ASU Department of Physics
Arizona State University

COLLOQUIUM

Thursday, November 16, 2023

Refreshments at 3:15pm outside PSF 101
Colloquium from 3:30pm - 4:30pm in PSF 101

Wiring Cells: Control of Microbial Behavior using Protein Nanowires for Environmental & Human Health

Associate Professor Nikhil Malvankar
Yale University

Abstract:

How can we monitor and control the growth and colonization of microbes deep inside the Earth and in human cells? This ability is central to understanding basic microbial function in their native environment with various applications such as reducing microbial methane emissions and treating multi-drug-resistant bacteria. Controlling microbial growth is challenging. Established optogenetics and fluorescent proteins have limited use in studying microbial communities due to their low penetration depth and inability to work in anoxic environments. Directing electrons derived from metabolism is an ideal tool to control microbial growth because all life processes are driven by electrons. However, proteins and cell surfaces are non-conductors. To bridge this gap, **we are studying proteins that allow microbial growth to be imaged and controlled with electrons**. This work is enabled by our discovery that microbes use chains of heme or aromatic moieties to export electrons to partner or host cells. This allows microbes to switch metabolism to respiration, and promote growth and colonization, without oxygen-like soluble electron acceptors. We found that microbes use intracellular pili as a switch to secrete nanowires and overexpress nanowire genes by sensing natural E-fields, allowing electronic control of gene expression Together, electron-conducting proteins and electrogenetics are the **electronic analogs of GFP and optogenetics.**

We hope to lay a foundation for far-reaching benefits to basic research as well as environmental and human health. To realize this vision, we are identifying mechanisms of nanowire biosynthesis, redox regulation for metabolic reprogramming, conductivity, and interaction partners that charge nanowires. The ability to wire any microbe and electronically control metabolism, communication, and host-colonization stands to reduce methane emissions that contribute to climate change and deliver treatments that prevent the adhesion of or outcompete microbes to defeat infectious diseases. I will focus on three aspects:

1. FUNDAMENTAL ADVANCES: Elucidating how bacteria assemble and use nanowires. Understanding nanowire synthesis for reconstitution & Defining ultrafast conductivity mechanism.

2. ENVIRONMENTAL HEALTH: Controlling electron exchange in microbes to lower atmospheric methane and thus, global temperatures by understanding interspecies nanowire connections.

3. HUMAN HEALTH. Control bacterial metabolic switching and host colonization via nanowires to develop antibiotics and probiotics by disrupting and accelerating electron export respectively.

Biography:

Nikhil is fascinated by how electrons move in nature-made and human-made systems. He worked on how electrons move in superconductors during his PhD in UMass which helped him to study electrons moving in living biofilms and protein nanowires. During his postdoc, he learnt structural biology and is now working on structures, functions, and electron transfer mechanisms of microbial nanowires.

Host: Prof. Rizal Hariadi
View our Fall 2023 Physics Colloquium schedule at https://physics.asu.edu/colloquia