Physics
AT QUEENS COLLEGE

Colloquium Notice

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How do bacteria use quantum effects to respire without oxygen? Protein nanowires as spin polarizers with ultrafast electron transport

Cells compute with chemistry and semiconductors compute with transistors – but both operate by controlling the flow of electrons. Biochemistry typically allows electron flow in proteins only over a few nanometers, whereas semiconductors use wires that can conduct quickly over long distances. What if cells have designed biomolecules that behave like wires? To breathe, living cells typically use soluble, membrane-ingestible molecules, like oxygen, to dispose of electrons generated during metabolism. But, we have found that to "breathe" in deep ocean and underground anoxic environments, soil bacteria, Geobacter have evolved nanowires to export electrons to extracellular acceptors that could be hundreds of cell lengths away.

I will present our recent discoveries that solve a longstanding mystery of how nanowires move electrons to soil minerals or help generate electricity. By correlating cryo-electron microscopy with multimodal functional imaging and a suite of electrical, biochemical and physiological studies, we find that nanowires are made up of polymerized cytochrome proteins that transport electrons via seamless stacking of metal-containing heme molecules over micrometer distances (Cell 2019, Nature Chem.Bio. 2020, Nature 2021). As metalloproteins were not known to polymerize, the discovery of these cytochrome nanowires opens an entirely new field for the development of next-generation living bioelectronics. My recent experimental studies on individual nanowires show inherent spin polarization and the highest electronic conductivity reported on proteins (> 100 S/cm with ultrafast electron transfer rate of ~200 fs). Computational studies suggest that quantum coherent transport accounts for the high conductivity of these nanowires. Identifying the role of quantum effects in these processes will help understand, predict, and ultimately control extracellular electron transfer by protein nanowires used by diverse environmentally important microbes to capture, convert and store energy. Moreover, cytochrome nanowires acting as Biocompatible Quantum Probes at room temperature will enable a route to engineer quantum technologies based on biology.

Note: Room C203

Wednesday
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Starts at **12:00 pm**
SB C203

This talk is accessible via **Zoom** or use
meeting ID 829 2687 2594 and **passcode 866995** to join