The Spatial Relationship to Metabolic Activity in Syntrophic Communities

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The majority of cells on the planet interact with other cells, and describing the types and effects of these interactions is a core goal of microbiology. Spatial proximity is thought to be a major contributor of cell-to-cell activity relationships, especially in low energy or nutrient limited regimes. However, measuring the activities of individual cells and relating this to spatial structure is challenging. Furthermore, interpreting the physiological "meaning" of any observed spatio-metabolic relationships is made difficult by the diversity of metabolic interactions found in nature.

Multispecies microbial consortia that carry out the anaerobic oxidation of methane (AOM) are premier examples of growth permitting metabolic coupling that may have spatial constraints. As observed through FISH-SIMS (Fluorescence In-Situ Hybridization coupled with Secondary Ion Mass Spectrometry), uptake of a general activity isotope reporter ($^{15}NH_4^+$) showed *intra*-consortia variability of cellular activity amongst phylogenetically identified cells. Aggregate structure and distance between microbial partners are observed to be contributors to single cell metabolic activity within consortia. Between individual cells, anabolic activity rates varied, yet were strongly correlated between neighboring members within a population, as well as between symbiotic partners. Surprisingly, the summed anabolic activity of an individual aggregate does not appear to be a function of spatial structure (*i.e.* segregated or well mixed), suggesting that environmentally derived resources are differentially partitioned within co-associated populations based on the geometry of cell-cell interactions. Using modeling approaches, the metabolic consequences of various symbiotic interactions are being tested to shed light on how both physiological, and spatial arrangement could produce the observed activity relationships. These investigations help us understand the metabolic landscape in AOM consortia, and also provide direction for the investigation of structured microbiological communities at-large, be they antagonistic, competitive, mutualistic, or engineered.