

Biomass R&D Programs at DOE-SC-BER *- update*

Biomass Research and Development
Technical Advisory Committee Meeting
19 May 2011

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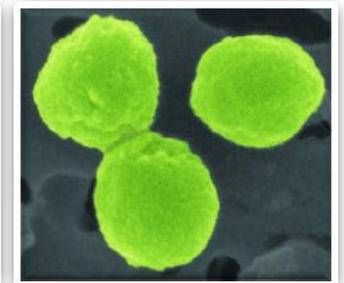
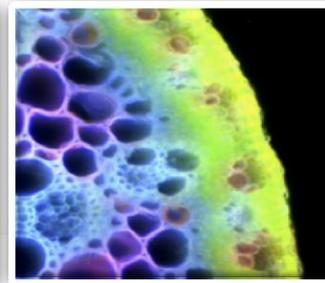
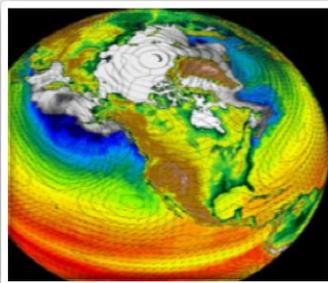


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Biological and Environmental Research Mission

- To understand complex biological, climatic, and environmental systems across spatial and temporal scales; provide the foundational science to:
 - **Support the development of biofuels as major, secure, and sustainable national energy resources**
 - Understand the potential effects of greenhouse gas emissions on Earth's climate and biosphere and the implications of these emissions for our energy future
 - Predict the fate and transport of contaminants in the subsurface environment at DOE sites
 - Develop new tools to explore the interface of biological and physical sciences

