Stevens Institute of Technology

Nanotechnology Graduate Program

Multifunctional Biomolecular Optical Antennas: Toward Gene Regulation and Real-time Monitoring Enzyme Activity in Living Cells

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Our understanding of biological systems is increasingly dependent on our ability to visualize and measure the dynamics of biomolecules with high spatial and temporal resolution in a living cell. Current fluorescent microscopy requires fluorescent labeling steps. The electron microscope (EM) can resolve subcellular structures without labeling, but EM imaging damages living cells. Moreover, fluorescence and EM microscopy cannot provide spectroscopic information (i.e. chemical fingerprints). However, biophotonic optical antennas in living cells can receive incoming electromagnetic field from outside of cells and function as a nanoscopic localized light sources, as well as transmitting molecular spectrum and modulating gene regulations. As radio antennas were developed for wireless communication, optical antennas can provide solutions for concentrating optical radiation to dimensions less than the diffraction limit. Optical antenna-based Plasmonic Resonance Energy Transfer (PRET) nanospectroscopy offer stability, biocompatibility, selectivity, and spectroscopic imaging capability. Using intracellular optical antennas, we obtain snapshots of what we, metaphorically speaking, refer to as the Cellular Galaxy. In essence, the optical antennas are functioning as “nanosatellites” to capture the molecular imaging (i.e. electronic and vibrational spectrum) inside of cells and to transmit to outside of cells. For the remote control of gene regulation and therapeutic applications, we have developed Oligonucleotides on a Nanoplasmonic Carrier Optical Switch (ONCOS). ONCOS-based molecular optogenetics allow precision gene regulations by on-demand optical gene switches of antisense DNA or siRNA with nanometer-scale spatial resolution and localized temperature controls in living cells. The ONCOS and PRET are being applied for molecular/cellular diagnostics, therapeutic applications, and system biology since these multifunctional biomolecular optical antennas will provide us precise spatial and temporal controls of gene interferences and spectroscopic information of living cellular mechanism.

Prof. Luke P. Lee is Arnold and Barbara Silverman Distinguished Professor of Bioengineering, UC Berkeley. He is also Co-Director of Berkeley Sensor & Actuator Center. He received both his B.A. and Ph.D. from UC Berkeley. His current research interests are bionanoscience, biophotonics, molecular diagnostics, preventive personalized medicine, and Biologically-inspired Photonics-Optofluidics-Electronics Technology and Science (BioPOETS). Prof. Lee has authored and co-authored over 240 papers on single cell analysis, optofluidics, microfluidic cell biology, biotechnology, optical MEMS, BioMEMS, SERS, SQUIDs, and nanogap biosensor for label-free biomolecule detection. http://biopoets.berkeley.edu.

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