

# ***2018 Genomic Sciences Program Annual PI Meeting***

**Todd Anderson, Ph.D.**

Director, Biological Systems Science Division,  
Department of Energy, Office of Biological &  
Environmental Research

February 26, 2018



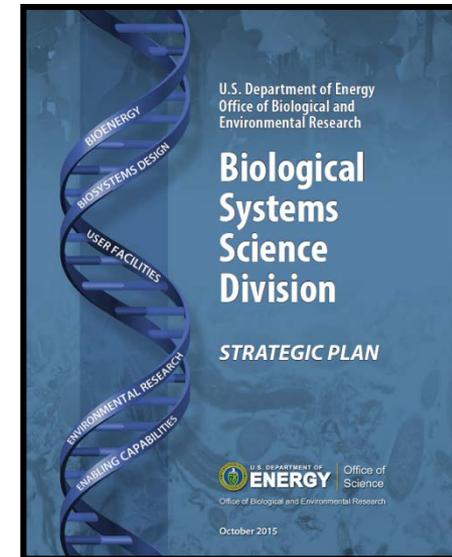
U.S. DEPARTMENT OF  
**ENERGY**

Office  
of Science

Office of Biological  
and Environmental Research

# Biological Systems Science Division

**Overarching Goal:** Provide the necessary fundamental science to understand, predict, manipulate, and design biological processes that underpin innovations for bioenergy and bioproduct production and to enhance the understanding of natural environmental processes relevant to DOE.



# New Bioenergy Research Centers

*Multidisciplinary fundamental science guided by milestones & deliverables, targeted to key areas needed to improve production of biofuels from renewable biomass.*

- **Center for Bioenergy Innovation (CBI)**  
Oak Ridge National Laboratory (<https://cbi.ornl.gov/>)



- **Great Lakes Bioenergy Research Center (GLBRC)**  
University of Wisconsin, Michigan State University (<https://www.glbrc.org/>)



- **Joint BioEnergy Institute (JBEI)**  
Lawrence Berkeley National Laboratory (<https://www.jbei.org/>)



- **Center for Advanced Bioenergy and Bioproducts Innovation (CABBI)**  
University of Illinois (UIUC) (<https://cabbi.bio/>)



Sustainability



Feedstock



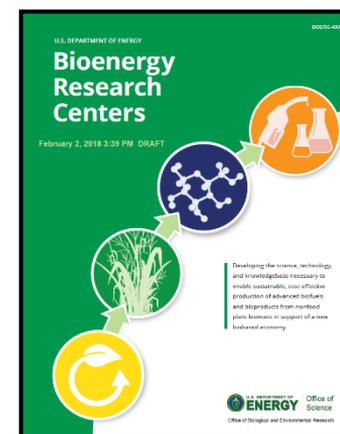
Biomass



Conversion  
biofuels &  
bioproducts

Development Deconstruction

<https://genomicscience.energy.gov/index.shtml>

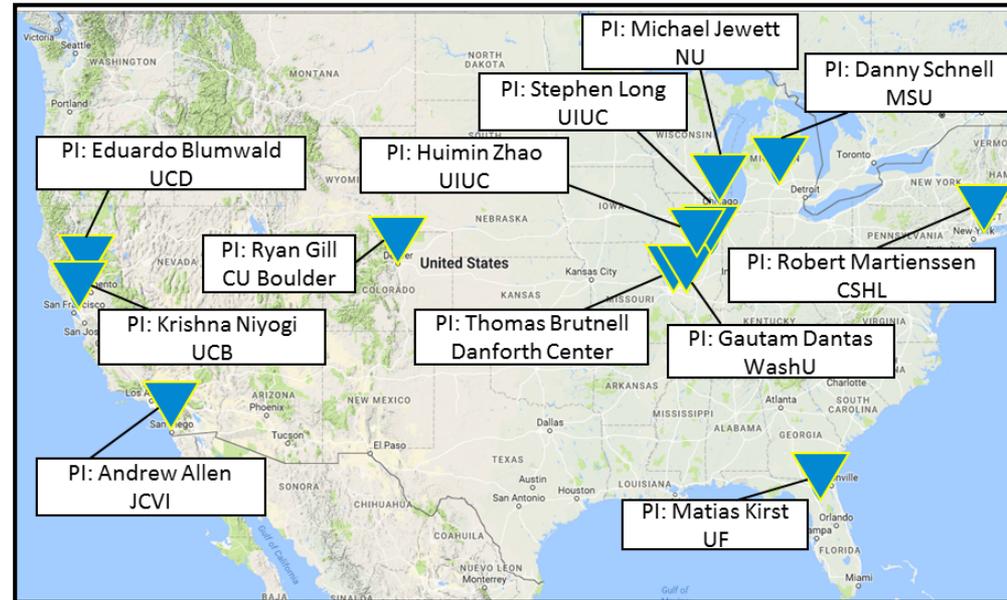


# New Biosystems Design Awards

Biosystems Design to Enable Next-Generation Biofuels and Bioproducts (DE-FOA-0001650)