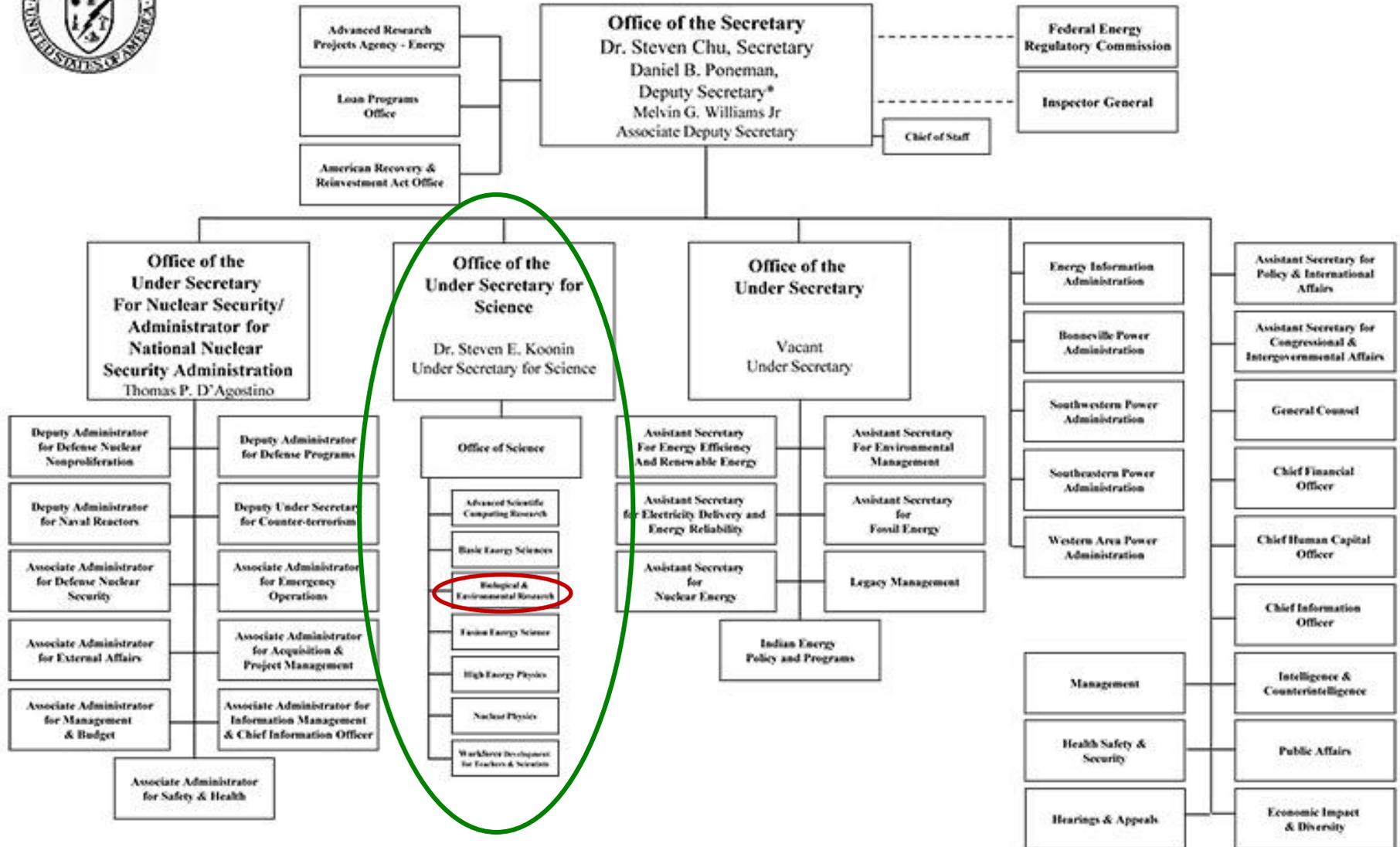


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* The Deputy Secretary also serves as the Chief Operating Officer

Biological and Environmental Research Biological Systems Science Division (BSSD) (FY 2011 : \$ 321,947 K)

Genomic Science Program (\$176,891 K)

- DOE Bioenergy Research Centers (\$25,000 K each)
- DOE Joint Genome Institute (\$69,267 K)
- USDA-DOE Plant Feedstocks Genomics for Bioenergy (DE-FOA-0000417)
- Genomic Science for Technology and the Environment (DE-FOA-0000368)
- DOE Systems Biology Knowledgebase (DE-FOA-0000143)



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Bioenergy Research Centers (BRCs)

Program Overview

- Funding: planned funding of **\$405 million over five years** for establishment and operation of **three BRCs**
- Goals: **transformational discoveries** in basic science to make production of **cellulosic ethanol** and other **plant fiber-based biofuels cost-effective** and **economically viable**
- Method: advanced **genomics-based systems biology** research on **plants** and **microbes**:
 - Developing and modifying dedicated bioenergy feedstock plants
 - Overcoming “recalcitrance” of lignocellulose – **key cost barrier** – deconstruction of plant fiber into fermentable sugars
 - Microbial synthesis of fuels – ethanol and beyond

Bioenergy Research Centers (BRCs)

Joint BioEnergy Institute (JBEI)

- Model plants (Arabidopsis and rice) - lignin modification;
- Synthetic biology approaches to fuels;
- Advanced biomass pretreatment;
- New stable, active cellulase enzyme in ionic liquids.

Great Lakes Bioenergy Research Center (GLBRC)

- Model and potential bioenergy plants;
- Microbial biorefineries;
- Sustainability of biofuel production;
- Improved screening of hydrolytic enzymes.

Bioenergy Science Center (BESC)

- Research to overcome recalcitrance
- Consolidated bioprocessing (CBP)
- New high throughput screening of chemical, structural, and genetic features of biomass; imaging



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Some BRC Highlights:

Induced “super” ethanol tolerance in genetically altered yeast cells by manipulating expression of the genes involved in high ethanol tolerance



Developed new microfluidic chip-based assay for rapid and precise characterization of the small sugars produced from biomass hydrolysis



Generated a genetically modified switchgrass that yields 30% increased ethanol and requires 3- to 4-fold less enzyme for processing.



