Temperature dependency of long range electron transport in microbial biofilms

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Certain microorganisms are able to transport electrons resulting from intracellular metabolic processes to extracellular insoluble terminal electron acceptors, providing a distinct metabolic niche in oxidant scarce environments. For example, *Geobacter sulfurreducens* can utilize a conductive surface as an electron acceptor to form a multi-cell thick biofilm able to conduct electrons originating from intracellular metabolic processes to the underlying electrode surface over large distances (10s of microns) - challenging long held notions that electron transfer (ET) in biological systems is limited to molecular length scales.

Two mechanisms have been proposed to explain ET occurring through electrode-grown *G. sulfurreducens* biofilms: coherent metallic-like conductivity similar to that of organic semiconductors and incoherent redox conductivity similar to that of redox polymers. Many studies have implicated one or the other mechanism. However, none have examined the effect of temperature on electrical conductivity for living biofilms. Temperature is an experimentally tractable parameter that clearly distinguishes between the two proposed mechanisms: metallic-like conduction predicts that biofilm conductivity should decrease with increasing temperature whereas redox conduction predicts the opposite trend. Here we show that the electrical conductivity of living, electrode-grown *G. sulfurreducens* biofilms decreases with decreasing temperature. The dependency follows the Arrhenius rate expression, with an activation energy of 0.13 ± 0.03 eV and reorganizational energy of 0.52 eV. These values are consistent with the reorganization energies for self-exchange ET reactions between hemes of the *c*-type cytochromes known to be critical for extracellular ET by metal-reducing bacteria.