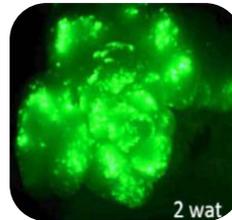
## Expands BER's Plant Biosystems Design Portfolio:

- Transitioning from model plants such as *Arabidopsis* and *Setaria* to *Camelina* and sorghum
- New efforts in energy cane and an aquatic monocot (duckweed)
- Targeting nitrogen fixation via engineering symbiosis
- Increased water use and photosynthetic efficiency
- Engineering oil production in stems and leaves



## ...And Microbial Biosystems Design Portfolio:

- New non-model yeasts that produce oils and organic acids
- Expanding genome-scale design and engineering to diatoms and green algae
- Developing *in vivo* and cell-free microbial bioprocessing systems
- Computer-aided design and high throughput re-combineering in model and non-model microorganisms



# *New Plant Feedstock Genomics Awards*

## *Plant Feedstock Genomics for Bioenergy: A Joint Research Funding Opportunity Announcement USDA, DOE (DE-FOA-0001688)*

**J. LeBoldus** (Oregon St.) *Towards durable resistance to Septoria stem canker and leaf spot: A molecular understanding of resistance*

**R. Bart** (Danforth Center) *Optimizing tradeoffs implicit during bioenergy crop improvement: Understanding the effect of altered cell wall and sugar content on sorghum-associated pathogenic bacteria*

**E. Eisenstein** (Univ. Maryland) *Elucidating Mechanisms of Rust Pathogenesis for Engineering Resistance in Poplar*

**D. Lowry** (Michigan St.) *Identification of Adaptive Fungal Pathogen Resistance Loci in Switchgrass*

**J. Sedbrook** (Illinois St.) *Advancing field pennycress as a new oilseed biofuels feedstock that does not require new land commitments*

**L. Comai** (UC Davis) *Discovery and characterization of dosage-dependent disease resistance loci in biomass poplar*

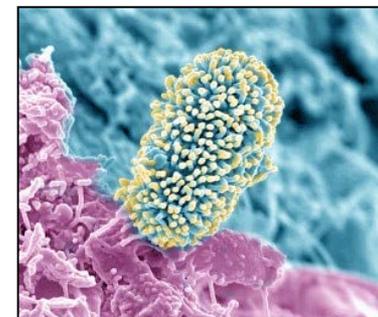


## *New Microbiome Research efforts at the DOE Labs*

*Los Alamos National Laboratory*

*Pacific Northwest National Laboratory*

*Lawrence Livermore National Laboratory*



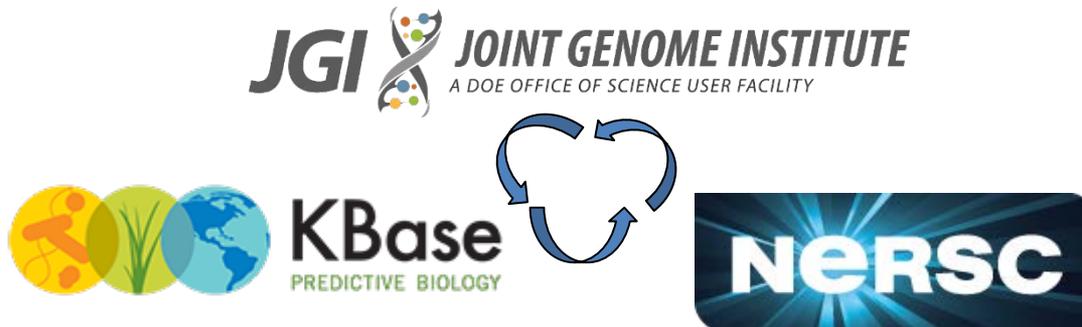
# *Integrative Capabilities Among User Facilities*

## ***New Joint User Facility Calls***

- *JGI and EMSL (Latest FICUS Call <https://jgi.doe.gov/>)*
- *JGI and NERSC Microbiome Data Science*
- *New Joint efforts between NSLS-II at BNL and the Neutron Sources at ORNL*
  - *Combining X-ray and neutron techniques*
- *New capabilities in KBase*
  - *Breakouts and workshops at this meeting*

## ***Closer Collaboration between KBase, the Joint Genome Institute (JGI) and NERSC***

- *Towards a common open-source, open-access IT infrastructure structure for bioinformatics and computational biology.*



# New Funding Opportunities for FY 2018

## **Plant Feedstock Genomics for Bioenergy: A Joint Research Funding Opportunity Announcement** **USDA, DOE (DE-FOA-0001857)**

- Plant genes/alleles that influence plant responses to pathogens.
- Plant genes/alleles that influence agronomic, yield, and quality traits of non-food oilseed crops

## **Systems Biology of Bioenergy-Relevant Microbes to Enable Production of Next-Generation Biofuels and Bioproducts** **(DE-FOA-0001865)**

- Emerging model microorganisms and/or microbial communities.
- Novel microbial functional capabilities and biosynthetic pathways.

