School of Engineering Distinguished Workshop:
The Future of Health Technology in Modern Medicine

The Hong Kong University of Science and Technology

Date: 3 June 2024 (Monday)

ABSTRACT

Plenary Session

Genetically Encoded Bioorthogonal Chemistry in Living Systems

Prof. Peng CHEN

Peking University

Abstract

Employing small molecules or other chemical means to modulate the function of an intracellular protein of interest, particularly in a gain-of-function fashion, remains highly desired but challenging. In this talk, I will introduce a “genetically encoded chemical decaging” strategy that relies on our recently developed bioorthogonal cleavage reactions to control protein activation in living systems. These reactions exhibit high efficiency and low toxicity for decaging the chemically “masked” lysine or tyrosine residues on intracellular proteins, allowing the gain-of-function study of individual enzymes within living cells and mice. Most recently, with the assistance of computer-based design and screening, we further expanded our method from “precise decaging” of enzyme active-sites to “proximal decaging” of enzyme pockets. This new method, termed Computationally Aided and Genetically Encoded Proximal Decaging” (CAGE-prox) (CAGE-prox), showed general applicability for switching on the activity of a broad range of proteins under living conditions. I will end by showcasing exciting applications of our CAGE-prox technique on: i) constructing orthogonal and mutually exclusive kinase signaling cascades; ii) temporal caspase activation for time-resolved profiling of proteolytic events upon apoptosis; and iii) on-demand activation of bacterial effectors as potential protein prodrugs for cancer therapy. Finally, by coupling with the proximity-labeling enzymes that have been used for subcellular targeting, we further developed a spatial-temporal resolved proteomics strategy for subcellular proteome profiling in living cells.

About the Speaker

Dr. Peng Chen is currently Boya Distinguished Professor and Chair of Chemical Biology at Peking University. He obtained Ph.D with Prof. Chuan He at The University of Chicago and finished postdoctoral training with Prof. Peter Schultz at The Scripps Research Institute. He is also the Director of Chemical Biology Division at Chinese Chemical Society and the Executive Editor of ACS Chemical Biology.

His lab is a leading group in developing bioorthogonal cleavage reactions for chemical controlled protein activation and profiling in living systems. This has created a new direction in bioorthogonal chemistry for gain-of-function study of proteins under living conditions.

From Lab bench to the world: "Smart Photonics" for life saving diagnostics and biomarker discovery

Prof. Sunghoon KWON

Seoul National University

Abstract

In this plenary session, we will explore the transformative journey of academic research within engineering laboratories as it evolves into commercially viable products that serve medical doctors and life scientists. Our discussion will focus on three pivotal innovations: the diagnosis of sepsis, the synthesis of DNA, and advances in digital molecular pathology. We will delve into the role of AI-enhanced smart optical technologies and their impact on driving forward clinical and life sciences innovations. Additionally, I will highlight the competitive advantages of lab startups that are built on the foundation of robust, internationally competitive academic research.

About the Speaker

Dr. Sunghoon Kwon is a full professor of School of Electrical and Computer Engineering at Seoul National University. He is a founder and CEO of Quanta Matrix Inc, a company that productized life-saving microfluidic-based antibiotic test for sepsis. He is a full member of the National Academy of Engineering of Korea. He received many prestigious awards including the KAST Young Scientist Award, the Presidential Young Scientist Award, the IEEK/IEEE IT Young Engineer Award, and the NAEK Young Engineer Award. He has published over 100 papers in international journals holds more than 80 international patents.

Dynamical Systems Biology

Prof. Luonan CHEN

Chinese Academy of Sciences

Abstract

Professor Chen will present a new concept "Dynamical Systems Biology" for quantifying dynamical processes, disease progressions and various phenotypes, including dynamic network biomarkers (DNB) for early-warning signals of critical transitions, spatial-temporal information (STI) transformation for short-term time-series prediction, partial cross-mapping (PCM) for causal inference among variables, and further AI applications to medicine. These methods are all data-driven or model-free approaches but based on the theoretical frameworks of nonlinear dynamics. We show the principles and advantages of dynamical data-driven approaches for phenotype quantification as explicable, quantifiable, and generalizable. In particular, different from statistical data-science, dynamical data-science approaches exploit the essential features of dynamical systems in terms of data, e.g. strong fluctuations near a bifurcation point, low-dimensionality of a center manifold or an attractor, and phase-space reconstruction from a single variable by delay embedding theorem, and thus are able to provide different or additional information to the traditional approaches, i.e. statistics-based data science approaches. The dynamical data-science approaches for the quantifications of various phenotypes will further play an important role in the systematical research of various fields in biology and medicine.

