

MCI Newsletter: 1st quarter FY 2011

MCI Newsletter, Issue 3, November 2010

Message from the Director:

ISME-13: Microbes – Stewards of a Changing Planet
August 22 – 27, 2010 Seattle, Washington

A major event for microbial communities research in the Pacific Northwest took place in Seattle during the third week of August. The International Society for Microbial Ecology's 13th Symposium was attended by more than 2000 scientists. The meeting had a broad international flavor – 55 countries were represented. Scientists from North America and Europe comprised about 75% of attendees, but Asian attendance continues to increase as the field of microbial ecology grows in South Korea and China, to build upon a long-term strong presence in Japan. The growth in Asia has been recognized by the Society, and the 2014 meeting will be held in Seoul, South Korea (in 2012, ISME-14 will be convened in Copenhagen, Denmark). The organization of ISME-13 had a strong PNNL connection – Jim Fredrickson was chair of the local organizing committee and Allan Konopka was co-chair.

Jim and I were very pleased to see the high quality of the scientific contributions and the enthusiastic response of the attendees to the science. The set of 7 plenary lectures were outstanding – they reflected different strands of research in microbial ecology, but the lecturers did an excellent job of connecting with the broad audience. In the September 2010 issue of the ISME Journal (nature.com/ismej/journal/v4/n9/index.html), there are a set of commentaries written by the scientists who delivered the plenary lectures. The contributed sessions covered the very broad swath of microbial ecology at a variety of scales – from micron-scale microbial interactions in biofilms or with plant or animal hosts, to global-scale feedbacks between microbial biogeochemical cycles and climate. Terry Hazen from Lawrence Berkeley National Laboratory organized a late-breaking session that presented results on microbial activities resulting from this summer's Deepwater Horizon oil spill in the Gulf of Mexico.

PNNL research was well represented at ISME-13, both from projects within the Microbial Communities Initiative (see presentations section below for complete list) and work emanating from DOE OBER programs within the Subsurface Biogeochemical Research and Genome Sciences Programs. The symposium was a great opportunity for PNNL scientists to connect with a broad international network of scientists in the field of microbial ecology. Topic areas that had a very high level of contribution at the meeting included biogeochemistry, engineered environments & biodegradation, application of molecular methods to community analysis, and plant-microbe interactions. Innovations in pushing analysis to smaller physical scales and to single cells were the subject of several focused sessions, and these developments are well in line with the objectives of MCI.

S&T Highlights:

When your project hits a major milestone, discovery, or other ‘nugget’, please draft a brief highlight and send it to Allan Konopka. There is no specific format but include a technical description, why the item is important (Scientific American level), who should care, and an image/graphic. The LDRD Office is periodically asked for material about PNNL’s LDRD portfolio. Highlights will serve as an ‘index card’ or starting point; if/when the LDRD office uses it, they will get back to the PI and/or Initiative leadership to tailor the highlight to the request the LDRD office has received

Project Updates:

In July 2010, a new project was initiated titled “Advancing the use of microfluidic models for studying microbial communities: Integration of microfluidic model experimentation, multimodal imaging, and modeling”. The project is summarized by co-PI Mike Wilkins in the Feature Article section of this newsletter.

A 7-month project, “Proof-of-Principle Demonstration of Fluorescence Labeling of Cellulose and Microscopic Fluorescence Imaging of Cellulose Degradation” ended on September 30. However, that project’s scope continues in the microfluidic model experimentation project listed above.

MCI Reviews- Highlights and Information:

Advisory Committee Annual Initiative Review- July 28th -29th, 2010

The report from the MCI Advisory Committee was overwhelmingly positive and complementary to all of you who are doing the research within this initiative. They were particularly struck with how well-integrated the group was, in that scientists from different disciplines understood the perspectives of their colleagues very well.

We made the argument that the initiative had been planned, reviewed and the scientists had made good progress on their projects during the first year, that augured continued success. The advisory committee agreed with all of this.

One suggestion made by the advisory committee was that "project team members should now begin to identify and pursue relevant scientific questions and hypotheses that can be investigated with the emerging tools in the near term. This will offer researchers to become familiar with the benefits and limitations of the technologies before they are applied to more complex experiments." That is, can you identify intermediate scientific questions (low hanging fruit) that can be answered on the way to your ultimate goal, that can lead in the short run to significant publications that impact science questions. Please keep this in mind as you go forward on your projects for FY11.

There will not be a mid-year review in FY11. The next full review will take place in summer 2011.