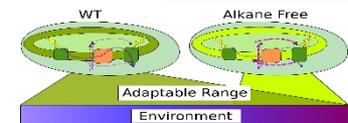
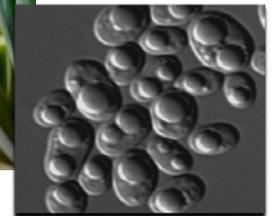
## **Bioimaging Research and Approaches for Bioenergy** **Funding Opportunity Number (DE-FOA-0001868 )**

- Development of new, innovative and/or significantly improved instrumentation and imaging approaches for BER research.

**And....**

## **Early Career Research Program Funding Opportunity** **Number: DE-FOA-0001761**

- Systems-Level Design and Engineering of Microbial or Plant Systems for the Production of Biofuels and Bioproducts



# Bioimaging Research PI Meeting

(February 28 – March 1, 2018 – Ash Grove Ballroom)

**Bioimaging and measurement technologies to characterize, visualize and integrate multiple cellular processes needed to gain a more predictive understanding of complex biological processes**

- Raman imaging and correlative electron microscopy
- Integrated mesoscale imaging techniques
- Chemical imaging techniques
- Dynamic multispectroscopic techniques
- Multifunctional plasmonics nanoprobes
- Soil sensors and experimental systems

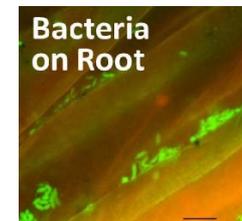
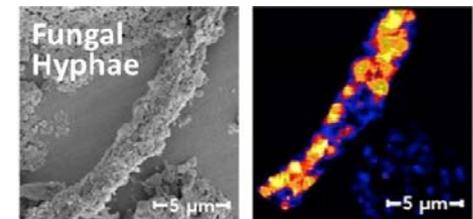
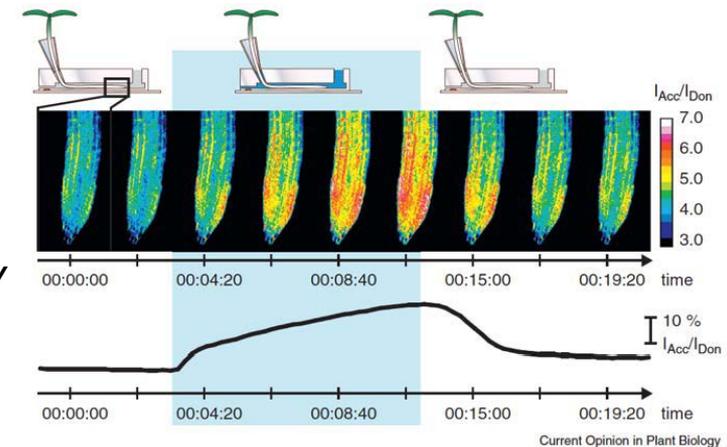
## Keynote Speakers

