Biological Systems Science Division Update

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Update Outline

- Completed Programmatic Actions
- New Notices
- Significant Activities
- Division Science Highlights
Programmatic Activities

FY2012 Reviews of DOE National Laboratory programs – Completed

- Bioenergy Research Centers
  - BioEnergy Science Center (Oak Ridge, TN) Oct. 31 – Nov. 1
  - Great Lakes Bioenergy Research Center (Madison, WI) Nov. 8-9
  - Joint BioEnergy Institute (Emeryville, CA) Dec. 11-12

Upcoming Science Focus Area (SFA) Triennial Reviews in FY2013

- Biofuels Research
  - Pacific Northwest National Laboratory - Feb 27
- Radiochemistry & Imaging
  - Lawrence Berkeley National Laboratory - TBD
  - Oak Ridge National Laboratory – TBD

2013 Genomic Science Program Annual PI Meeting

- Bethesda North Marriott Hotel (February 25-27) - Next week!
New Notices

Plant Feedstocks Genomics for Bioenergy: A Joint Research Funding Opportunity Announcement USDA, DOE (DE-FOA-0000770)
- Issued November 20, 2012
- Pre-apps due December 18, 2012
- Full applications due February 25, 2013

Systems Biology Enabled Research on the Role of Microbial Communities in Carbon Cycling (DE-FOA-0000866)
- Issued February 1, 2013
- Pre-apps due March 4, 2013
- Full applications due April 19, 2013

Subject to FY2013 Availability of Funds
Significant Activities

Joint Call for Exploratory Collaborations

- **First-ever call between EMSL and DOE-JGI**
- **Focused on plant, fungal, soil and microbial interactions and physiology related to**
  - Biofuel production
  - Carbon cycling
- **Must require capabilities from both facilities**
- **Schedule:**
  - Letters of Intent due February 11 – April 8
  - Invited full proposals due May 27
  - Approved proposals start October 1, 2013
  - Details: [http://www.emsl.pnl.gov/access/calls/jgi/](http://www.emsl.pnl.gov/access/calls/jgi/)
Through a series of Talks, Demonstration and Tutorials the KBase team will illustrate early functionality of KBase including:

- Large Scale Integrated Gene Regulatory and Metabolic Capabilities in KBase
- Functional Characterization of Adaptive Variation in Plants
- Capabilities to integrate, search and visualize experimental data and existing models within the KBase environment
- Capabilities to integrate your own research methods into the KBase environment
- Vision, Progress and Longer term objective will also be discussed
Bioenergy Research Centers (BRCs)
2012 Annual Reviews

Significant progress towards understanding:
- Sustainability of bioenergy crop production
- Plant metabolism and techniques to decrease biomass recalcitrance
- Pretreatment methods to increase the efficiency of cellulose extraction
- Enhanced enzymatic methods to produce sugars from cellulose
- Modifications to microorganisms to combine conversion capabilities, tolerate biofuel production conditions and produce a range of biofuel compounds

As of the last review the BRCs have generated:
1100 journal articles,
286 Invention disclosures
146 patent applications
**Nanoscale Architecture of Plant Cell Walls Determines Their Accessibility and Digestibility by Enzymes**

**Objective:** Understand enzymatic digestion of biomass during pretreatment processes

**Approach:** Researchers at National Renewable Energy Laboratory conducted real-time in situ imaging of the action of two commercially-relevant enzyme systems (i.e., bacterial cellulosomes and fungal cellulases) on biomass under controlled digestion conditions across 10 nm to 10 µm length-scales.

**Results/Impact:** Imaging reveals different mechanisms of enzymatic breakdown of biomass. Fungal enzymes penetrate into the cell wall, resulting in fast digestibility, large cellulosomes digest the cell wall from the surface. Lignin physically hinders the accessibility of polysaccharides in the cell wall to enzymes.

Ideal pretreatments should maximize lignin removal and minimize polysaccharide modification thereby retaining the essentially native microfibrillar structure and improving accessibility.

Making the best biofuel-producing microbes identify themselves

**Objective:**
Develop a generalized approach to screen or select microbes with improved small-molecule biosynthesis capabilities involved in biofuel production.

**Approach:**
- JBEI researchers developed transcription factor-based biosensors for desired small-molecules and coupled these sensors with the expression of a gene that confers a selection advantage to the microbe (e.g. resistance to the antibiotic tetracycline)
- Plasmids for the biosynthesis of a desired molecule, such as butanol, were then introduced and thus microbial growth rate was directly linked to the production of specific biofuel products.

**Results/Impact:**
This approach facilitates the selection of microbial strains that produce large quantities of any small molecule, an important step toward the development of renewable biofuels.

**Objective:**
In the design and bioengineering of metabolic pathways it is important to understand and eventually manipulate the movement of atoms in these biochemical reactions.

**Approach:**
- A new computational system (Minimum Weighted Edit-Distance or MWED) allows researchers to map the flow of atoms in biochemical reactions.
- MWED relies on predicting the propensity of forming or breaking chemical bonds during a biochemical reaction and optimizes all possible solutions to the reactions of interest.

**Results/Impact:**
2,446 manually curated biochemical reactions from the KEGG database were fully mapped with an error rate of 0.9, offering scientists an extremely fast and highly accurate method to model the movement of all atoms in biochemical reactions.

**Genomic Science Program Highlights**

**Discovery of New Types of Nitrous Oxide (N$_2$O) Consuming Bacteria**

**Objective:**
Models of the soil nitrogen cycle predict that more of the greenhouse gas N$_2$O should be produced than is actually observed. Why is this?

**Approach:**
Use comparative genomics to identify new types N$_2$O-consuming bacteria and search for them in soil environments.

**Results/Impact:**
A novel metabolic pathway for N$_2$O consumption was identified in the soil bacterium *Anaeromyxobacter dehalogenes*. Genes of this pathway were detected in soil samples and appear to be associated with other common soil microbes as well. These organisms may represent the missing “sink” for N$_2$O in soil ecosystems.

**Objective**
Understand how archaeal flagella (archaella) assemble and cause movement by identifying essential components and modeling how they come together.

**Approach**
Study the ATPase enzyme Flal in *Sulfolobus acidocaldarius*. Obtain its structure in solution using Small Angle X-ray Scattering (SAXS) and build models using crystal structures of the enzyme interacting with other key elements of the archaella. Determine which portions of Flal are involved in assembly and which are involved in motion.

**Results/Impacts**
“Overall, collective results reveal detailed and global Flal activities in transducing nucleotide binding and hydrolysis into translational and rotatory motions suitable for assembly and motility without destabilizing the integrity of the hexameric crown assembly”

Low Dose Science Highlight

Low dose radiation-induced epigenetic alterations in the A\textsuperscript{vy} yellow agouti mouse model

- Irradiation of pregnant mouse mothers in gestational day 4 increased methylation of agouti gene in the offspring
- DNA sequence of the A\textsuperscript{vy} gene locus was not altered
- Larger numbers of offspring were darker brown as a function of dose, with concomitant better health
- Anti-oxidant supplementation of mouse mothers reduced locus methylation, and the ratio of brown/yellow mice to near control levels
- Conclusion: In this isogenic mouse model, low dose-induced epigenetic changes play a role in radiation hormesis

Selected JGI Publications – Feb. 2013


JGI Publication Highlights: [http://www.jgi.doe.gov/News/pubs.html](http://www.jgi.doe.gov/News/pubs.html)
Systems science to meet DOE mission needs in bioenergy, climate and the environment.

http://science.energy.gov/ber

Thank you!

http://genomicscience.energy.gov