Mechanisms of Methanogenic Electron Uptake from Electrodes. A. Rowe[1,2], S. Xu[1], P. Girguis[3], Jan Amend[2], Mohamed El-Naggar[1], [1]Department of Physics and Astronomy, University of Southern California, [2] Department of Earth Sciences, University of Southern California, [3]Department of Organismic and Evolutionary Biology, Harvard University.

Introduction: Syntrophic interactions are a hallmark of anaerobic microbial food webs. They often entail a metabolic partnership that facilitates the consumption of substrates that are not metabolized by the un-partnered species alone. The mechanistic nature of these partnerships, especially in environmental systems, has been widely debated [1]. Syntrophic species have been cultured that utilize diffusible intermediates, such as hydrogen, formate, and/or acetate suggesting microbes can share these intermediates. However, these molecules pose challenges for efficient electron transfer between cells including: mass transfer/rate limitations, the challenge/necessity for proximity between partners, and the potential loss of metabolites due to competition and/or diffusion. Recently, more "direct" electron transfer (or hydrogen independent) mechanisms have been highlighted in several anaerobic communities including carbon-degrading [2], methanogenic [3], and methane oxidizing partnerships [4, 5]. Though the modes of electron transfer in the electron donating partner have been implicated in several cases [3, 5], the mechanisms of electron acquisition by the electron accepting metabolic partners remain unknown.

Methanosarcina barkeri in an important model system for understanding energy conservation in methanogens, as it is genetically tractable, and utilizes a wide range of substrates from methanogenesis. It has also been shown to receive electrons from electrochemical active Geobacter metallireducens when grown in consortia [3], making it an ideal model organism for studying syntrophic electron uptake. Using cathodes as electron donors, we have confirmed the ability of M. barkeri to enhance cathodic current, or electron uptake from solid surfaces, while generating methane. We are presently investigating the mechanism of this electron uptake, including recently proposed ideas that extracellular secreted enzymes (e.g. hydrogenase) can facilitate cathodic EET to other methanogens [6]. We demonstrate that a hydrogenase deletion mutant can also facilitate cathodic electron uptake, coupled to methane production. However, the total yields for current and methane are dramatically reduced (near 10-fold reduction), suggesting that multiple modes of electron uptake (i.e., hydrogenase, and non-hydrogenase mediated) are functioning in methanogen electrochemical systems. Our current work is focusing on developing electrochemical tests to resolve the different mechanisms at play, as well as understanding their biophysical basis.

References:

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