Wed. 1:30 – 2:30PM

**Dr. Na Ji** (UC Berkeley) – “Advanced Fluorescence Microscopy for Opaque Samples”

Thurs. 9:30 – 10:30 AM

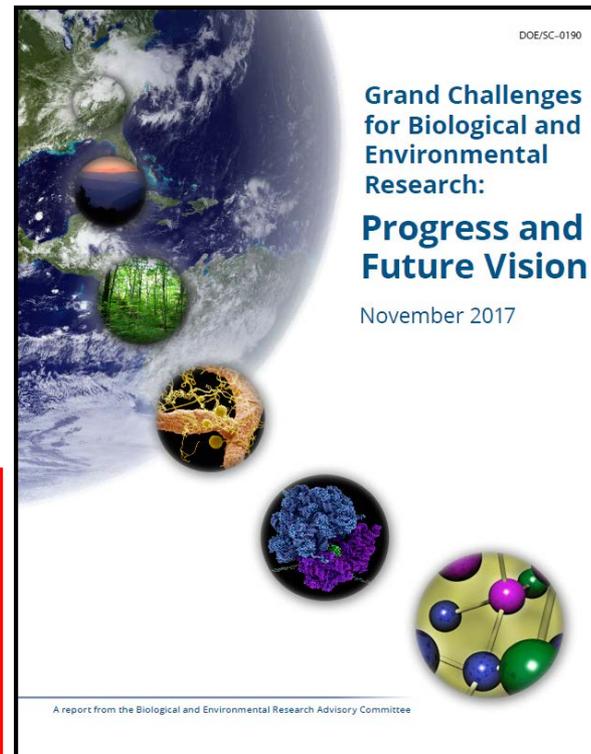
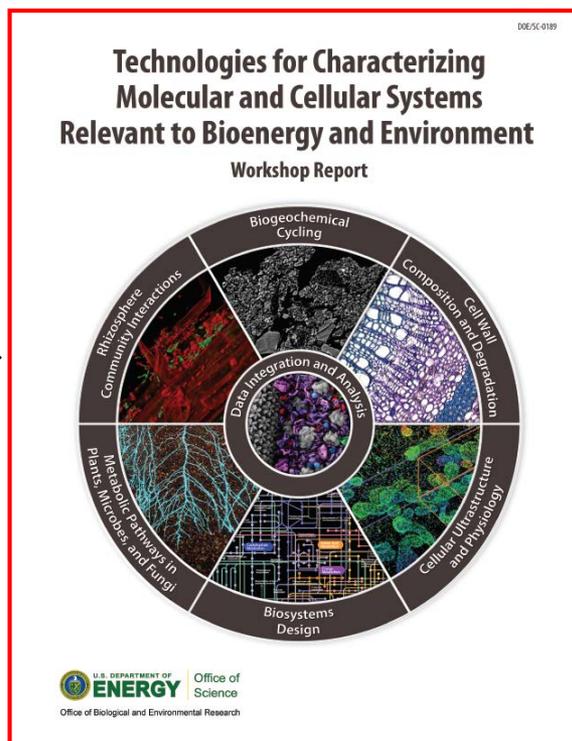
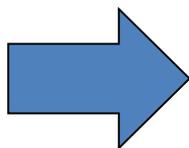
**Dr. W.E. Moerner** (Stanford) - *The Promise and Challenges of 3D Super-Resolution Optical Microscopy and Single-Molecule Tracking in Cells as Probes of Structure and Dynamics*



# New Reports/Brochures

- Updated Bioenergy Research Centers descriptions
- Advisory Committee (BERAC) Grand Challenges report
- Latest workshop report on imaging and characterization technologies

*Brief-out by workshop  
co-chair:  
Dr. Elizabeth Wright  
Emory University  
Wednesday 10:20AM*



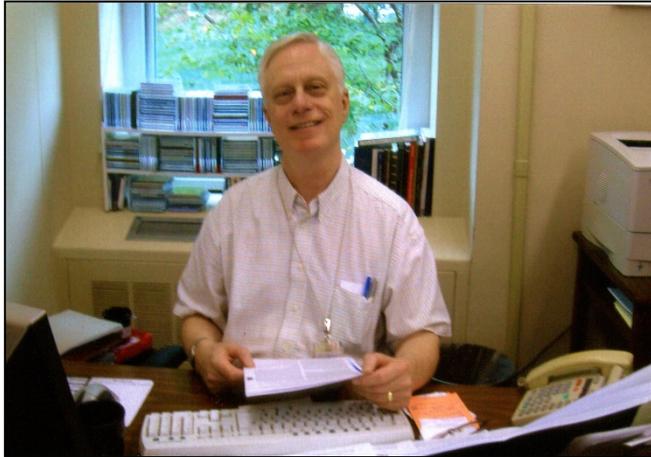
**Report Available at:**

<https://science.energy.gov/~/media/ber/berac/pdf/Reports/BERAC-2017-Grand-Challenges-Report.pdf>

**Workshop report available online at:**

<https://genomicscience.energy.gov/technologies/>

# *Biological Systems Science Division : Personnel Changes*



**Roland Hirsch** – Genomic Science Program,  
Structural Biology Infrastructure, Subsurface  
Biogeochemical Research (CESD)  
Retired from Federal Service on Jan 30.

