinical impacts, particularly in ophthalmology. Izatt was credited with the first published images of the ocular anterior chamber with optical coherent tomography (OCT) in 1994 (ref. 1). Some of the most important contributions in his pioneering work on OCT included optimization of interferometer designs and detection[2,3] and propelling the translational potential of OCT from the optics bench towards clinical applications. His contributions expanded beyond biophotonics and encompassed all aspects of biomedical optical engineering, including signal processing and high-speed system integration for real-time visualization, topics that are emphasized throughout his long list of (over 200) academic publications and (over 75) patents.

Throughout his career, Izatt demonstrated innovative approaches to increase the information obtained through optical imaging, most notably in his contributions toward motion contrast for angiography, spectroscopic approaches for molecular contrast, and high-resolution imaging. Through the novel combination of these topics, his work culminated in high-impact and non-invasive imaging and sensing in living biological tissues, such as ultra-compact hand-held pediatric imaging[4] and super-resolution retinal imaging[5]. Izatt had a brilliant mind and a unique ability to see into the future, connecting seemingly distant scientific disciplines. His thought leadership on the combination of artificial intelligence and robotics with biophotonics led to exciting and potentially transformative advances in automation for image acquisition, for example making sophisticated ophthalmic instrumentation available even in non-specialist centres[6].

Izatt was a visionary, transformative researcher. Early in his career, he conceptualized improving ophthalmic care by creating and implementing new imaging technologies at the point-of-care. He succeeded in bringing ophthalmic OCT to both bedside and surgical use, inspiring and mentoring many engineers and clinician-scientists along the way. In 2001, as early tabletop OCT systems were moving into clinical care, Izatt's group demonstrated Fourier domain OCT of the eye at up to 16 frames per second, creating the first human ophthalmic handheld OCT probe[7]. By 2012, his handheld portable Spectral Domain OCT system, developed by Bioptigen, Inc. – a company he cofounded – had been FDA-cleared for use in neonates, infants, children and adults for anterior segment (front of the eye) and posterior segment (back of the eye) ocular imaging. This device opened the door for diagnostic OCT imaging in preterm infants and children who were at risk of developing vision-threatening eye diseases but for whom this breakthrough technology had not been accessible[8].

In parallel, Izatt's breakthrough technology also brought OCT to the operating room[9]. At first, this was done through use of the handheld system prior to, or at pauses during, eye surgery to reveal depth-resolved details of ocular microanatomy. Izatt's research group at Duke University integrated the OCT optics with the surgical microscope and this too was commercialized through Bioptigen and later sold to Leica, Inc. This transformative technology paved the way for OCT imaging to directly inform observations within the microscope and enabled guidance during surgery, using what was referred to as "4D (three-dimensional imaging over time) microscope-integrated OCT"[10]. Izatt's translational developments have had profound and lasting impacts in the fields of pediatric OCT imaging and microsurgical OCT. He had a special gift, and commitment, to reaching out and working with students and clinicians to create transformative technology.

Izatt was passionate in his support of an accessible scientific community, and as a community leader he brought together researchers at interdisciplinary forums. Izatt was co-chair of the Optical Coherence Tomography and Coherence Domain Optical Methods conference within SPIE Photonics West for over two decades before stepping down earlier this year. He was also the first editor-in-chief of *Biomedical Optics Express*, which was spun out of *Optics Express* in 2010 within the *Optica* (formerly *Optical Society of America*) family of journals. Under his

leadership, the journal quickly grew in size and impact and is now widely recognized as one of the most important journals in the field of OCT research. For his volunteering and contributions to academic meetings and publications Izatt was awarded the Stephen D. Fantone Distinguished Service Award by *Optica* in 2022.

In recognition of his scientific contributions, he was named a Fellow of the National Academy of Inventors and Fellow of the American Institute for Medical and Biological Engineering. He received *Optica*'s Edwin H. Land Medal in 2021 "for foundational contributions to the invention, development, and commercialization of optical coherence-based technologies for in vivo biomedical imaging, and for the education and mentoring of distinguished scientists and engineers".

Izatt was described as an amazing mentor by his past and present students. He was an outstanding role model who mirrored enthusiasm for new ideas, answered all questions with respect, and was always honest. In recognition of his mentoring, he was awarded both the 2008 Pratt School of Engineering's Capers and Marion McDonald Award for Excellence in Mentoring and Advising and the 2017 Graduate School Dean's Award for Excellence in Mentoring. He inspired his students, and they inspired him back. In an interview with *Optica*, he explained, "I know if I'm out of town for a couple of days, when I come back, I've got a group of brilliant students who can't wait to tell me what they've been doing and what they've done and the results that they have. And that is so exciting for me. It just never gets old. That's my favorite part about what I do"[11].

Most importantly, Izatt's dedication to his family and the joy of life outside of work during his busy career allowed his students to appreciate the importance of family in all of their lives. He cultivated a spirit of friendship and comradery in his group, building a tight-knit "lab family" among his students and peers. The laboratory year would not have been complete without the weekly lunches and lively discussions at journal club, the summer research retreat to the beach house, the lab adventure during Association for Research in Vision and Ophthalmology meetings, and JoeFest during SPIE Photonics West.

Izatt met his wife, Susan, when they were undergraduates at MIT. They were blessed with three children: Elizabeth, Gregory, and Daniel. He took great joy in sharing his passions and time with his family. He helped his children build a 10-foot trebuchet in the driveway, supported a myriad of Elizabeth's and Gregory's Science Olympiad building projects, tutored trigonometry and calculus on a traditional chalkboard hung on the kitchen wall, and mentored his children in his lab. He journeyed across the state supporting Daniel's travel teams and was always a familiar face running the concession stand at high-school home games. Izatt had a particular love for flying and aviation. He never missed a chance to take the family to the National Air and Space Museum. Every Christmas had to involve at least one remote control toy aircraft; and the newest versions of *Flight Simulator* were installed on the home computer the day they were released. He fulfilled a personal dream when he obtained his pilot's license, taking great joy in flying his family above Raleigh and the islands of the Outer Banks.

Izatt will be missed by his family, friends and colleagues. His enthusiasm and positive energy infected those around him in research, entrepreneurship, and in conferences. We who worked with him were grateful for his generous spirit, which made each of us a better scientist and partner.

Marinko V. Sarunic [1,2] ✉ & **Cynthia A. Toth** [3,4] ✉

[1]Institute of Ophthalmology, University College London, London, UK. [2]Department of Medical Physics and Biomedical Engineering, University College London, London, UK. [3]Department of Ophthalmology, Duke University School of Medicine, Durham, NC, USA. [4]Department of Biomedical Engineering, Duke University, Durham, NC, USA.
✉e-mail: m.sarunic@ucl.ac.uk; cynthia.toth@duke.edu

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Competing interests

The authors declare no competing interests.