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Recent progress in optical probing and manipulation of tissue: introduction

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Abstract: This feature issue of Biomedical Optics Express represents a cross-section of the most recent work in tissue optics, including exciting developments in tissue optical clearing, deep tissue imaging, optical elastography, nanophotonics in tissue, and therapeutic applications of light, amongst others. A collection of 33 papers provides a comprehensive overview of current research in tissue optics, much of it inspired and informed by the pioneering work of Prof. Valery Tuchin. The issue contains three invited manuscripts and several mini-reviews that we hope will benefit researchers in this exciting area.

The "Recent progress in tissue optics" special issue of *Biomedical Optics Express* is a collection of 33 papers that covers the latest advances in the field with a focus on recent exciting developments in tissue optical clearing, deep tissue imaging, optical elastography, nanophotonics in tissue, and therapeutic applications of light, and more. Much of this work has been inspired and informed by the pioneering work of Prof. Valery Tuchin, who recently celebrated his 75th birthday. Prof. Tuchin has been Chair of the Division of Optics and Biophotonics, Saratov State University (Russia), since 1985. As a leader of the research team, he has pioneered studies on tissue optics, tissue optical clearing and control of the optical properties of tissues and cells. His book "Tissue Optics: Applications in Medical Diagnostics and Therapy" [1] has received over 2,000 citations and was recognized by OSA/SPIE Joseph W. Goodman Book Writing Award. He is the recipient of numerous scientific awards and prizes, including the most recent 2019 Michael S. Feld Biophotonics Award. "Valery Tuchin is synonymous with the term Tissue Optics – most new entrants to the field begin with his landmark book that places the "biophotonics planets" in their "solar system". His leadership in the field has been inspirational." - says Prof. Sampson from the University of Surrey, UK. "One of the main features of V. Tuchin is his openness to interaction and active assistance in the development of numerous scientific teams in the field of Biophotonics around the world." adds Prof. Kistenev from Tomsk State University.

As a result of Tuchin's pioneering work, there has been rapidly growing interest in tissue optical clearing and controlling of tissue optical properties extending imaging depth of optical microscopy techniques to mm/cm range in highly scattering media to whole organs (see papers in this issue [2-5]). Extending tissue optical clearing to in vivo applications not only enhances the performance of various optical imaging methods, but also promises improved laser control of neurons, cells and vessels. The authors of the mini-review entitled "In-vivo and ex-vivo optical clearing methods for biological tissues" testify that "Every optical

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imaging technique has a limited penetration depth in biological tissues because of scattering. Possible solutions to overcome this problem consist of limiting the detrimental effects of scattering by reducing optical inhomogeneities within the sample using Optical Clearing Agents (OCAs). The development of aqueous clearing solutions by Tuchin and co-workers in the mid 90's provoked an upsurge in the field. These techniques and current state-of-the-art methods used for testing the effects of various components on the optical properties of biological tissues in both in-vivo and ex-vivo samples are discussed in [2]."

As another example of Prof. Tuchin's contributions, the field of optical elastography has experienced significant growth over the past few years as biomechanical mapping of tissues and cells enables new understanding of disease formation and stimulates development of effective therapies (see papers in this issue [6-8]). The authors of [6] state, "Prof. Tuchin worked a lot on optical methods of visualization of scatterer motions in biological tissues using sequential variability of speckle in coherent images, first of all in the context of visualization of microcirculation of blood. These principles can be used in various variants, either for processing en face images obtained under coherent illumination of the studied region or by analyzing variability of speckles in OCT images (which has resulted in creation of OCT-based microangiography). In a broad sense, similar principles can be used to visualize the collective motion of scatterers related to deformation of biological tissues. In recent years, these principles have been realized via phase-sensitive OCT for imaging of strain and distribution of tissue stiffness." Dr. Zaitsev from Institute of Applied Physics, Russian Academy of Sciences adds: "Valery Tuchin, to me, as well as to many other scientists, is our biophotonic lantern forming our understanding in fields of tissue optics who paved the way in formulating the fundamentals of light scattering in biological tissues, in defining advanced concepts for tissue clearing and probing, in explaining the physics of dynamic optical coherence tomography, and in qualifying/guiding an entire new generation of biophotonics students, researchers and scientists."

In the past decade, there was a boost of non-labeling optical imaging techniques applied for the study of embryonic development, which, not only opened new avenues in embryology, but also extended the power of light in the natural developmental process of a new life (see papers in this issue [9, 10]). Speckle technologies are continue advancing their methodology for tissue imaging and analyses (see an example in [11]). The authors of [12] mention that they "*are proud to be the friends of Valery Tuchin, his students and followers in science. This work of ours [12], like many others, is inspired by friendly and professional discussions and cooperation with Valery*."

The readers of this special issue will find a number of original manuscripts related to Optical Coherence Tomography [13,14], Optoacoustics/Photoacoustics [15,16], and opto-nanotechnology [17,18]. The issue also includes 3 invited reviews including from Prof. Schneckenburger: "Working in the fields of Biomedical Spectroscopy and Microscopy I felt myself inspired by Valery Tuchin to extend my work to Laser Micromanipulation. My Mini-Review on Laser Optoporation [19] results from this inspiration and includes Valery's as well as my own work."

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Disclosures

The authors declare that there are no conflicts of interest related to this article.

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