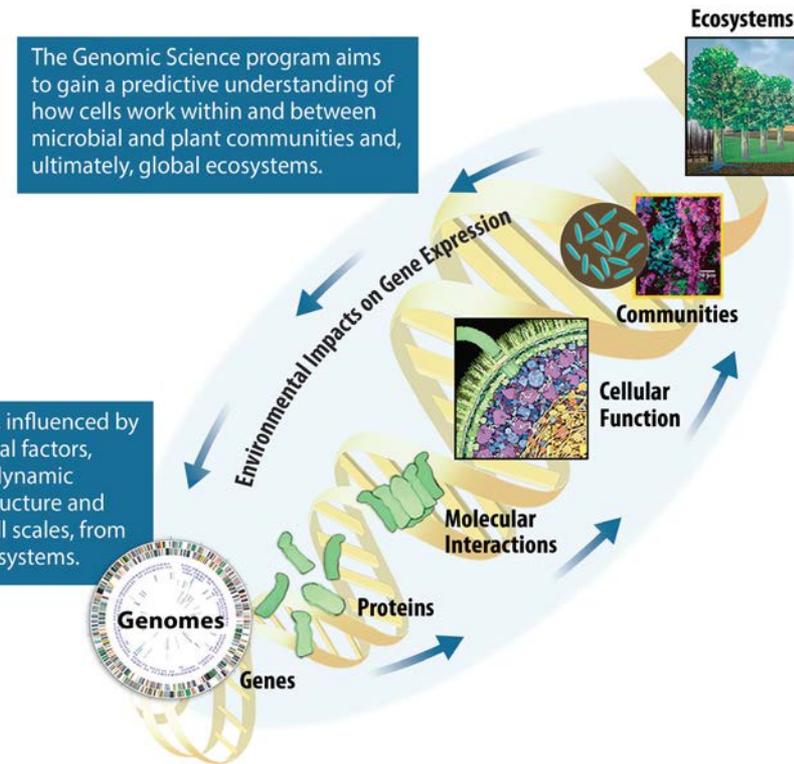


**Joanne Corcoran** – Program Support Specialist  
Retired from Federal Service on Dec 29.

# Genomic Science Program

## Main Program Components

- Bioenergy Research Centers (BRCs)
- Systems Biology for Bioenergy
- Plant Feedstocks Genomics
- Biosystems Design
- Carbon Cycle/Environmental Microbiological Research
- Computational Biosciences
- Sustainability Research for Bioenergy



**Where do the DOE Laboratory programs fit in to this structure?**

# DOE National Laboratory Science Focus Areas (SFAs)

## Plant Microbe Interfaces

### Oak Ridge National Laboratory

*Understanding the physical, molecular, and chemical interfaces between Populus and its associated soil microbial community as key elements to determining their functional roles in biological and environmental systems.*

**Laboratory Research Manager: Mitch Doktycz**

*Plant-Microbe Interactions*



<http://pmiweb.ornl.gov/>

## Soil Metagenomics and Microbial Carbon Cycling in Terrestrial Ecosystems

### Los Alamos National Laboratory

*Developing and applying community genomics approaches to link the biological processes controlling belowground carbon storage and release to the community of microorganisms conducting those processes.*

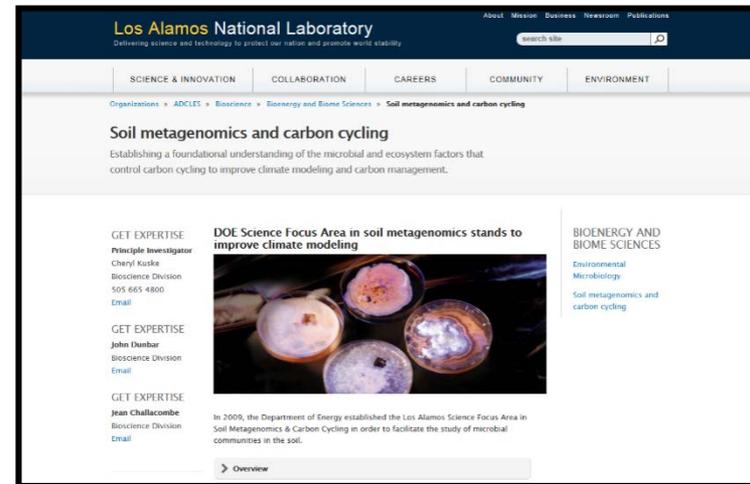
**Laboratory Research Manager:**

**John Dunbar/Cheryl Kuske**

*Environmental Microbiology*

*Biogeochemistry*

*Plant-Microbe Interactions*



<http://www.lanl.gov/org/padste/adcles/bioscience/bioenergy-biome-sciences/soil-carbon.php>

# DOE National Laboratory SFAs

## ENIGMA (Ecosystems and Networks Integrated with Genes and Molecular Assemblies)

### Lawrence Berkeley National Laboratory

Development of laboratory and computational tools that link the molecular functions within individual microbes to the integrated activities of microbial communities as they interact with their environment.

**Laboratory Research Manager: Paul Adams**

**Technical Co-Manager: Adam Arkin**

*Environmental Microbiology*

*Microbiome*

*Computational Biology*

## A Systems Biology Approach to Interactions and Resource Allocation in Bioenergy-Relevant Microbial Communities

### Lawrence Livermore National Laboratory

Community systems biology research to gain a predictive understanding of microbial consortia closely associated with bioenergy-relevant plants and algae.

