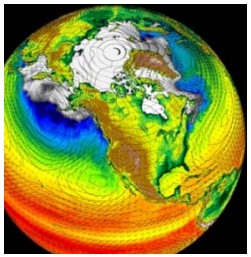
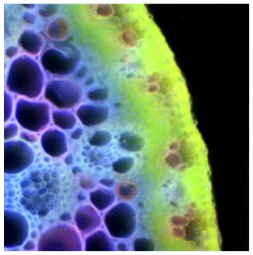
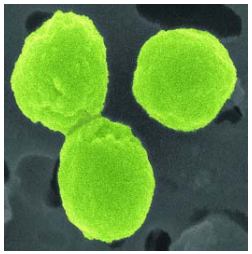


DOE-BER Workshop: Research for Sustainable Bioenergy

Biological and Environmental Research Advisory Committee Meeting

October 29, 2013
Rockville, MD

Catherine M. Ronning
Program Manager
Biological Systems Science Division

Research for Sustainable Bioenergy

October 2-3, 2013

DOE Germantown (A-410)

Co-Chairs:

Phil Robertson, Michigan State University/GLBRC
Jennifer Pett-Ridge, LLNL
Michael Udvardi, Samuel Roberts Noble Foundation

Dan Stover, Program Manager, BER-CESD

Support from ORISE

Workshop: Research for Sustainable Bioenergy

Focus: To understand the influence of biotic, abiotic and genetic variables and combinations of variables on long-term plant feedstock performance and the delivery of ecosystem services.

Goals:

- To identify research gaps to better understand the interconnections between sustainable bioenergy feedstocks and ecosystem services such as climate mitigation, water and nutrient conservation, biodiversity amenities, and pest regulation.
- To identify paths for developing models that can accurately predict the impact of plants, microbes, and environmental attributes on the sustainability of feedstock production and ecosystem services at appropriate geographic scales.
- *To identify novel ways to link genomes and ecosystems using the tools of systems biology, genomics, and ecosystem science.*

Expected outcome: State-of-the-art community scientific recommendations and critical research priorities that will help inform BER program direction in plant science for sustainable bioenergy.

Workshop Participants

Co-Chairs:	Phil Robertson MSU/GLBRC	Jennifer Pett-Ridge LLNL	Michael Udvardi Noble Foundation

Breakout Group 1	Breakout Group 2	Breakout Group 3
Tom Schmidt, U Michigan	**Julie Jastrow, ANL**	**Jonathan Lynch, Penn St**
Vanessa Bailey, PNNL	Paul Adler, USDA-ARS*	Chris Blackwood, Kent St
Bruno Basso, MSU/Kellogg	Aimee Classen, U Tennessee	Eoin Brodie, LBL
Heike Bucking, S Dakota St U	Kelly Craven, Noble	Kristen DeAngelis, U Mass
Ray Callaway, U Montana	Mary Firestone, UC Berkeley	Anne Hirsch, UCLA
Evan de Lucia, UIUC	Maria Harrison, BTI	Cesar Izzauralde, U Maryland/PNNL*
Steve DiFazio, WVU	Cheryl Kuske, LANL	Shawn Kaeppler, U Wisconsin
Tom Juenger, U TX	Ken Moore, Iowa St U	Patricia Klein, TAMU
Dave Myrold, Oregon St U	Bill Parton, Colorado St U	David Kramer, MSU
Kathleen Treseder, UC Irvine	Wilfred Vermerris, U FL	Donald Wyse, U Minnesota/CINRAM
	David Weston, ORNL	

*unable to attend

Observers

- DOE Office of Energy Efficiency and Renewable Energy
- DOE Office of Basic Energy Sciences

Invited but unable to attend:

- National Science Foundation
- U.S. Department of Agriculture

Agenda

Day 1: Wednesday, Oct. 2, 2013

Plenary Session: Three brief introductory talks focusing on plant, microbial, and ecosystem aspects

Plenary I: **Jonathan Lynch,** Pennsylvania State University
"Resource Use Efficiency in Plants: Challenges and Opportunities"

Plenary II: **Mary Firestone,** University of California Berkeley
"Sustainability is in the Soil"

Plenary III: **Evan De Lucia,** University of Illinois Urbana-Champaign
"Biogeochemistry of bioenergy driven land use change: promise and challenge"

Breakout I: Brainstorming

General discussion – Are we asking the right questions?

