Pacific Northwest NATIONAL LABORATORY

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PNNL's Microbial Communities Initiative is a 5-year, $9.25 million investment to understand the complex world of microbes—bacteria, Archaea, algae and fungi—and the communities in which they live. The goal of research within the MCI is to provide:

- Novel transforming technologies to "see the world that microbes see"
- Understanding of mechanistic forces driving microbial communities
- Models for analyzing microbial communities that allow prediction and, ultimately, controlled manipulation to address DOE missions.

At the completion of the MCI, we expect to have a set of integrated technologies that drive environmental science to a mechanistic understanding of microbial communities at the microscale.

U.S. DEPARTMENT OF ENERGY

Achieving a Predictive Understanding of Microbial Communities

THE CHALLENGE

The United States faces a series of critical problems related to the production and consumption of energy and the resulting environmental consequences. Solutions include:

- Sustainable bioenergy and bioprocessing
- Assessment of climate change impact and adaptation
- Strategies for carbon sequestration
- Cost-effective cleanup technologies.

In the past two decades, application of new technologies has given scientists deeper insights into the critical role that microbes play in the ecosystem and as catalysts in solving these problems. A key role is carbon cycling, which is a critical element of understanding and predicting climate change.

MICROBIAL COMMUNITIES ARE COMPLEX ADAPTIVE SYSTEMS

Microorganisms in natural or engineered ecosystems rarely live alone, but instead function as integrated units—or communities—that process energy and materials and thereby impact their environment.

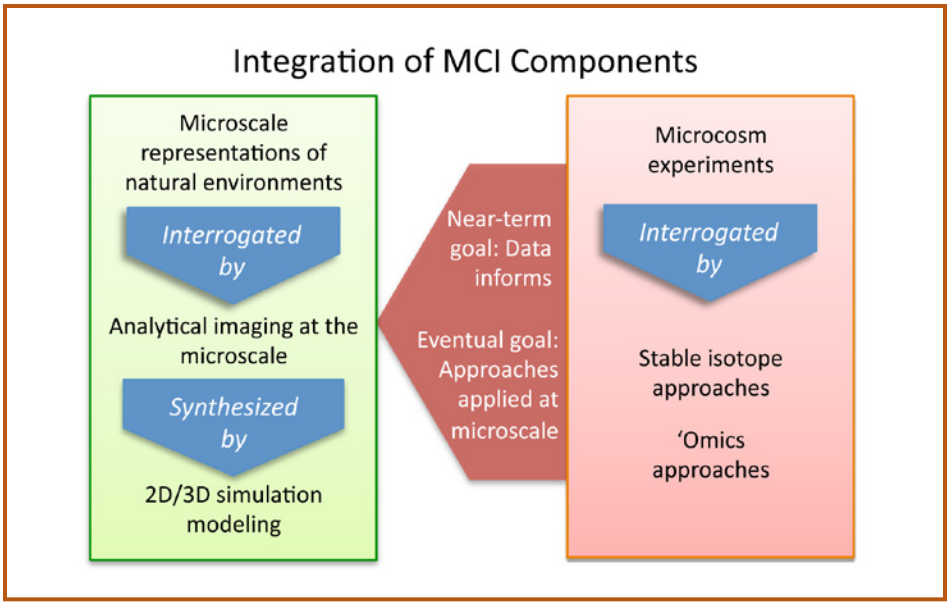
Despite their importance, we know little about microbial community function and behavior. As a result, we have little ability to predict changes in microbial community dynamics during either natural cycles of change or environmental perturbations—such as climate change or exposure to pollutants.

MICROBIAL COMMUNITIES INITIATIVE: UNDERSTANDING MICROBIAL COMMUNITY INTERACTIONS AT THE MICROSCALE

The Microbial Communities Initiative, or MCI, is a 5-year investment by Pacific Northwest National Laboratory that focuses on understanding microbial community interactions at the fundamental scale at which they occur—the microscale (<100 microns).

The goal is to create transforming technologies, clarify mechanisms and develop theoretical frameworks for analyzing and predicting the behavior of microbial communities. To do this, our researchers will integrate biological and ecological experimentation, analytical chemistry and simulation modeling.

Because these interactions occur at the microscale, our science questions and associated capabilities and technologies are largely focused on making measurements at or near the scale of single cells. This focus requires significant technology development and its specific application to community-level ecological questions.



Within the Microbial Communities Initiative, experiments at the microcosm—or representative system—level will provide valuable data for developing models and technologies that will further understanding of microbial communities at the microscale.

TRANSFORMING TECHNOLOGIES

The transforming technologies developed by the MCI are ones that enable:

- Analysis at a spatial scale of microns
- Analysis of individual cell properties related to material and energy flux rates and environmental stress responses
- Movement of genomic/proteomic technologies from a descriptive to functionally predictive level.

FOCUS AREAS

The MCI consists of three Focus Areas:

- **Microengineering and Microanalytics** – This focus area addresses the capacity to measure the chemical environment, distribution, and activity of microbes at the microscale, as well as coupling biogeochemical reaction rate analyses to specific identification of the microbes responsible for those biogeochemical transformations.
- **Simulation Modeling** – This focus area aspires to develop novel simulation models that represent the biological diversity of microbial communities as well as the physical and chemical heterogeneities of natural environments at the microscale.
- **Extending Genomics & Proteomics to Quantitative Functional Analyses** – This focus area will develop techniques to apply these technologies to address community ecology questions; in particular, the analysis of functional redundancy in microbial communities.

LEVERAGING PNNL'S STRENGTHS

The MCI leverages:

- PNNL's longstanding expertise in examining environmentally relevant microbes using a systems biology approach
- Our significant strengths in subsurface science, microbiology, fungal genomics, microscale analytics and simulation modeling
- Capabilities within the Environmental Molecular Sciences Laboratory (EMSL), many of which can be applied and modified to address key scientific questions in microbial community ecology.

ABOUT PNNL

Pacific Northwest National Laboratory is a Department of Energy Office of Science national laboratory where interdisciplinary teams advance science and technology and deliver solutions to America's most intractable problems in energy, national security and the environment. PNNL employs 4,250 staff, has a $918 million annual budget, and has been managed by Ohio-based Battelle since the lab's inception in 1965.

For more information about the Microbial Communities Initiative, contact:

Allan Konopka, Ph.D.
Pacific Northwest National Laboratory
Phone: (509) 371-6950
E-mail: allan.konopka@pnl.gov
http://www.pnl.gov/biology/research/mci/

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