



Chemical Engineering

Spring 2024 Seminar Series

Talking to Cells: Biomolecular Engineering for Deep Tissue Imaging and Control of Cellular Function



Mikhail G. Shapiro, Ph.D.
California Institute of Technology

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66-110
3:00-4:00pm
2:45pm Reception

The study of biological function in intact organisms and the development of targeted cellular therapeutics necessitate methods to image and control cellular function *in vivo*. Technologies such as fluorescent proteins and optogenetics serve this purpose in small, translucent specimens, but are limited by the poor penetration of light into deeper tissues. In contrast, most non-invasive techniques such as ultrasound and magnetic resonance imaging – while based on energy forms that penetrate tissue effectively – are not effectively coupled to cellular function. Our work attempts to bridge this gap by engineering biomolecules with the appropriate physical properties to interact with magnetic fields and sound waves. In this talk, I will describe our recent development of biomolecular reporters and actuators for ultrasound. The reporters are based on gas vesicles – a unique class of gas-filled protein nanostructures from buoyant photosynthetic microbes. These proteins produce nonlinear scattering of sound waves, enabling their detection with ultrasound. I will describe our recent progress in understanding the biophysical and acoustic properties of these biomolecules, engineering their mechanics and targeting at the genetic level, developing methods to enhance their detection *in vivo*, expressing them heterologously as reporter genes, and turning them into dynamic sensors of intracellular molecular signals. In addition to their applications in imaging, gas vesicles can be used to control cellular location and function by serving as receivers of acoustic radiation force or seeding localized bubble cavitation. Additional remote control is provided by thermal bioswitches – biomolecules that provide switch-like control of gene expression in response to small changes in temperature. This allows us to use focused ultrasound to remote-control engineered cells *in vivo*.

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