

Marine Biological Laboratory (MBL) – Workshop on Molecular Evolution, Woods Hole, MA
NASA Astrobiology Early Career Collaboration Award Report

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The MBL Workshop on Molecular Evolution, directed by Joseph Bielawski (Dalhousie University) and Mark Holder (University of Kansas), is an annual and highly regarded summer workshop offering intensive training in molecular evolution and evolutionary genomics. My purpose for attending was to learn new statistical and computational tools for application towards my research on ancient nitrogenase enzymes, as well as to network with peers and leading scientists in the field of molecular evolution.

My research centers on the deep history of nitrogenases and their connection to the ancient geochemical record of nitrogen fixation. Nitrogenase is the only enzyme that is capable of transforming (or “fixing”) atmospheric sources of nitrogen into essential, biologically useable compounds, and its ancestry may extend through more than 3 billion years of molecular evolution. Because nitrogenase is a crucial enzymatic component of the biosphere, our understanding of its evolutionary history is tied to our general understanding of the co-evolution of life and the physicochemical environment, both on Earth and potentially on other worlds. This work incorporates the computational reconstruction of ancestral nitrogenase sequences, as well as their synthesis and experimental characterization related to preserved isotopic biosignatures in the rock record. It was my goal to obtain a foundational knowledge and skillset of phylogenetic and ancestral sequence reconstruction methods that would underpin my successful experimental investigations of ancient nitrogenases.

The workshop was organized as a series of lectures on topics that included basic phylogenetic principles, population and comparative genomics, adaptive protein evolution, and divergence time estimation. In addition, computer laboratory sessions allowed participants to gain hands-on experience in commonly used and sophisticated software tools, typically taught by the authors of the software themselves. During free time, other participants and I were able to have productive one-on-one conversations with faculty regarding individual research topics, as well as other important aspects of scholarship and collaboration. I particularly benefited from lectures and conversations with Joseph Bielawski and Belinda Chang concerning natural selection pressure, adaptive protein evolution, and experimental analysis of reconstructed ancestral proteins. Labs on PAML (Joseph Bielawski), RAxML & Garli (Emily Jane McTavish), and IQ-TREE (Bui Quang Minh) software were enormously useful, and gave me the experience and confidence to independently apply these tools to my nitrogenase research.

I have left this workshop with the necessary knowledge of evolutionary and phylogenetic principles and mentorship to conduct my investigations on ancient nitrogenases and the

geochemical record of nitrogen fixation. My experience was truly transformative, and I would highly recommend that early career scientists associated with the NASA Astrobiology Institute attend. I can see the relevance of many astrobiology-related topics that utilize genomic data, including experimental evolution, origins and biological complexity, paleobiology, and geomicrobiology. I'm incredibly appreciative of the NASA Astrobiology Program and the Early Career Collaboration Award organizers for this opportunity to attend the MBL Workshop on Molecular Evolution.



Paul Lewis teaches the basics of maximum likelihood phylogenetics.



Workshop participants listen intently to a lecture on phylogenomics.



MBL Workshop on Molecular Evolution, Class of 2018.