**Laboratory Research Manager: Henry Shaw**

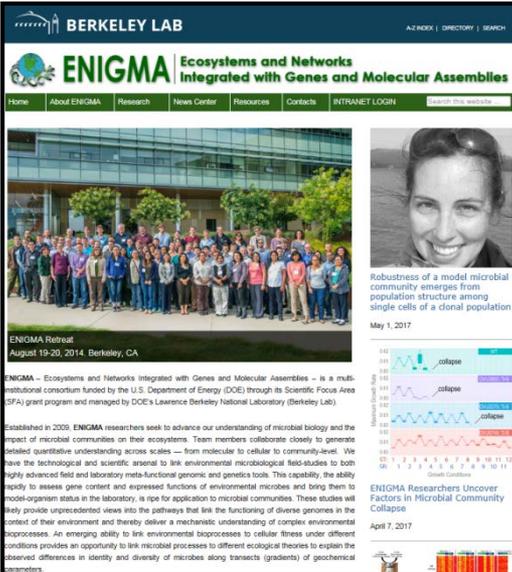
**Technical Co-Manager: Rhona Stuart**

*Environmental Microbiology*

*Microbial Physiology*

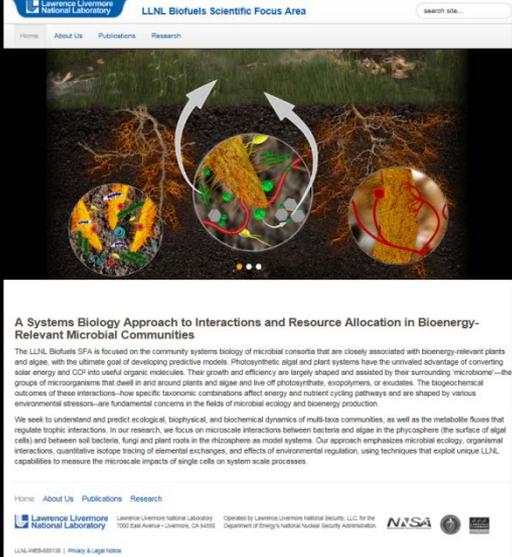
*Plant-Microbe Interactions*

*Computational Biology*



The screenshot shows the ENIGMA website header with the logo and navigation menu. Below the header is a large group photo of researchers. To the right is a portrait of a woman with a caption: "Robustness of a model microbial community emerges from population structure among single cells of a clonal population" dated May 1, 2017. Below the photo is a line graph showing community size over time for different conditions. The caption for the graph reads: "ENIGMA Researchers Uncover Factors in Microbial Community Collapse" dated April 1, 2017.

<http://enigma.lbl.gov/>



The screenshot shows the LLNL Biofuels Scientific Focus Area website. The main image is a diagram of a microbial community with arrows indicating interactions. Below the image is the title "A Systems Biology Approach to Interactions and Resource Allocation in Bioenergy-Relevant Microbial Communities". The text describes the LLNL Biofuels SFA's focus on community systems biology of microbial consortia associated with bioenergy-relevant plants and algae. It mentions the goal of developing predictive models and the use of microorganisms that dwell in and around plants and algae. The text also mentions the use of quantitative isotopic tracing of elemental exchanges and effects of environmental regulation.

<https://bio-sfa.llnl.gov/home>

# DOE National Laboratory SFAs

## **Dynamic visualization of lignocellulose degradation by integration of neutron scattering imaging and computer simulation**

### **Oak Ridge National Laboratory**

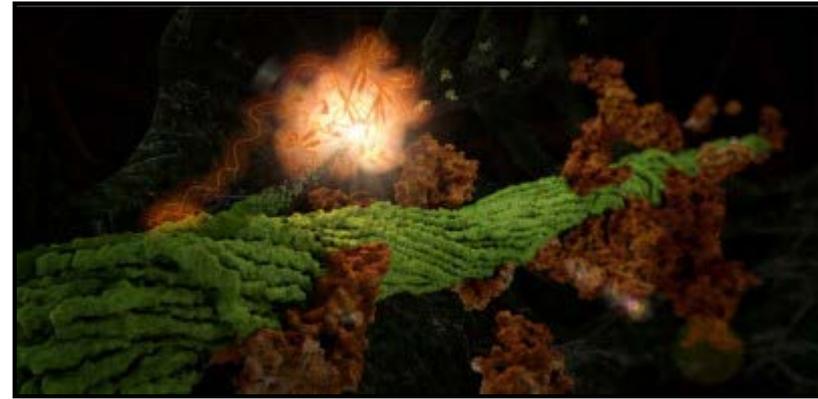
*The overarching objective is to obtain a dynamic, holistic picture of biomass structure and deconstruction at multiple length and time scales that will assist in the targeted improvement of biomass crops, pretreatment methods, and bioconversion to fuels.*

**Laboratory Research Manager: Brian Davison**

**Technical Co-Manager: Jeremy Smith**

*Deconstruction*

*Lignin Valorization*



<http://cmb.ornl.gov/research/neutron-scattering/lignocellulose-dynamics>

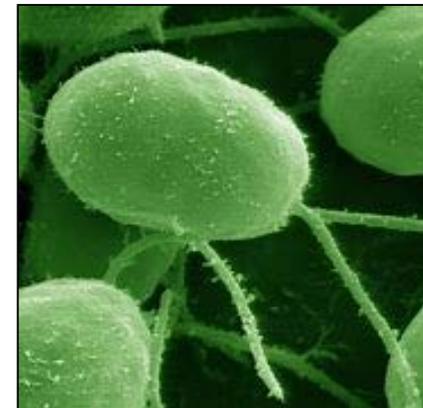
## **The Algal Ferredoxin Interactome**

### **National Renewable Energy Laboratory**

*Gaining a systems-level understanding of the ferredoxin-centered pathways for H<sub>2</sub> and other biofuels production, and their role in oxidative stress protection in green algae.*