Breakout II: Identify key knowledge gaps and opportunities

Breakout II-A: Sustainable biofuel crop improvement and environmental impacts
Breakout II-B: Below- and above-ground processes
Breakout II-C: Environmental effects/factors

Groups check in: 10 min summary per group

Agenda - *continued*

<u>Day 2: Thursday, Oct. 3, 2013</u>

Breakout III: Summary – Bridging molecular and ecosystem studies

Presentations from the breakout groups

Discussion and wrap-up

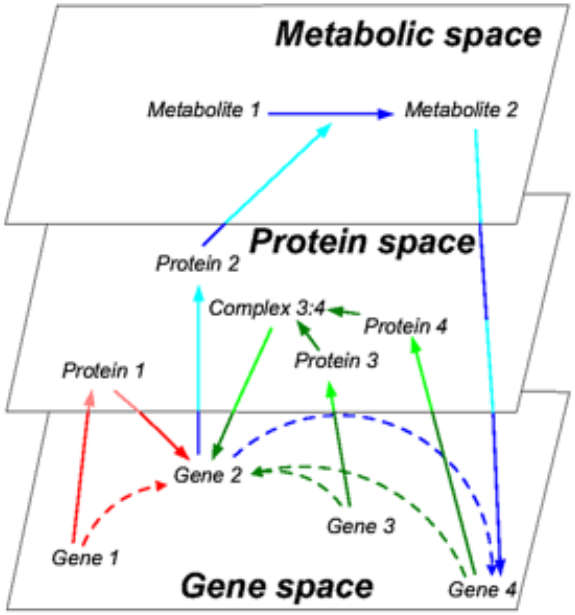
Participants adjourn

Lunch/discussion (Co-chairs, breakout leads, DOE BER staff)

Writing session (Co-chairs, breakout leads, DOE BER staff)

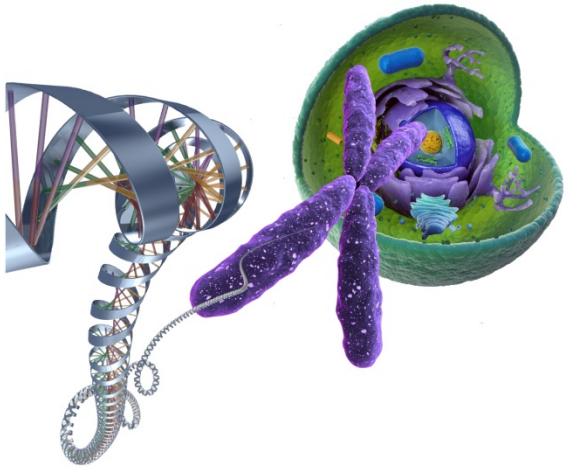
<u>Day 3: Friday, Oct. 4, 2013</u>

Writing session (Co-chairs, breakout leads)



Breakout I. Brainstorming: Identify Topic Areas

- Identify the most compelling questions related to plant genome-phenome x environment interactions and their implications for sustainable bioenergy production and ecosystem services.



Breakout II. Identify key knowledge gaps and opportunities

- Identify ways in which 'omics and ecosystem knowledge can be linked to address gaps and opportunities.
- Identify research priorities for addressing gaps and opportunities.

Three subsections:

A. *Sustainable Biofuel Crop Improvement and Environmental Impacts*
B. *Below- and Above-Ground Processes*
C. *Environmental Effects/Factors*

Breakout II. Identify key knowledge gaps and opportunities

- *Identify ways in which 'omics and ecosystem knowledge can be linked to address gaps and opportunities (e.g., conceptual and experimental approaches; new instrumentation, field, facility needs).*
- *Identify research priorities for addressing gaps and opportunities.*

Subsection A. Sustainable Biofuel Crop Improvement and Environmental Impacts

1) How can crop breeders use this knowledge of environmental effects on interactions to enhance crop improvement efforts?
2) To what extent can candidate biofuel crops be bred or engineered to improve productivity and environmental performance traits (e.g. water and nutrient use efficiency, carbon sequestration, persistent plant cover) in non-optimal environments?
3) What role can microbial interactions play in these improvements?
4) How can we maximize soil carbon sequestration and minimize greenhouse gas production without sacrificing aboveground plant performance, especially in low fertility soils?
5) How do plant-microbe-environment interactions affect tradeoffs and synergies?

Subsection B. Below- and Above-Ground Processes
Subsection C. Environmental Effects/Factors

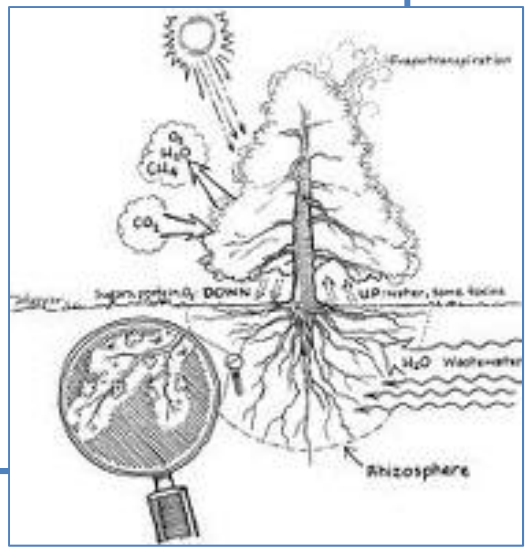
Breakout II. Identify key knowledge gaps and opportunities

