Introduction: Feature Issue on Cellular Imaging of the Retina

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Abstract: The editors introduce the *Biomedical Optics Express* feature issue, "Cellular Imaging of the Retina," which includes 14 contributions from the vision and optics community.

OCIS codes: (000.1200) Announcements, awards, news, and organizational activities; (110.1080) Active or adaptive optics; (110.2960) Image analysis; (170.0170) Medical optics and biotechnology; (170.4500) Optical coherence tomography; (170.5755) Retina scanning; (330.4460) Ophthalmic optics and devices; (330.5310) Vision-photoreceptors; (330.7327) Visual optics, ophthalmic instrumentation

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Retinal imaging is a powerful tool, enabling clinicians to directly observe pathology and researchers to probe retinal structure and function. Cellular resolution imaging of the retina is a broad and rapidly growing field, benefiting from continued advances in optical

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instrumentation as well as data and image processing capabilities. In many cases, this can be accomplished *in vivo*. Advances in retinal imaging are made possible through interactions between the vision and optics communities, something that the Optical Society of America has staunchly supported throughout its history. Reflecting the continued commitment to this field, we were invited by the editors at *Biomedical Optics Express* to organize a feature issue highlighting recent advances in the field of Cellular Imaging of the Retina. We were quite pleased with the response (outlined below), and believe the assembled feature issue appropriately captures the current state of the field.

The 14 papers in this issue span many disciplines, including clinical imaging, new instrumentation, image analysis, imaging in animal models, and functional retinal imaging. Reflecting the multidisciplinary nature of this field, most papers fit in multiple categories, and here we provide a brief précis of the entire issue.

Using a variety of imaging techniques, the majority of the papers examined the human retina. Among the imaging tools used to acquire retinal images were stand-alone and adaptive-optics enhanced: scanning laser ophthalmoscopy/scanning ophthalmoscopy (AOSLO/AOSO), optical coherence tomography (OCT), and fundus imaging. Adaptive optics (AO) has opened numerous avenues of research in cellular resolution retinal imaging, thus it is no surprise that we find AO at the heart of many of the papers in this feature issue.

Dubra *et al*. [1], Zawadzki *et al.* [2], Manzanera *et al*. [3], and Vohnsen and Rativa [4] introduced new instrumentation for imaging the photoreceptor mosaic using a broadband AOSO, an integrated AO-OCT SLO, a new MEMS-based AOSLO, and an annular-illumination SLO, respectively. What we take away from these papers is that there is a continued drive to improve the technology even further, which must occur in parallel to robust application of existing imaging tools to studying the retina in order to keep the field moving forward at its current pace.

Four additional papers examined structural and functional properties of the photoreceptor mosaic. Kacaoglu *et al*. [5] examined spatial and temporal evaluation of individual cone photoreceptors using AO-OCT. Rativa and Vohnsen [6] probed the directionality of cone photoreceptors at different retinal eccentricities using scanning laser ophthalmoscopy. Dees *et al*. [7] examined variability in parafoveal cone density in normal trichromatic individuals using a high-speed flood-illuminated AO fundus camera. Dubra *et al*. [8] move beyond cones and demonstrate striking images of the rod photoreceptor mosaic at various retinal locations using a newly developed confocal AOSO.

Moving to clinical imaging, Tam *et al*. [9] developed a method to characterize capillary flow dynamics in the living human retina using an AOSLO, something which could be quite valuable for studying certain retinal diseases. In glaucoma patients, Hood and Raza [10] provide a method for comparing functional visual field defects to local nerve fiber and retinal ganglion cell damage seen on OCT. Hood *et al*. [11] present a method to define visual field boundaries from an analysis of the inner segment/outer segment border in OCT images of patients with retinitis pigmentosa. While the image resolution in these latter cases is not cellular, the approach provides a key step forward in linking retinal structure with function, and could be extended to some of the cellular imaging techniques described in this feature issue.

The final three papers applied high-resolution imaging techniques to animal models. Moayed *et al*. [12] provide volumetric imaging of the chicken retina *in vivo* using spectral domain OCT. Also in the chicken, but *ex vivo*, Bueno *et al*. [13] developed an AO multiphoton microscope for examining multiple retinal layers. Lu *et al*. [14] examined the cellular sources of autofluorescence in freshly isolated frog retinas using a two-photon excitation fluorescence microscope. Ultimately, there are questions that just can't be addressed by imaging the human retina, and animal models will continue to be needed. As such, adaptation and development of cellular imaging systems for use in various animal preparations remains an area of need in this field.

All papers in this issue have undergone a rigorous peer review process, and we are indebted to the referees for their efforts in ensuring that the Optical Society of America's

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standards for quality and integrity were met. We are especially gratefully to Joseph A. Izatt (Editor-in-Chief), Gregory W. Faris (Deputy Editor), and the publication staff at the Optical Society of America for their hard work and dedication to this feature issue: Joe Richardson, Miriam Day, Kelly Cohen and the many others who contributed behind the scenes. We hope you find the papers in this feature issue as enlightening as we did, and expect that they will stimulate research to further move the field forward.

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