Symposium 5: New technologies for visualizing and controlling the brain functions (Thu July 29, 9-11AM JST)
Chair: Won Do Heo (KAIST, Daejeon, Korea)

9:00-9:30 Won Do Heo (KAIST, Daejeon, Korea)
Molecular optogenetics: tool development and applications from cell biology to neuroscience

9:30-10:00 Robert E. Campbell (Dept of Chem, Sch of Sci, Univ of Tokyo, Japan and Univ of Alberta, Canada)
Recent progress in developing genetically encoded ion sensors

10:00-10:30 Michael Z. Lin (Stanford Univ Sch of Med, California, USA)
The need for speed: kilohertz-rate voltage imaging in the nervous system

10:30-11:00 Young-Gyun Park (Dept of Bio and Brain Eng, KAIST, Korea)
Demystifying brain network using 3D tissue profiling techniques

Symposium 5 Speaker 1
Won Do Heo
Professor
Korea Advanced Institute for Science and Technology (KAIST)
Daejeon, Korea
wondo@kaist.ac.kr

Molecular optogenetics: tool development and applications from cell biology to neuroscience

My group has been developing various bio-imaging and optogenetic tools for the study of cell signaling in live cells as well as neuronal functions in vivo. Novel optogenetic toolkit developed by my group is highly advantageous compared with conventional approaches in that it allows finely manipulated signaling pathways in a spatial and temporal resolution, thereby making it possible to dissect and analyze the transient dynamics of signaling processes within a defined period. These tools are very useful not only for imaging based researches in cell biology, but also for the studies in neuroscience. Recently developed optogenetic strategies have brought significant changes the way in which signaling in living cells is studied in neurobiology and other disciplines. Novel optogenetic toolkit my group has been developing are capable of providing what channelrhodopsins could not offer previously, contributing in a disparate perspective of neuroscience. We are applying the new technologies to the study of spatiotemporal roles of signaling proteins and second messengers in learning and memory in normal and disease mouse models.

Symposium 5 Speaker 2
Robert E. Campbell
Professor
Department of Chemistry, School of Science, The University of Tokyo and The University of Alberta
Tokyo, Japan
campbell@chem.s.u-tokyo.ac.jp

Recent progress in developing genetically encoded ion sensors

The advent of fluorescent protein (FP)-based biosensors started a revolution in our ability to spy on the otherwise invisible world of intracellular signalling. The single most impactful class of FP-based biosensors are the genetically encoded calcium ion (Ca^{2+}) indicators (GECIs) that change their fluorescence intensity or color in response to a change in Ca^{2+} concentration. GECIs are frequently used in combination with optogenetic actuators to enable simultaneous control and visualization of neural signalling with precise spatial and temporal resolution. Over the past decade, our lab has led efforts to develop red-shifted GECIs with performance that rivals that of the most highly optimized green fluorescent GECIs. Advantages of red-shifted GECIs can include: new opportunities for multiplexed imaging; decreased cross-talk with blue-light activated optogenetic actuators; decreased phototoxicity; and deeper tissue imaging.

In this seminar I will describe our most recent efforts to use protein engineering to make a new generation of GECIs with improved properties and an expanded range of potential applications. Specifically, I will present our latest efforts to engineer red, far-red, and near-infrared GECIs. In addition, I will describe our recent efforts to develop genetically encoded potassium ion (K+) indicators (GEKIs) for imaging of neural activity.

Symposium 5 Speaker 3:

Michael Z Lin
Associate Professor
Stanford University School of Medicine
Palo Alto, California, USA
mzlin@stanford.edu

The need for speed: kilohertz-rate voltage imaging in the nervous system

Information is conveyed and calculated in the nervous system through electrical impulses that are modulated with millisecond-level time resolution. To understand how individual neurons perform computations and how neuronal circuits represent and process information, it will be crucial to record transmembrane voltage in populations of neurons at high speed. Genetically encoded voltage indicators (GEVIs) are an emerging technology for achieving voltage recordings with single-cell resolution and genetic specification, but have historically been limited by slow or small responses and the technical difficulty of acquiring signals from multiple locations at high sampling rates. I will discuss recent progress in GEVI engineering and multiphoton microscopy methods that finally enable fast, sensitive, and long-term voltage imaging in the mammalian brain.

Symposium 5 Speaker 4:

Young-Gyun Park
Assistant Professor
Department of Bio and Brain Engineering, Korea Advanced Institute of Science and Technology (KAIST)
Daejeon, Korea
ygpark12@kaist.ac.kr

Demystifying brain network using 3D tissue profiling techniques

Brain function emerges from complex interactions among brain cells. Mapping brain network with structural and molecular details of individual cells is necessary to mechanistically understand brain functions and dysfunctions, however, it has been an unmet goal due to the complexity and heterogeneity of neural networks. I address this challenge by developing tools that allow holistic phenotyping of organs with subcellular resolution. SHIELD can preserve diverse biomolecules (fluorescence proteins, proteins, mRNAs) and cellular structures in transparent intact brains using multifunctional polyepoxide crosslinkers. Combining with its physically expandable nature, SHIELD tissue enabled high-resolution imaging of intact neural circuitry and resulted in a comprehensive structural and molecular diagram of neural network. eFLASH is a rapid (1day for whole mouse brain), cost-effective, and broadly applicable 3D immunostaining technique enabled by engineering antibody transport and antibody-antigen interactions. In this talk, I will introduce the tools and present neural network maps and novel biological findings enabled by my tools. I will also discuss their applications in fundamental and translational studies in brains and other biological systems.