Upcoming Events:

Mini-Symposium: Vanessa Bailey and Mike Wilkins are organizing a mini-symposium to be held at PNNL in early 2011. The one-day symposium will consist of invited external and internal speakers. The tentative theme for the mini-symposium is “Beyond the Batch Culture: Physical and Biological Structure of Microbial Communities”.

Meetings and Conferences:

Below is a broad cross-section of MCI-relevant meetings and conferences. MCI PIs and/or co-PIs are encouraged to use project funds to attend a meeting or conference that they normally would not attend.

December 13-17, 2010. American Geophysical Union (AGU) Fall Meeting. Moscone Convention Center, San Francisco, CA.

<http://www.agu.org/meetings/>

January 30 - February 4, 2011. Geobiology. Ventura Beach Marriott, Ventura, CA.

<http://www.grc.org/programs.aspx?year=2011&program=geobiology>

March 25-30, 2011. Keystone Meeting on Microbial Communities: Microbial Communities as Drivers of Ecosystem Complexity. Beaver Run Resort, Breckenridge, CO.

<http://www.keystonesymposia.org/Meetings/ViewMeetings.cfm?MeetingID=1059>

April 27-May 5, 2011. Ecology of Soil Microorganisms: Microbes as Important Drivers of Soil Processes, Top Hotel and Conference Center, Prague, Czech Republic.

http://www.biologicals.cz/conferences/index.php?conference_id=7

May 21-24, 2011. American Society for Microbiology 111th General Meeting, New Orleans, LA.

<http://www.asm.org/index.php/meetings/general-meeting.html>

May 29 – June 2nd, 2011. Bacterial Genetics and Ecology: 11th Conference on Bacterial Genetics and Ecology, BAGECO11. Corfu, Greece.

<http://www.bageco11.org/>

June 26 - 30, 2011. 4th Congress of European Microbiologists FEMS 2011: Advancing Knowledge on Microbes. Geneva, Switzerland.

<http://www2.kenes.com/fems2011/Pages/Home.aspx>

July 10-15, 2011. Applied & Environmental Microbiology: Functional Interactions from Molecules to Biomes. Mount Holyoke College, South Hadley, MA

<http://www.grc.org/programs.aspx?year=2011&program=applied>

July 10-15, 2011. Ecological & Evolutionary Genomics. University of New England, Biddeford, ME

<http://www.grc.org/programs.aspx?year=2011&program=ecolevo>

July 17-21, 2011. Enzymes in the Environment: The 4th International Conference. Bad Nauheim, Germany.

<http://oarc.osu.edu/ee2011>

Jul 17-22, 2011. Microbial Population Biology. Proctor Academy, Andover NH.

<http://www.grc.org/programs.aspx?year=2011&program=mircpop>

August 7 -11, 2011. Microscopy Microanalysis, Nashville, TN

<http://www.microscopy.org/MandM/2011/index.cfm>

August 14 – 19, 2011. Goldschmidt 2011. Prague Congress Centre, Prague, Czech Republic.

<http://www.goldschmidt2011.org/>

MCI Seminars:

MCI will again be sponsoring a seminar series in FY2011. The series is currently in draft form. Information will be sent out soon with speaker names and tentative dates- stay tuned.

Past Seminars

- ***Tuesday, September 8th, 2009***- Dr. Michael Kuhl, University of Copenhagen. “Planar Optode Research”
- ***Friday, December 4th, 2009***- Dr. Doraiswami Ramkrishna, Purdue University. “The Metabolic Modeling Landscape”
- ***Thursday, February 4th, 2010***- Dr. Pieter Visscher, University of Connecticut. “Microbial Interactions in Saltern Microbial Mats”
- ***Monday, April 19th, 2010***- Dr. Bruce Hungate, University of Northern Arizona. “From the Globe to the Cell and Back: Microbial Biogeochemistry in a Changing World”
- ***Tuesday, June 8th, 2010***- Dr. Cameron Currie, University of Wisconsin-Madison/Great Lakes Bioenergy Research Center. “Leaf Cutter Ant Microbial Community”

Presentations:

Callister SJ, MJ Wilkins, AT Wright, BL LaMarche, BK Ahring, MS Lipton, and A Konopka. 2010. “Proteomics Measurements of Functional Redundancy and Stability Testing of Cellulose Degrading Microbial Communities within Engineered Bioreactors.” International Symposium on Microbial Ecology- ISME 13, Seattle, WA. PNNL-SA-71886

Hess NJ, SJ Fansler, D Hu, and VL Bailey. 2010. "Discrimination of Microorganisms using Surface-Enhanced Raman Spectroscopy." International Symposium on Microbial Ecology- ISME 13, Seattle, WA. PNNL-SA-71793.