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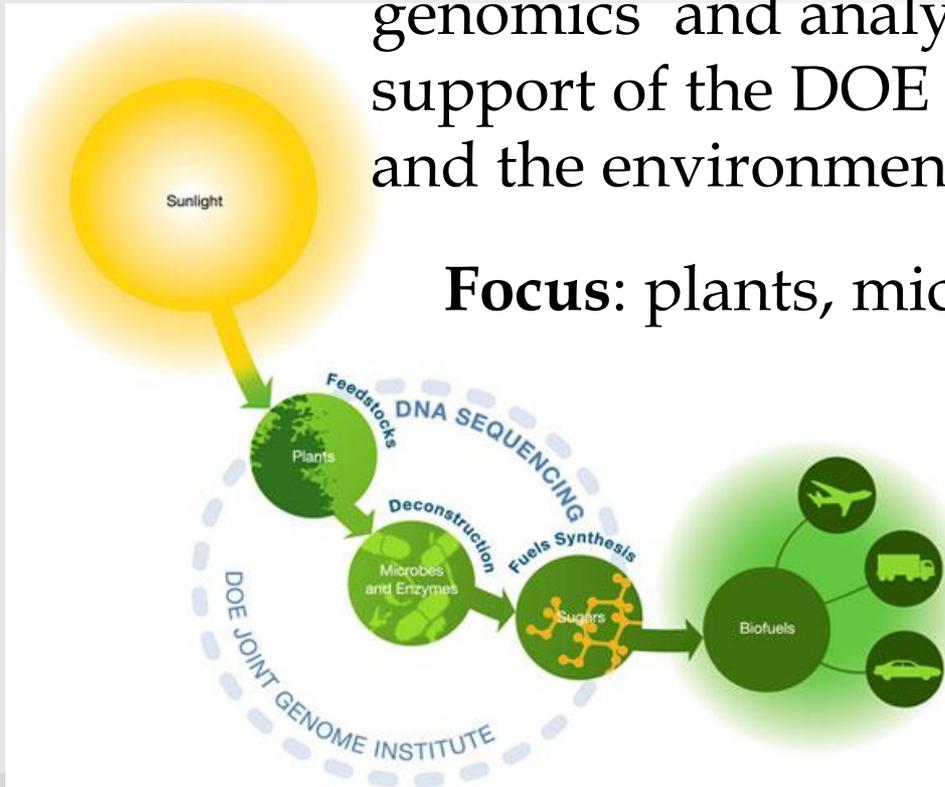


The DOE Joint Genome Institute (JGI)

Mission: to serve the scientific community as a user facility enabling application of large-scale genomics and analysis of plants and microbes in support of the DOE mission needs in bioenergy and the environment.

Focus: plants, microbes, fungi, metagenomes

Provides state-of-the-science capabilities for sequencing and analysis.



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2011 JGI Community Sequencing Program (CSP) Portfolio

Focus on large projects: microbial & fungal collections, single cell genomes, metagenomes, plant resequencing

35 new projects:

- Plants, algae, fungi, microbial (including single-cell), metagenome, metatranscriptome

Setting the ground work for Tera-Peta base projects

Leadership in development of required sample handling, project management and analysis



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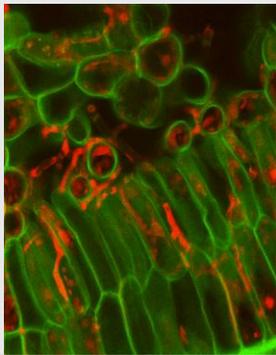
Some Recently Completed Genomes



Daphnia pulex (water flea): 1st crustacean sequenced



Selaginella moellendorffii (spikemoss): 1st non-seed vascular plant (lycophyte) sequenced



Melampsora larici populina (poplar leaf rust);
Puccinia graminis f. sp. tritici (wheat stem rust): 1st rust fungal genomes sequenced



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A Systems Biology Knowledgebase for Energy and the Environment (Kbase)

- **Knowledgebase:** Cyber infrastructure to integrate, search and visualize, in an open environment, experimental data, associated information (metadata), corresponding models and analysis tools.