About the Speaker

Prof. Luonan CHEN has obtained his B.S. degree in Electrical Engineering at Huazhong University of Science and Technology (Wuhan, China). He then graduated with M.E. and Ph.D. degree in Electrical Engineering at Tohoku University (Sendai, Japan). He was a professor in Osaka Sangyo University (Japan), Professor and Director of Institute of Systems Biology in Shanghai University (China) and Visiting Professor at the Department of Computer Science in University of California (USA). He is now a Professor and Executive Director of Key Laboratory of Systems Biology at Shanghai Institutes for Biological Sciences in Chinese Academy of Sciences and Chair Professor at Hangzhou Institute for Advanced Study in Chinese Academy of Sciences. He was elected as the founding president of Computational Systems Biology Society of OR China, and Chair of Technical Committee of Systems Biology at IEEE SMC Society. In recent years, he published over 400 journal papers and four monographs (books) in the area of bioinformatics, nonlinear dynamics and machine learning. Prof. Chen’s research interests include bioinformatics, computational biology, systems biology, machine learning and artificial intelligence.

Intelligent Imag-Activated Cell Sorting

Prof. Keisuke GODA

University of Tokyo

Abstract

A fundamental challenge of biology is to understand the vast heterogeneity of cells, particularly the link between their spatial architecture and physiological function. However, conventional technologies such as fluorescence-activated cell sorting and the Coulter counter fall short in revealing these connections. In this presentation, I will introduce Intelligent Image-Activated Cell Sorting, a groundbreaking technology that enables real-time, intelligent, image-based sorting of cells at an unprecedented rate of >1000 cells per second (Nitta et al, Cell 2018; Nitta et al, Nat. Commun. 2020; Mikami et al, Nat. Commun. 2020). This technology seamlessly integrates high-throughput optical imaging, cell focusing, cell sorting, and deep learning within a hybrid software-hardware data-management infrastructure. This integration facilitates real-time automated operations, including data acquisition, data processing, intelligent decision-making, and actuation. I will also present its novel applications across various fields such as immunology, cancer biology, infectious disease research, microbiology, and food science.

About the Speaker

Professor Keisuke Goda obtained a B.A. degree summa cum laude from the University of California, Berkeley in 2001 and a Ph.D. from Massachusetts Institute of Technology (MIT) in 2007, both in Physics.

Keisuke is currently a professor in the Department of Chemistry at the University of Tokyo, an adjunct professor in the Department of Bioengineering at University of California, Los Angeles (UCLA), and an adjunct professor in the Institute of Technological Sciences at Wuhan University. He joined the Department of Chemistry at the University of Tokyo as a professor in 2012. He then joined the Department of Electrical Engineering at UCLA as a postdoctoral researcher and program manager where he worked on laser-based ultrafast optical imaging and spectroscopy and microfluidic biotechnology in 2017. In 2019, he joined both the Department of Bioengineering at UCLA and the Institute of Technological Sciences at Wuhan University as an adjunct professor.

Keisuke is an expertise in Photonics, Biomedical Engineering, Analytical Chemistry and Medicine. His research group aims to develop serendipity-enabling technologies based on laser-based molecular imaging and spectroscopy together with microfluidics and computational analytics, using them to push the frontiers of human knowledge and medicine. From 2014 to 2019, he joined the “Planned Serendipity” program with ImPACT funded by the Cabinet Office, Government of Japan as a program manager, which developed the world’s first intelligent image-activated cell sorting (iIACS) technology. In 2019, he formed Serendipity Lab, a multi-continental open innovation platform with participants all over the world, including the US, Canada, Australia, China South Korea, Taiwan, Mexico, and Japan.

Keisuke has launched several startup companies. He is the Chief Scientific Officer of CYBO, which commercializes the developed technology to help researchers and medical doctors worldwide make new scientific discoveries and develop new therapeutic techniques. He is also the Chief Scientific Officer of LucasLand, which commercializes radically new types of chips for surface-enhanced Raman spectroscopy for healthcare applications.

Keisuke is a fellow of American Association for the Advancement of Science (AAAS), the Society of Photo-Optical Instrumentation Engineers (SPIE) and Royal Society of Chemistry (RSC). Keisuke received the 2017 Nobel Prize in Physics for detection of gravitational waves during his time in the Laser Interferometer Gravitational-Wave Observatory (LIGO) group, where he worked on the development of quantum-enhancement techniques, at MIT. He has also received many other awards, including the Konica Minolta Imaging Science Award (2013), MEXT Young Scientist Award (2014), Eiichi Takano Award (Japan Society of Applied Physics, 2018), Yomiuri God Medal (2019), MEXT Prize for Science and Technology (2020), SPIE Biophotonics Technology Innovator Award (2021) and Frontiers of Science Award (International Congress of Basic Science, 2023).