LaMarche BL, SJ Callister, AR Shah, AT Wright, MJ Wilkins, ME Monroe, KL Crowell, GA Anderson, and RD Smith. 2010. "A mathematical approach for reference selection in high throughput proteomics." Abstract submitted to American Society for Mass Spectrometry, Salt Lake City, UT. PNNL-SA-70704.

McCue LA, VL Bailey, SJ Fansler and AE Konopka. 2010. “Community Diversity in Individual Soil Aggregates.” International Symposium on Microbial Ecology- ISME 13, Seattle, WA. PNNL-SA-71780.

Moran JJ, MK Newburn, ML Alexander and HW Kreuzer-Martin. 2010. “Spatially Resolved Stable Isotope Analysis at the Microbial Community Level.” International Symposium on Microbial Ecology- ISME 13, Seattle, WA. PNNL-SA-71778.

Proposals:

In order to have adequate access to EMSL’s high-end microscopes, an EMSL User proposal was written. The proposal was in the top 10% of proposals received, so we have a large block of instrument time in support of the new microfluidic model experimentation project.

Publications:

Moran JJ, MK Newburn, ML Alexander, HW Kreuzer. “Laser ablation isotope ratio mass spectrometry for enhanced sensitivity and spatial resolution in stable isotope analysis.” Submitted to Rapid Communications in Mass Spectrometry

MCI Feature Article:
Mike Wilkins, LDRD Co-PI

Advancing the use of microfluidic models for studying microbial communities: Integration of microfluidic model experimentation, multimodal imaging, and modeling

The microbial breakdown of cellulose and related by-products is a key process in the global carbon (C) cycle (figure 1). Cellulose is a primary structural component of plants, and the most common organic compound on Earth. Estimates suggest that annually over 10^{11} tons of cellulose is synthesized by plants, and subsequently degraded by microorganisms. In soil environments, this cellulosic material provides a carbon and energy source to many heterotrophic microorganisms, which in turn produce CO_2 via respiratory processes. While this CO_2 production may seem insignificant on a local scale, this globally accounts for the release of between 75-100 billion metric tons of C on an annual basis. It is clear therefore that a greater understanding of the factors and processes controlling the temporal and spatial dynamics of soil microbial respiration is necessary for addressing issues related to (i) climate change, (ii) modeling Earth systems, and (iii) land use policy.

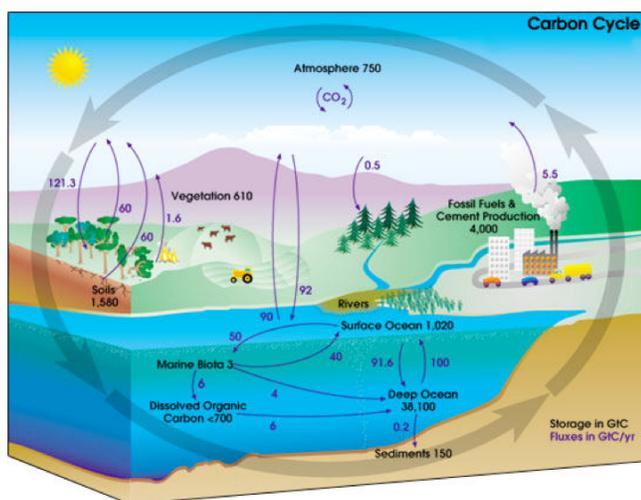
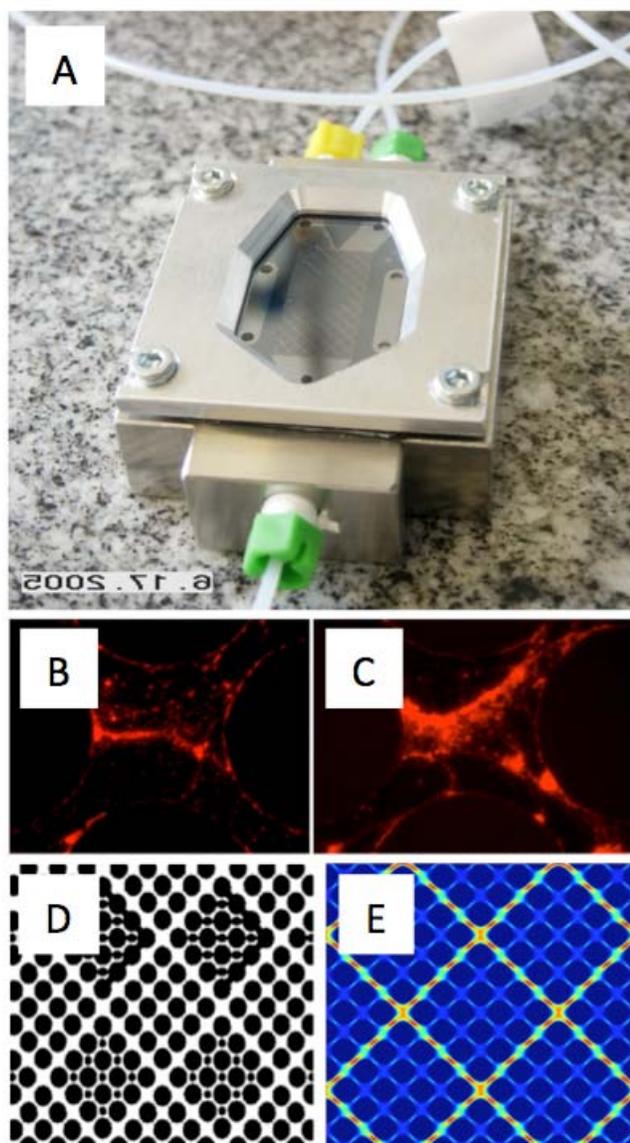


