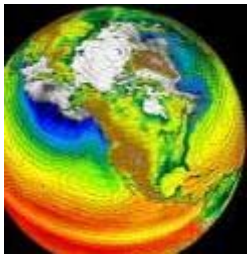
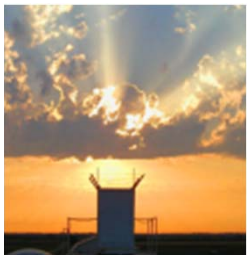

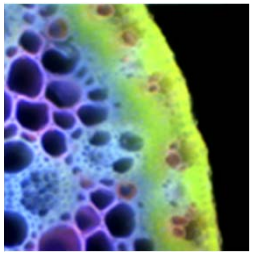
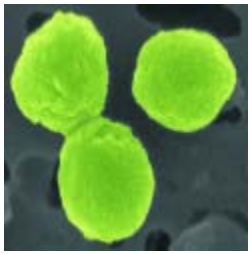

Overview: Bioenergy Workshop

held on
June 23-24, 2014
Renaissance Marriott Hotel
Washington, DC

N. Kent Peters, Ph.D.
Program Manager
Biological Systems Science Division
Department of Energy
Office of Biological & Environmental Research (BER)

Bioenergy Funding in BER

- BER supports basic research in bioenergy
  - Three Bioenergy Research Centers (BRC)
  - Annual Plant Feedstocks through joint FOA with USDA
  - Genomic Science FOA on bioenergy-relevant microbes and microbial systems
  - National Laboratory Biofuels Science Focus Area (SFA) programs
  - Biosystems Design projects
  - SBIR grants

Bioenergy Research Center Program

- BER supports basic research in bioenergy
- Original Goals of the BRCs
  - Feedstocks
  - Enhance Deconstruction
  - Fuel Synthesis (lignocellulosic ethanol → advanced biofuels
  - Enabling Technologies
  - Technology Transfer
- Annual reviews document success of BRCs at meeting stated goals
- BRCs finishing year 7 of a second 5-year funding period
- Need to define the state-of-the-science, and remaining gaps and barriers to inform BER future of funding basic bioenergy research

Workshop Participants

- Co-Chairs
  - Dr. Kristala Jones-Prather, Massachusetts Institute of Technology
  - Dr. Erich Grotewold, Ohio State University
- 45 Participants
  - 4 Industry
  - 7 DOE National Laboratories
  - 34 Academic institutions

Workshop Organization

- Presentations with Break-Out Discussions

- Speakers
  - Chris Somerville, Energy Bioscience Institute, University of California - Berkeley
  - Maureen McCann, Purdue University, C3Bio
  - Greg Stephanopoulos, MIT
  - Jay Keasling, JBEI, LBNL
  - Lee Lynd, BESC, Dartmouth University
  - Ken Keegstra, GLBRC, Michigan State University
  - Michael Martin, Monsanto Corporation

Workshop Organization (cont)

- Break-Out Discussion Groups
  - Biomass Development
    - Thomas Brutnell – Danforth Center
    - David Braun – University of Missouri
  - Deconstruction of Biomass
    - Birgitte Ahring – Washington State University
    - Michael Ladisch, Purdue University
  - *Specialty Fuels*
    - Terry Papoutsakis, University of Delaware
    - Ryan Gill, University of Colorado
  - *Bioproduct Development*
    - Elizabeth Hood, Arkansas State University
    - Brent Shanks, Iowa State University

Expected Workshop Outcomes

- A report with
  - An assessment of the current state-of-the-science with regard to the production of advanced cellulosic biofuels and bioproducts,
  - Identification of remaining scientific and technical barriers to the establishment of a sustainable domestic next generation biofuels and bioproduct commercial sector,
  - Information and perspectives to inform BER's bioenergy program goals.

Findings - Biomass Production

- Advances
  - Identification of genes involved in cell wall biosynthesis and their regulation
  - Demonstrated ability to genetically engineer biofuel crops for reduced recalcitrance and greater sugar yields
  - Demonstrated genetic engineering to alter lignin composition and hydrolizablilty
- Gaps and Barriers
  - Further work needed to optimize lignocellulosic biofuel and bioproduct crops
  - Continue work on switchgrass, Miscanthus, energy cane and poplar, to name the most prominent
  - Improve biofuel traits through a combination of selection of natural variants, genotype assisted breeding, and genetic engineering
  - Prioritized traits include reduced recalcitrance, water and nutrient recycling, and delayed flowering

Findings - Deconstruction

- Advances
  - Several effective pretreatment technologies
  - Better understanding of plant cell wall structure and origins of recalcitrance
  - Promise shown by consolidated bioprocessing with engineered thermophiles
  - Effective enzymes farming using metagenomics, genomic sequencing and gene synthesis
- Gaps and Barriers
  - Need for standardized biomass samples to use for comparative analysis
  - Better analytical tools for characterizing the lignocellulose and the break-down intermediates
  - Need deconstruction streams that provide for fermentable sugars as well as valorization of lignin
  - Establish a basic toolbox for lignin catabolism

Findings – Specialty Biofuels

- Advances
  - Engineered microbes with higher conversion efficiencies and greater inhibitor tolerance
  - Engineered thermophile to make lignocellulosic ethanol without pretreatment
  - New tools for synthetic biology and metabolic engineering resulting in an expanded suite of accessible molecules beyond ethanol to serve as biofuels or their precursors
- Gaps and Barriers
  - Selecting the appropriate targets, based on meaningful evaluation of the accessible markets, remains a challenge
  - Methods to test thousands of variants of a pathway in a high throughput manner will greatly impact the rate of discovery and optimization
  - It remains difficult to predict the performance of a microbe in industrial scale fermentation from benchtop scale experiments

Findings - Biomass Bioproducts

Gaps and Barriers

- Separation technologies- lack cost effective extraction of manufactured product or raw material
- Inadequate integration of manufacturing with the fuel production site
- Inadequate compositional analysis of potential byproduct streams
- Lack of efficient, stable and scalable biocatalysts for desired bioproducts
- Lack efficient and economical continuous processes
- Lack flexible process technology to accommodate multiple feedstock sources
- Lack synthetic biological and/or chemical chassis that only require minor modification for a range of bioproducts

Summary and Future Directions

- Continued support for biofuel crop development
- Continued support for improved deconstruction
- Expand to include specialty fuels and bioproducts
  - Replace petroleum as starting material for carbon-neutral production
  - Pathway to aromatics through less toxic intermediates than benzene and toluene
  - An infinite diversity of new products
- Continued value in vertical integration

Closing Comments

- An Executive Summary is available in the back of room etc.
- Draft report is back in the hands of the co-chairs before sending to professional editor/publisher

The End