**Laboratory Research Manager: Maria Ghirardi**

*Microbial Physiology*



*C. reinhardtii*

# ***New Efforts DOE National Laboratory SFAs***

## **Soil Microbiome Research**

### ***Phenotypic Response of the Soil Microbiome to Environmental Perturbations***

**Pacific Northwest National Laboratory (PNNL) (PI: Janet Jansson/Kirsten Hofmockel)**

*Environment Microbiology, Microbial Physiology, Microbiome*

### ***Bacterial:Fungal Interactions and Their Role in Soil Functioning***

**Los Alamos National Laboratory (LANL) (PI: Patrick Chain)**

*Environment Microbiology*

### ***Microbes Persist: Systems Biology of the Soil Microbiome***

**Lawrence Livermore National Laboratory (LLNL) (PI: Jennifer Pett-Ridge)**

*Environment Microbiology*

## **Two Pilot Projects**

### ***Quantitative Plant Science Initiative (QPSI)***

**Brookhaven National Laboratory (BNL) (PI: Crysten Blaby-Haas)**

*Technology*

### ***m-CAFÉs: Microbial Community Analysis and Functional Evaluation in Soils***

**Lawrence Berkeley National Laboratory (LBNL) (PI: Louise Glass)**

*Environment Microbiology, Microbiome, Technology*

**DOE SFA listings posted at:**

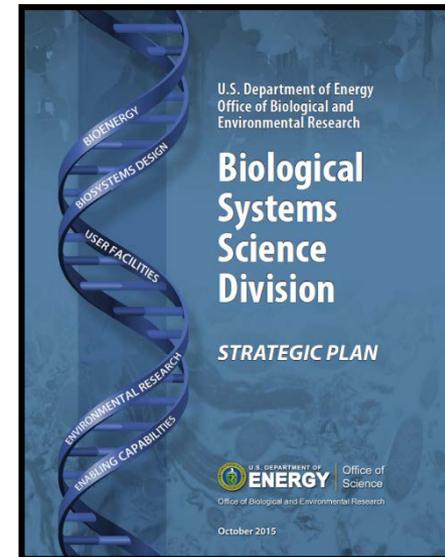
<https://genomicscience.energy.gov/research/sfas/index.shtml>

# Biological Systems Science Division

**Overarching Goal:** *Provide the necessary fundamental science to understand, predict, manipulate, and design biological processes that underpin innovations for bioenergy and bioproduct production and to enhance the understanding of natural environmental processes relevant to DOE.*

## Objectives

- Provide a basic understanding of plant and microbial biology to underpin the production of biofuels and bioproducts from sustainable plant biomass resources.
- Develop the fundamental understanding of genome biology needed to design, modify, and optimize plants, microbes, and biomes for beneficial purposes.
- Gain a predictive understanding of biological processes controlling the flux of materials (e.g., carbon, nutrients, and contaminants) in the environment and how these processes impact ecosystem function.
- Develop the enabling computational, visualization, and characterization capabilities to integrate genomic data with functional information on biological processes.
- Broaden the integrative capabilities within and among DOE user facilities to foster a more interdisciplinary approach to BER-relevant science and aid interpretation of plant, microbe, and microbial community biology.

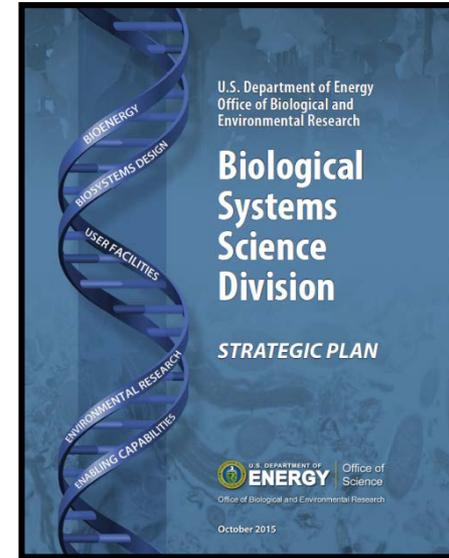


# *Biological Systems Science Division*

**Overarching Goal:** *Provide the necessary fundamental science to understand, predict, manipulate, and design biological processes that underpin innovations for bioenergy and bioproduct production and to enhance the understanding of natural environmental processes relevant to DOE.*

