Indian Institute of Science

Centre for BioSystems Science and Engineering

BSSE Seminar

4th November 2019 (Monday), 12:00 PM, CES Seminar Hall, 3rd floor, Biological Sciences Building

Natural and Engineered Biological Sensors: Visualizing Cellular Dynamics and Discoveries in Natural Light Sensing

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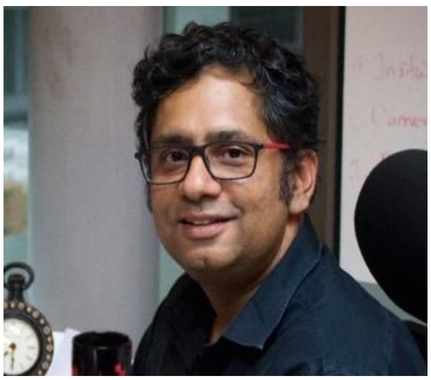
ABOUT THE SPEAKER



Dr. Akash Gulyani received his PhD in Chemical Sciences from the Indian Institute of Science, Bangalore and post-doctoral training at The Scripps Research Institute, San Diego and the Department of Pharmacology, University of North Carolina, Chapel Hill, US. Akash's work is highly interdisciplinary, and he has established a unique program on natural and engineered biosensors, spanning multiple facets of life sciences, chemistry, imaging and bioengineering. The Gulyani lab has pioneered several new biosensors for cellular dynamics. His group has also made major new discoveries in the area of natural light sensing, establishing completely new lines of inquiries using simple flatworm model organisms (work covered by major international publications like NY Times, The Atlantic and New Scientist). A recent work won the 2018 Cell Press-TNQ award for the best paper in life sciences in India. He has also been awarded the American Heart Fellowship and an award for excellence in mentorship by the University of North Carolina, US. He has received multiple national and international grants.

ABSTRACT

I will present our multidisciplinary approach of devising new measurements, sensing dynamics across scales and exploring new natural biosensors for basic biology and health. Often, cellular outputs are controlled not by protein levels but local protein activity. For this, we have pioneered fluorescent biosensors that directly recognize 'active' states of signaling proteins in live cells and tissues (*Mukherjee-Gulyani et al manuscript in review; BioRxiv https://doi.org/10.1101/726133*; *Gulyani et al Nature Chemical Biology 2011*). Our approach is general and compatible with microscopy readouts like FRET and fluorescence lifetime imaging (FLIM) and multi-color ratio imaging. A new biosensor for a specific Src family kinase (Fyn) reveals how signaling activity can be spatially compartmentalized, show oscillations over time and subject to localized signal integration between integrins and growth factor receptors. For mapping cell states, we have also developed new mitochondrial sensors. Currently, live imaging of mitochondrial activity relies on measuring mitochondrial potential, but this has significant drawbacks. To address this gap, we have developed new bright, highly stable chemical probes that sense changes in the local micro-environment, activity and the state of the mitochondria, with high spatial and temporal resolution (*US and India Patent pending, Raja-Gulyani et al 2017, Gulyani lab manuscripts 2019*). These probes offer a platform to study mitochondrial dysfunction in cellular models of human disease. Our search for new sensing systems has led us back to nature. I will showcase our recent ground-breaking discoveries on how organisms can sense and process light itself. We have established a new sensory paradigm wherein 'colorblind' worms are able to 'sense' small changes in light wavelengths ('colors') and completely switch their behavior (*Shettigar-Gulyani et al Science Advances 2017*). This is a fascinating example of organisms with very simple eyes and 'early brains' showing acute gradient sensing coupled to binary processing. Since flatworms regenerate, natural light sensing itself can now be used to assay for molecular mechanisms underpinning *functional* eye-brain regeneration. We can essentially watch how an ability to 'compute' recovers in a simple sensory network. Further, we have ALSO uncovered extraordinary new mechanisms through which simple organisms can sense light *independent* of their eyes. This has led to discovery of new light sensing proteins (molecular switches), unique photoreceptor cells and delocalized but functional neural networks. This has radical implications in evolution of light sensing in nature, human health, biomimetic devices and novel optogenetics.