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# Protein Photonics for Imaging, Sensing, and Manipulation: Honoring Prof. Osamu Shimomura, a Pioneer of Photonics for Biomedical Research

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Professor Osamu Shimomura discovered the protein aequorin and green fluorescent protein in the jellyfish *Aequorea victoria* in 1961. He isolated those proteins at the Friday Harbor Laboratories (see Fig. 1) of the University of Washington to answer the curious question, "Why do jellyfish emit light?" This discovery has been combined with genetic engineering and has brought us an invaluable tool for biological research. Based on his discovery, Prof. Shimomura was awarded the 2008 Nobel Prize in Chemistry for the discovery and development of the green fluorescent protein (GFP).

In many scenes in current biology, fluorescent proteins have been utilized to visualize target proteins and structures


**Fig. 1** A group of scientists who were working on fluorescent protein gathered for a symposium on Calcium-Regulated Photoproteins and Green Fluorescent Proteins held at Friday Harbor, Washington, in 2004. This group includes Prof. Shimomura and several of the guest editors.

in live cells and tissues. The usage of fluorescent proteins is not limited to labeling, but they can also be used as reporters of intracellular environments, such as ions and adenosine triphosphate concentrations, pH, and temperature. In combination with FRET or FRAP techniques, fluorescent proteins even allow us to trace the molecular-level dynamics of protein structures in live cells. The switchable capability of fluorescence emission has allowed us to realize superresolution microscopy techniques, research that was awarded the 2014 Nobel Prize in Chemistry. Recently, chemiluminescence, which was Professor Shimomura's main research interest, became available to image intracellular targets even without light illumination. The discovery of fluorescent protein thus initiated the idea of using light-protein interactions for biological research. For example, optogenetics can manipulate cell and animal activities by light-induced conformational change of rhodopsin.

In honor of Prof. Osamu Shimomura's ground-breaking contribution to biomedical photonics, we organized a special section on Protein Photonics for Imaging, Sensing, and Manipulation: Honoring Prof. Osamu Shimomura, a Pioneer of Photonics for Biomedical Research. In this special section, we accepted five contributed papers that utilize fluorescent proteins for cutting-edge research, ranging from the development of optical techniques to biological applications. Although the papers published in this section cannot cover all the examples of experiments using fluorescent proteins, they surely describe how the discovery of fluorescent protein continues to contribute to the development of new techniques and inspires scientists to create new experiments that can tackle biological problems. The guest editors are grateful to the editor-in-chief, Lihong Wang, for giving us opportunity, and also to the contributors and the JBO staff for their great efforts to realize this special section.

**Katsumasa Fujita** has received his PhD in applied physics from the Graduate School of Engineering, Osaka University, Japan, in 2000. He has been working on development of laser microscopes using nonlinear optical phenomena for imaging biological specimens. Since 2007, he has been an associate professor in the Department of Applied Physics, Osaka University. His recent research interests are superresolution microscopy and Raman/SERS microscopy for visualization of biological cells/tissues and their functions.

**Takeharu Nagai** is a professor in the Institute of Scientific and Industrial Research, Osaka University, Japan. He is focusing on development of bioimaging tools by engineering both fluorescent and bioluminescent proteins. Recent representative works in his laboratory include the invention of an ultrasensitive Ca2+ indicator [yellow cameleon-Nano (Nat. Methods 2010)], the brightest luminescent proteins [Nano-lantern (Nat. Commun. 2012)], and a fast photoswitchable fluorescent protein [Kohinoor (Nat. Methods 2015)].

**Nathan Shaner** received his undergraduate degree in physics from Oberlin College in 1999. Afterwards he worked as a research technician at the University of Pennsylvania, where he discovered his love of fluorescence microscopy. He then entered the biomedical sciences graduate program at the University of California, San Diego, working under Dr. Roger Tsien. After completing his doctoral degree in 2006, he held postdoctoral fellowship positions at the Salk Institute and at the Monterey Bay Aquarium Research Institute. In 2012, he cofounded a new research institute in San Diego, the Scintillon Institute, dedicated to fostering innovative biological tool-builders. His research continues to focus on improving and diversifying the "optical toolkit" for biological imaging.

**Alexander Egner** is the director of the Laser-Laboratory Göttingen and head of the Department of Optical Nanoscopy. He has worked in the field of superresolved fluorescence microscopy for almost 20 years. Alexander earned his PhD in physics from Heidelberg University and was a postdoctoral researcher, and later a senior scientist, in the Department of NanoBiophotonics at the Max-Planck-Institute for Biophysical Chemistry, Germany. He has published more than 40 journal papers, has been named as an inventor on several patents in the field of optical nanoscopy, and is cofounder of Abberior Instruments.