Ph.D. Defense in Biochemistry

Mackenzie Morgan Lynes

Thursday, July 6 at 1:00 pm in the Byker Auditorium

"Distribution, Diversity, and Physiology of Uncultured MCR-encoding Microbial Populations in Yellowstone Hot Springs."

Abstract: Methane, a climate active gas, is an integral component to the global carbon cycle. Microbial activity mediates the transformations of carbon, with methanogenic archaea driving the conversion of organic matter to methane in anoxic environments. Understanding the distribution and activity of methanogenic archaea is essential for estimating their contribution to the carbon cycle and global methane emissions. In the last decade, metagenomic sequencing has expedited the formulation of hypotheses regarding archaea classified outside of established methanogenic lineages, which possess genes responsible for methane production. However, the verification of these hypotheses is often hindered by the difficulties encountered in culturing these organisms. Additionally, these organisms often encode other energy conserving pathways, thus underscoring the necessity for experimental validation of their metabolism.

This dissertation is dedicated to exploring the diversity and physiology of methanogenic populations in hot springs of Yellowstone National Park beginning with the collection of primary data from previously uncharacterized geothermal features. To date, this has resulted in the most extensive geochemical and microbiological survey conducted within the Yellowstone geothermal complex. This dataset served as a foundational basis for investigating uncultured methanogenic lineages and their activities in geothermal environments. Through the integration of amplicon sequencing, metagenomics, and mesocosm experiments, the presence and diversity of methanogenic communities in hot springs was revealed and novel lineages were stimulated under methanogenic conditions, resulting in their enrichment. This study emphasizes the impact able to be achieved by combining environmental metagenomics with laboratory-based experiments.

To further explore the methanogenic potential revealed by these experiments, our focus shifted towards enriching a novel methanogenic lineage. Through our efforts, we were successful in cultivating the first methanogenic member of the family Archaeoglobaceae, providing genomic and transcriptomic evidence to validate its ability to live as a methyl-reducing methanogen, reducing methylamines to methane. Comprehensively, the work presented here broadens our understanding of methanogenic communities in Yellowstone National Park and contributes to the broader understanding of methanogenesis in geothermal environments.

Graduate Committee

- Dr. Roland Hatzenpichler (Research Advisor)
- Dr. Brian Bothner (Chemistry and Biochemistry)
- Dr. Mark Young (Chemistry and Biochemistry)

- Dr. Tim McDermott (Land Resources and Environmental Sciences)

Publications

- Lynes, M.M., Krukenberg, V., Jay, Z.J., Kohtz, A.J., Gobrogge, C.A., Spietz, R.L., Hatzenpichler, R. "Diversity and function of methyl-coenzyme M reductase-encoding archaea in Yellowstone hot springs revealed by metagenomics and mesocosm experiments" ISME Communications. March 22, 2023.
- Wiegand, T., Wilkinson, R., Santiago-Frangos, A., Lynes, M.M., Hatzenpichler, R., Wiedenheft, B. "Functional and Phylogenetic Diversity of Cas10 Proteins" The CRISPR Journal. March 13, 2023.
- Kohtz, A.J., Jay, Z.J., Lynes, M.M., Krukenberg, V., Hatzenpichler, R. "Culexarchaeia, a novel archaeal class of anaerobic generalists inhabiting geothermal environments" ISME Communications. September 20, 2022.
- Gionfriddo, C.M., Wymore, A.M., Jones, D.S., Wilpiszeski, R.L., Lynes, M.M., Christensen, G.A., Soren, A., Gilmour, C.C., Podar, M., Elias, D.A. "An improved hgcAB primer set and direct high-throughput sequencing expand Hg-methylator diversity in nature" Frontiers in Microbiology. October 6, 2020.

Manuscripts in Preparation

- Lynes, M.M., Jay, Z.J., Kohtz, A.J., Hatzenpichler, R. "Methyl-reducing methanogenesis in Archaeoglobi: Cultivation of Ca. Methanoglobus hypatiae from a Yellowstone hot spring" Submission 2023.
- Lynes, M.M., Jay, Z.J., Gobrogge, C.A., Hatzenpichler, R. "Exploring the geochemical and microbial diversity of 100 geothermal features in Yellowstone National Park" Preparation 2023.

After Graduation: I am committed to pursuing a meaningful career in industry, dedicated to developing and advocating for microbial solutions that benefit the environment and society in a sustainable way.