Biomaterials Plenary Session
Room A120-121 - Session BP-SuA

Biomaterials Interfaces Plenary (ALL INVITED SESSION)
Moderator: Caitlin Howell, University of Maine

3:00pm **BP-SuA-1 Microbial Electron Conduits: Adventures at the Biotic-Abiotic Interface***, **Mohamed El-Naggar**,* University of Southern California **INVITED**

Electron Transfer (ET) is the stuff of life. The stepwise movement of electrons within and between molecules dictates all biological energy conversion strategies. With such a universal role across all domains of life, the fundamentals of ET and its precise impact on bioenergetics have received considerable attention, and the broad mechanisms allowing ET over small length scales in biomolecules are now well appreciated.

In what has become an established pattern, however, our planet's oldest and most versatile organisms are now challenging our current state of knowledge. With the discovery of bacterial nanowires, conductive biofilms, and multicellular bacterial cables, the length scales of microbial ET observations have jumped by 7 orders of magnitude, from nanometers to centimeters, during the last decade alone! This talk will take stock of where we are and where we are heading as we come to grips with the basic mechanisms and immense implications of microbial long-distance electron transport. We will focus on the biophysical and structural basis of long-distance, fast, extracellular electron transport by metal-reducing bacteria. These remarkable organisms have evolved direct charge transfer mechanisms to abiotic surfaces, allowing them to use abundant minerals as electron acceptors for respiration, instead of oxygen or other soluble oxidants that would normally diffuse inside cells. From a technological perspective, microbial extracellular electron transport is heavily pursued for interfacing redox reactions to electrodes in renewable energy technologies.

But how can an organism transfer electrons to a surface many cell lengths away? What molecules mediate this transport? And, from a physics standpoint, what are the relevant length, time, and energy scales? We will describe new experimental and computational approaches that revealed how bacteria organize heme networks on outer cell membranes, and along quasi-one-dimensional filaments known as bacterial nanowires, to facilitate long-range charge transport. Using electron cryo-tomography, *in vivo* fluorescent microscopy, and single molecule tracking, we are gaining new insight into the distribution of multiheme cytochromes along membranes. In addition, we will examine the fundamental limits of extracellular electron transport, down to single molecules and energy acquisition by individual cells. These findings are shedding light on one of the earliest forms of respiration on Earth while unraveling surprising biotic-abiotic interactions.

3:40pm **BP-SuA-3 Conductive Biofilms As Living Electronic Materials***, **Sarah Glaven**,* U.S. Naval Research Laboratory*; L Bird, E Onderko,* National Research Council*; D Phillips, R Mickol,* American Society for Engineering Education*; A Malanoski, M Yates, B Eddie,* U.S. Naval Research Laboratory **INVITED**

Natural living conductive biofilms transport electrons between electrodes and cells, as well as among cells fixed within the film, catalyzing an array of reactions from acetate oxidation to CO_2reduction. Synthetic biology offers tools to modify or improve electron transport through biofilms, creating a new class of engineered living conductive materials. However, these applications are currently limited by a lack of understanding of the physiological constraints of the host bacterium (chassis) to properly and predictably express and orient electron transfer (ET) proteins (e.g. *c*-type cytochromes) in the cell membrane, the ability to rapidly screen a large number of constructs for different ET pathways, and a library of operationally relevant chassis strains. In this talk I will describe results demonstrating the use of a suite of highly-optimized small molecule sensors (Marionette) developed for control over *E. coli*cellular processes and used here to control expression of the *Shewanella*MtrCAB pathway, and accessory electron carriers, in *Marinobacter atlanticus*. Marionette sensors were transformed into *M. atlanticus*and assessed for expression of yellow fluorescent protein (YFP) after the addition of 7 different small molecules (choline, vanillin, naringenin, DAPG, cumate, tetracycline, and IPTG) during both planktonic growth and in biofilms. A broad dynamic range of YFP expression was observed similar to that demonstrated with *E. coli.* When YFP was replaced with ET proteins, expression of MtrCAB led to an increase in current compared to the wild type strain when induced prior to inoculation into a bioelectrochemical system (BES). However, the effect was not robust. Moving the MtrCAB pathway from a plasmid construct to the chromosome enabled more control over the quantity of protein expressed, however, no improvement in current was observed. Based on these results, we conclude that the MtrCAB pathway can be successfully expressed in *M. atlanticus*and requires further optimization for reliable biofilm based ET. Engineered living conductive materials could be used in a range of applications for which traditional conducting polymers are not appropriate including improved catalytic coatings for microbial fuel cell electrodes, self-powered sensors for austere environments, and next-generation living components of bioelectronic devices that interact with the human microbiome.

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