- *Identify ways in which 'omics and ecosystem knowledge can be linked to address gaps and opportunities (e.g., conceptual and experimental approaches; new instrumentation, field, facility needs).*
- *Identify research priorities for addressing gaps and opportunities.*

Subsection A. Sustainable Biofuel Crop Improvement and Environmental Impacts

Subsection B. Below- and Above-Ground Processes

1) What below-ground processes and mechanisms (microbial, mycorrhizal, other) beneficially influence plant growth and development?
2) How do plant-associated organisms overcome the plant's defense mechanisms (i.e., how does the plant differentiate between pathogen and mutualist)?
3) What controls microbial-plant interactions?
4) How is the composition and behavior of the surrounding communities (e.g., rhizosphere, endosphere) affected by different plant genotypes?
5) How is plant phenotype affected by the composition and behavior of the surrounding microbial communities?



Subsection C. Environmental Effects/Factors

Breakout II. Identify key knowledge gaps and opportunities

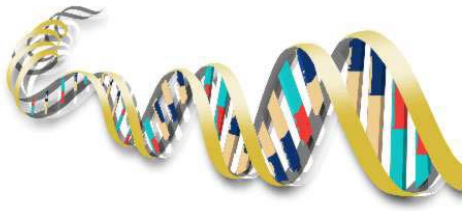
- *Identify ways in which 'omics and ecosystem knowledge can be linked to address gaps and opportunities (e.g., conceptual and experimental approaches; new instrumentation, field, facility needs).*
- *Identify research priorities for addressing gaps and opportunities.*

Subsection A. Sustainable Biofuel Crop Improvement and Environmental Impacts
Subsection B. Below- and Above-Ground Processes

Subsection C. Environmental Effects/Factors

1) What environmental factors (e.g., drought, temperature, soil) affect microbe, plant, and microbe-plant interactions, both beneficially and detrimentally, and in particular at the molecular scale?
2) How do these effects vary by environment?
3) What are the molecular drivers for such variation?
4) How are new genotypes (and phenotypes) selected and maintained?

Breakout III. Bridging molecular and ecosystem studies

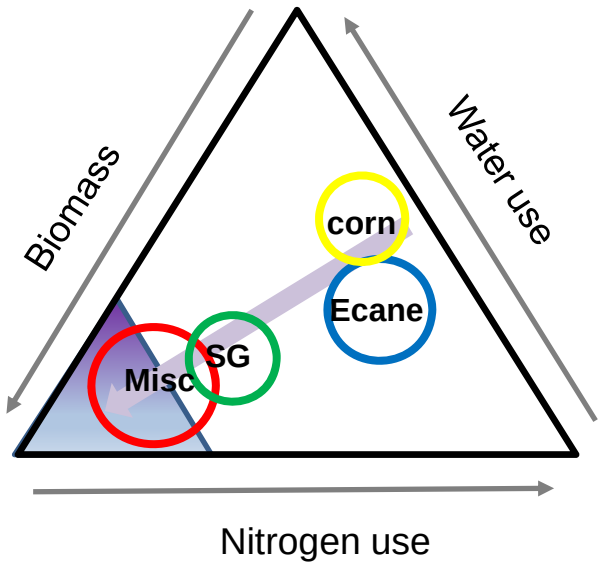


- How can we best utilize or adapt the tools of genomics to understand interactions and bridge molecular and ecosystem studies?

- What studies need to be done, and how should data be collected and managed to best facilitate development of models that accurately predict the effects of environmental perturbations on the underlying molecular processes and ultimately the phenotypic characteristics of biofuel ecosystems?

- How can we ensure the delivery of ecosystem services while enhancing long-term performance of plant bioenergy feedstocks?

Wrap-up/Discussion



I. Brainstorming

- Unforeseen consequences; ecoregional approach; field trials
- Extreme environmental events – ecosystem resilience / recovery, mechanisms of adaptation for plants, microbes
- Modeling and scaling

II. Knowledge gaps and opportunities

- SOM decomposition/stabilization; biogeochemistry
- Spatial heterogeneity – when, where, and how does it matter?
- Temporal studies – measure trends rather than treatment effects: experiments across gradients
- Plant breeding that maximizes ecosystem services; identify tradeoffs (root architecture)
- Plant-microbe-soil ecosystem interactions/feedbacks at establishment phase, stress adaptation, etc
- Environmental inputs: define environmental constraints and stress complexes

III. Bridging molecular and ecosystem studies

- Long-term experiments, replicated across environments and management practices (GxExM)
- Approaches that tie small scale 'omics to whole plant to field; coordinated measurements, integration of data at multiple (time and space) scales
- 'Omics, computation, imaging approaches to understand plant-microbial physiology and biogeochemistry

Thank you!