Session 2SFA—the symposium “Elucidation of biological functions by optical control” on BSJ2019 at Miyazaki, Japan

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Abstract

The symposium “Elucidation of biological functions by optical control” was held during the 57th annual meeting of the Biophysical Society of Japan (BSJ2019) at Miyazaki, Japan. In this commentary, we introduce invited speakers of this symposium and summarized their research topics.

To understand biological functions, we must first clarify their characteristics and elucidate their detailed mechanisms. Furthermore, we can obtain deeper insights by manipulating biological functions using various stimuli. Recently, methods using optical stimuli have been developed to control functions by genetically introducing photosensitive proteins into specific cells and manipulating their responses with light. Light is an ideal stimulus because it can be controlled with high spatiotemporal resolution. In particular, optogenetic approaches that manipulate specific neural cells by introducing channelrhodopsins, light-driven ion channels, has revolutionized neurosciences. The concept of optical control has also been applied to other research fields such as biomedicine, and the Japan Science and Technology Agency (JST), which is a funding agency and the co-sponsor of this symposium, has supported basic and applied studies on optical control.

At this symposium, we invited six young and active researchers to introduce their studies and to promote the progress of optical control. The invited speakers were Drs. Noriaki

Ohkawa (Dokkyo Medical University), Takayuki Yamashita (Nagoya University), Takashi Tokuda (Tokyo Institute of Technology), Yutaka Nomura (Institute for Molecular Science), Kazuo Takayama (Osaka University), and Keiichi Kojima (Okayama University). The symposium was very successful and the presentations were followed by active discussions with researchers in the audience.

Following the introductory presentation by one of the organizers (Shichida), Dr. Ohkawa talked about the neuronal basis of memory engrams. He combined Ca^{2+} imaging, electrophysiological recording, and channelrhodopsin-based optogenetics to reveal how and where memory engrams form in the hippocampus (Ghandour et al. 2019). His data demonstrated the power of this combined approach for identifying neurons that are involved in memory formation. Next, Dr. Yamashita introduced a new optical control technique that employs infrared light for fiberless optogenetics. Although visible light is conventionally used to stimulate optogenetic tools (typically blue light for channelrhodopsin), he injected lanthanide micro-particles into the brains of mice and successfully stimulated channelrhodopsins in the brain using up-conversion luminescence following irradiation with infrared light (Miyazaki et al. 2019). He has also attempted to develop optogenetic approaches using X-ray irradiation (Matsubara et al. 2019). Dr. Tokuda talked about ultra-small electronic devices that emit visible light to stimulate channelrhodopsins. Notably, his devices are only 1 mm³ and weigh approximately 2 mg (Tokuda et al. 2018), allowing applications in living animals. Dr. Nomura presented his study on a thulium-doped fiber laser that emits long-wavelength infrared light (~1.8 μm). The laser is ideal for multiphoton microscope imaging of deep tissues. He is working on implementing the laser to develop a new microscope. Dr. Takayama has established photoactivatable adenovirus vectors

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that can be used for virus-based gene therapy. These vectors can introduce Cas9-based and light-dependent gene editing activity and can be used to selectively treat tumors (Takayama and Mizuguchi 2018). Dr. Kojima talked about novel microbial rhodopsins with molecular properties that differ from those of channelrhodopsins and other rhodopsins (Kojima et al. 2019). Through extensive mutagenesis, he optimized the properties of these rhodopsins for optogenetic and imaging research applications. After the presentations by the invited speakers, another organizer, Tsukamoto, concluded the symposium by summarizing the contribution of biophysics to optical control research and introduced an optical control tool based on animal opsin, which is a light-sensitive G protein-coupled receptor.

Overall, the symposium showed that research on optical control has flourished due to the efforts of many researchers. Extensive analysis of biological functions requires the accumulation of a wide range of technologies, and so collaborative studies by many researchers in different fields are expected to lead to further developments. JST continues to promote such collaborative studies, and with the ongoing efforts of researchers and funding agencies, this research area is anticipated to expand further.

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