Figure 1. Schematic of the global carbon cycle, illustrating the relatively high C content within soils, and the associated flux of C to the atmosphere as CO_2

Within soil systems, the microbial processes that drive cellulose degradation and CO_2 production occur within pore spaces, where a range of advective and diffusive transport processes supply biomass with nutrients, O_2 (in the case of aerobic systems), and remove the products of microbial respiration and growth. Experimental investigations utilizing microcosms, mesocosms, or even field experiments do not allow for the study of these processes at the pore-scale. To achieve this level of resolution, this MCI project is utilizing microfluidic models (“micromodels”) as structures for studying pore-scale microbe-cellulose interactions via a range of novel non-destructive imaging-based technologies. Micromodels consist of a series of pillars and channels etched into a substrate that simulate networks of pores and channels in soil environments (see figure 2 A). A variety of pore structures will be utilized within these microfluidic models to obtain both advection-dominated and diffusion-dominated regions (figure 2 E and D respectively). A number of technical challenges present themselves within the project; cellulose films must be created within the micromodel for cellulose-degrading bacteria to act upon. Work is ongoing to optimize techniques that allow the deposition of cellulose films in the pore spaces, and non-destructive imaging to quantify cellulose degradation. Currently, microcrystalline Avicel has been successfully introduced into the micromodels. As the cellulose film is degraded, a corresponding decrease in intensity of its natural fluorescence should be observed. Fluorescently tagged nanocrystalline cellulose thin films are also being developed which, in combination with highly advanced imaging approaches, should enable more sensitive imaging of cellulose degradation. Cellulose imaging will be carried out in conjunction with a novel optode-based O_2 sensor for determining O_2 concentrations within the micromodel. We anticipate that as cellulose breakdown proceeds in the pore spaces, certain regions

(such as diffusion dominated regions) may become O₂-limited. By coupling O₂ readings to measurements of the remaining cellulose, we aim to determine the effects of geochemical heterogeneity on C cycling.



Initial experiments will aim to grow one or two cellulose-degrading bacterial strains in the micromodels. These initial proof-of-concept experiments will attempt to integrate the technologies being developed for detection of cellulose degradation and O₂ utilization. In addition, a range of novel approaches will be deployed for monitoring biomass accumulation within the pore spaces of the micromodel, including the use of Raman spectroscopy, and fluorescently-labeled bacterial strains. Following the successful demonstration of these technologies, more complex cellulose-degrading communities will be introduced into the models. Ultimately, the aim of this research is to interrogate ecological concepts associated with cellulose degradation in a heterogeneous pore-scale system. The spatial distribution of cellulose films within these micromodels will allow resource island hypotheses to be investigated, while microbial niche concepts will be inferred from growth patterns. Data from these studies can then be integrated into modeling efforts being carried out as part of another MCI project.

Figure 2. (A) Microfluidic model, (B,C) Growth within pore spaces by a fluorescently-tagged bacterium, (D) Model design illustrating dead-end pores where diffusion-dominated processes will occur, (E) Flow velocity within a model design.

Coming Soon!
MCI Wiki Site

<https://microbialcommunities.pnl.gov>

We will send out more info on the newly released MCI Wiki Site soon