Long Term Goals:

- Rapidly and accurately reconstruct metabolic and regulatory pathways for 100-1000 **microbes**;
- Integrate experimental and field data with key **plant** genomes, associate experimental data with phenotype, predict relationships between phenotype, genotype, environment;
- Integrate experimental 'omics data with reference **metagenome** sequences, develop metabolic reconstructions and modeling in natural microbial communities.



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DOE Office of Science FOA DE-FOA-0000143: *Computational Biology and Bioinformatic Methods to Enable a Systems Biology Knowledgebase*

\$5 million per year for three years, funding 11 projects

Annotation: New methods that computationally integrate data and information into the assignment of gene functions

'Omic Data Integration: New computational methods to integrate multiple data types

Integrated Pathway Reconstructions: Significant improvements in methodologies to couple metabolic and regulatory pathways

Whole Cellular Simulations: New methods to model complex cellular processes



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Knowledgebase Proposals and Review:

4/27/11 - 4/29/11

Funding at \$10/million to \$12/million per year

Proposal 1: Develop a Knowledgebase node for the integration of data and modeling capabilities for biological networks in plant and microbes with a strong application to cloud computing.

Proposal 2: Provide a framework to enable community functional annotation of microbes, plants and metacommunities through the integration of data and models. Framework enables social networking tools to integrate different biological communities around experimental data.

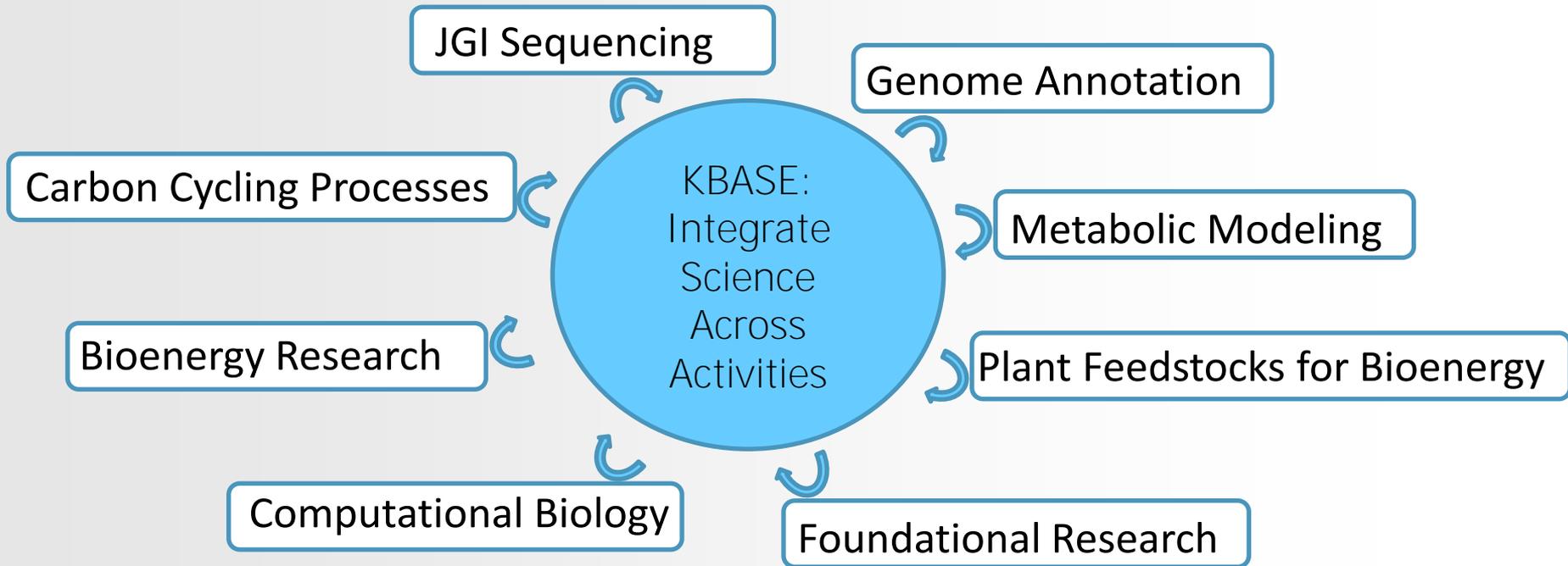
Proposal 3: Provides a unifying platform to link different databases and data types with modeling capabilities for plants, microbes and metacommunities.



