UNIVERSITY OF Southampton

Quantum Nanobiology and Applications in Healthcare

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University of Southampton

Luke P. Lee is Arnold and Barbara Silverman Distinguished Professor at UC Berkeley. He is also Co-Director of Berkeley Sensor & Actuator Center. He received both his BA and PhD from UC Berkeley. Prof. Lee has authored and co-authored numerous papers on biophotonics, nanoscale biophysics, single cell analysis, microfluidic quantitative cell biology, and biomedical devices. His current research interests are quantum nanobiology, integrative molecular diagnostics of infectious and neurodegenerative diseases, *in vitro* organogenesis, bioinspired neural interfaces, and solving both developed and developing countries healthcare challenges. http://biopoets.berkeley.edu

Abstract

It is critical time to solve the problems of both developed and developing countries healthcare challenges. In the first part of talk, I will present quantum nanobiology (i.e. *photonic gene regulation*) for the fundamental understanding of gene regulation in human cell biology and translational medicine. High-precision and selective remote controls of nanoscale *biophotonic optical antennas* allow real-time, noninvasive study of gene regulations in living cells. Since the abnormal NFκB signaling pathway has been associated in cancer, infectious diseases, inflammation, neurological diseases, and aging, we found a way to induce the spatiotemporal control of NF-κB regulatory circuitry by selective liberations of IκB siRNA and p65 siRNA from biophotonic optical antennas. By creating *biophotonic gene circuits*, the efficacy of multi-step bidirectional control of specific gene expression is demonstrated through the expression measurements of IP-10 and RANTES activated by nuclear p65. In addition, since alternative messenger RNA splicing is a fundamental process of gene regulation, and errors in RNA splicing are known to be associated with a variety of different diseases, we also demonstrated a quantitative method for monitoring mRNA splice variants in living cells using *biophotonic optical antennas*.

In the second part of talk, I will discuss the applications of quantum nanobiology (i.e. *photonic gene amplifications*) in *integrated molecular diagnostic systems* (*iMDx*) and *integrative microphysiological analysis platforms* (*iMAPs*) for human *organ functions on chips*. The *iMDx* comprises a self-contained sample preparation from whole blood, multiplexed protein assays, and ultrafast nucleic acid amplification assays on chip with a sample-to-answer readout platform. As we gain more insight into the genomic basis of pathogen infectivity and drug resistance, point-of-care nucleic acid testing with photonic gene amplifications will likely become an important tool for global healthcare in both developed and developing countries. I will also discuss the progress on patient-specific iPSCs-based iMAPs organs on chip with *photonic gene circuits* for personalized medicine. Q*uantum nanoscopes* might provide solutions for concentrating optical radiation to dimensions less than the diffraction limit and imaging electron transfer dynamics of enzymes by *Plasmonic Resonance Energy Transfer (PRET)* nanospectroscopy in living cells. The emerging iMAPs organ on chip technology with multiplexed molecular imaging capability has the potential to become an alternative to 2D and 3D cell cultures and animal models for experimental medicine, human disease modeling, drug development, and toxicology.