71. Understanding microbial carbon cycling in soils using novel metabolomics approaches

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http://www.northenlab.org/research/biological-soil-crusts-biocrusts/

Project Goals: The Department of Energy has made major investments in soil sequencing efforts that have the potential to revolutionize predictive models of soil nutrient cycling. Yet we lack vital data to link sequence data to metabolic transformations in soils. This program aims to help bridge this gap by pioneering new soil metabolomics approaches that link microbial community structure to soil organic matter dynamics.

The organic matter that is cycled by soil microbes is a complex mixture of metabolites derived primarily from microbes, plant exudates and decomposing plant litter. It has a major impact on community structure since microbes may be both stimulated or inhibited by specific soil metabolite concentrations. Therefore, understanding soil metabolite composition and utilization by microbes would provide critical insights into how microbial communities are shaped and how, in turn, they shape soil metabolite composition.

Using tractable desert biological soil crust microbial communities (biocrusts) we take advantage of the cascades of microbial activities that follow wetting of dry soil to correlate soil metabolite composition and turnover to active microbes. These biocrusts are communities of organisms inhabiting the upper layer of soil in arid environments. They persist in a desiccated dormant state for extended periods of time and experience pulsed periods of activity facilitated by infrequent rainfall. Microcoleus vaginatus, a non-diazotrophic filamentous cyanobacterium, is an early pioneer in colonizing arid environments and key primary producer in early successional biocrusts. Metabolic interactions among biocrust microorganisms are poorly understood yet presumably play a key role in determining the community dynamics and cycling of carbon and nitrogen. This talk will describe our initial studies aimed at systematically deconstructing the metabolic foodwebs within these biocrusts. We have developed liquid chromatography tandem mass spectrometry soil metabolomic methods which we have used to characterize hundreds of metabolites from soils including many novel compounds. Exometabolite profiling of spent vs. fresh media is being used to link the uptake or release of these metabolites to specific bacterial isolates from biocrust. From this we find that Microcoleus vaginatus releases a broad range of metabolites. Many of these metabolites are found to be uptaken up by heterotrophs but there were surprisingly few metabolites uptaken by all soil bacteria. This points to a competition for a small set of central metabolites and specialization of individual heterotrophs towards a diverse pool of available organic nutrients. Overall, this initial study indicates that understanding the substrate specialization of biological soil crust bacteria can help link community structure to nutrient cycling.

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