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The Knowledgebase both leverages and serves Genomic Sciences



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USDA-DOE

Plant Feedstock Genomics for Bioenergy

A joint competitive grants program initiated in 2006
(DOE-BER and USDA-NIFA)

Genomics-based research leading to improved use of biomass and plant feedstocks for the production of fuels such as ethanol or renewable chemical feedstocks:

- Improve biomass characteristics, biomass yield, or sustainability;
- Systems biology approaches enabling efficient manipulation and breeding;
- Prediction of phenotype from genotype that could lead to improved feedstock characterization and sustainability.



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USDA-DOE Joint Program:

2006-2010 Portfolio

46 projects total to date:

Populus
Medicago
Foxtail millet
Sorghum
Switchgrass
Brachypodium

Rice
Miscanthus
Sunflower
Maize
Soybean

Resource development
Small RNAs
Plant-microbe interactions
Cell wall



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USDA-DOE Joint Program: FY2011 (DE-FOA-0000417)

Phenotyping plant germplasm collections, advanced breeding lines of bioenergy crops (Brachypodium, energy cane, Miscanthus, sorghum, switchgrass)

Translation of genomics information into cultivar improvement in bioenergy crops (Brachypodium, Miscanthus, Populus, sorghum, switchgrass)

- 53 proposals evaluated (April 27-28, 2011)
- 2 recommended for funding by USDA (sorghum)
- 7 recommended for funding by DOE (sorghum, poplar, switchgrass, sugar cane)



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DOE Switchgrass Community Coordination Workshops - 1

January 18, 2011, PAG XIX, San Diego, CA

CoChairs: Jeff Bennetzen (UGA) and Tom Juenger (U TX)

Goals: Discuss coordination of genome sequencing project; identify research needs and gaps

Participants: Switchgrass researchers from university and government labs; federal program managers

Needs: HTP screening; high-efficiency genetic transformation; genome-based markers

Action Items: Form switchgrass executive committee; define scope; develop processes for information sharing (wiki site, annual meeting)



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DOE Switchgrass Community Coordination Workshop - 2

April 11, 2011, Genomic Sciences PI Meeting, Crystal City, VA

Organizer: Robin Buell (Michigan State U)

Goal: Information exchange on the BRC and JGI activities/research

Participants: Switchgrass researchers from the BRCs, JGI, and Plant Feedstocks awardees; Federal program managers as observers

Agenda Topics: Switchgrass research efforts and genome needs of GLBRC, JBEI, BESC; JGI switchgrass genome sequencing efforts; Going forward-what's next ?

Action Items: *ad hoc* committee to solicit nominations for the election of an advisory board; community website and listserve



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Genomic Science for Technology and the Environment (DE-FOA-0000368)

- a) **Microbial Environmental Processes:** processes that link internal metabolic processes to external biogeochemical activities;
- b) **Microbial and Plant Processes for Bioenergy:** systems biology of biofuel production (e.g., utilization of lignocellulosic biomass and microbial synthesis of advanced biofuel);
- c) **Characterizing Key Molecular Species, Events, and Multicellular Processes for Genomic Science:** innovative approaches.

137 Proposals evaluated: (December 8-10, 2010)
Recommended for funding: 16 biofuel
9-11 microbial



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For more on BRCs and BRC Science:

<http://genomicscience.energy.gov/centers/index.shtml>

the JGI:

[http://www.sc.doe.gov/ober/BSSD/jgi.html/;](http://www.sc.doe.gov/ober/BSSD/jgi.html/)

<http://www.jgi.doe.gov/>

the DOE Kbase Implementation Plan:

http://genomicscience.energy.gov/compbio/kbase_plan

the joint Plant Feedstocks Program:

<http://genomicscience.energy.gov/research/DOEUSDA/>

the Switchgrass Community:

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

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