## **Objectives**

- ***Plant & Microbial Bioenergy Research***
- ***Biosystems Design & Synthetic biology***
- ***Carbon/Nutrient Cycling and Environmental Microbiology***
- ***Enabling Capabilities***
- ***User Facility Integration***



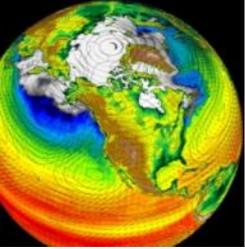
# Mapping Research Efforts onto BSSD Objectives

Core Objectives in:	FOA-led efforts	DOE Lab-led efforts
<b>Plant &amp; Microbial Bioenergy Research</b>	<ul style="list-style-type: none"> <li>Bioenergy Research Centers</li> <li>Plant Feedstocks Genomics</li> <li>Systems Biology for Bioenergy</li> <li>Sustainability Research for Bioenergy</li> <li>DOE-UCLA Institute</li> </ul>	<ul style="list-style-type: none"> <li>Bioenergy Research Centers</li> <li>ORNL – Lignocellulosic degradation</li> <li>LLNL – Resource allocation in microbial communities</li> <li>NREL – Algal Ferredoxin Interactome</li> <li><b>(Pilot)</b> BNL- Quantitative Plant Science</li> </ul>
<b>Biosystems Design &amp; Synthetic Biology</b>	<ul style="list-style-type: none"> <li>Biosystems Design</li> <li>Harvard Project</li> </ul>	<ul style="list-style-type: none"> <li><b>(Pilot)</b> LBNL m-CAFÉs</li> <li>elements of the BRCs</li> </ul>
<b>Carbon/Nutrient Cycling &amp; Environmental Microbiology</b>	<ul style="list-style-type: none"> <li>Carbon/Nutrient Cycling Environmental Microbiology</li> <li>Sustainability Research for Bioenergy</li> </ul>	<ul style="list-style-type: none"> <li>LBNL- ENIGMA project</li> <li>LANL – Soil Metagenomics</li> <li>ORNL- Plant-Microbe Interactions</li> <li>LANL</li> <li>LLNL</li> <li>PNNL</li> <li><b>(Pilot)</b> LBNL m-CAFÉs</li> </ul> <p style="margin-left: 150px;">} Microbiome Research</p>
<b>Enabling Capabilities</b>	<ul style="list-style-type: none"> <li>Computational Biology*</li> <li>Bioimaging Research</li> </ul>	<ul style="list-style-type: none"> <li>KBase</li> <li>Computational Biology</li> <li>Bioimaging Research</li> </ul>
<b>User Facility Integration</b>		<ul style="list-style-type: none"> <li>Joint Genome Institute</li> <li>Structural Biology Infrastructure</li> <li>Environ. Mol. Science Lab (EMSL)</li> <li>NERSC</li> </ul>

# Combining Research with Enabling Capabilities

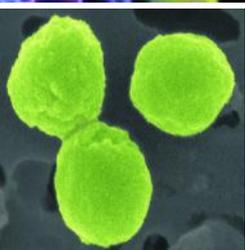
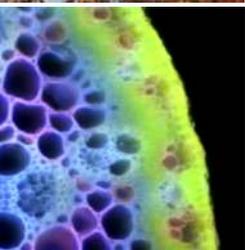
- Continuing to push new research directions
- Developing new enabling capabilities
- Connecting DOE facilities for multidisciplinary research
- Creating a portfolio that is “greater than the sum of its parts”
- Delivering the basic science needed for DOE mission goals
  - Sustainable Bioenergy
  - Environmental Research
  - Biosystems Design



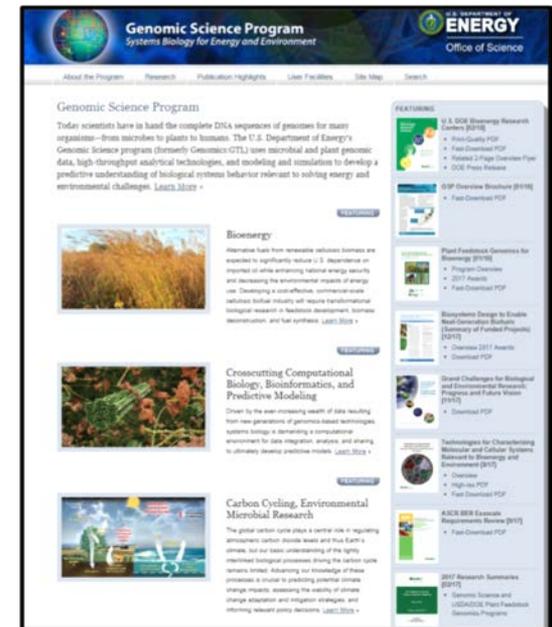


**Systems science to support DOE's energy, environment and basic research missions.**

<http://science.energy.gov/ber>



**Thank you!**



<http://genomicscience.energy.gov>