

BioFueling The Future Challenges - Opportunities^{GT}

Art J. Ragauskas

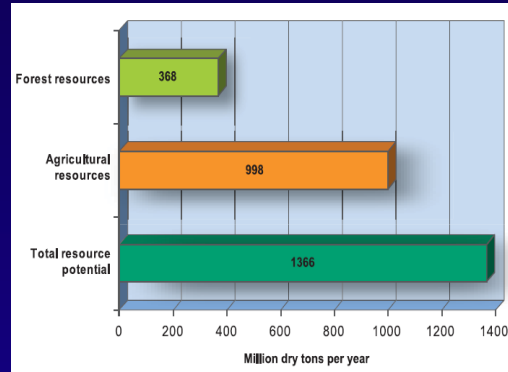
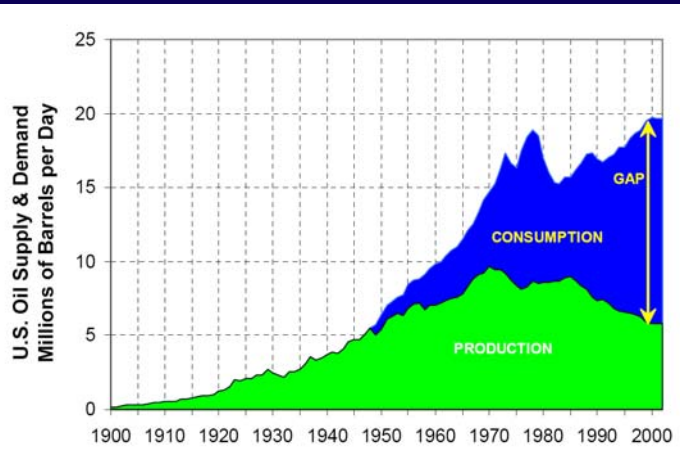
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To: Georgia Tech Advisory Board

April 16, 2007

BioFuels Future Biomass Resources



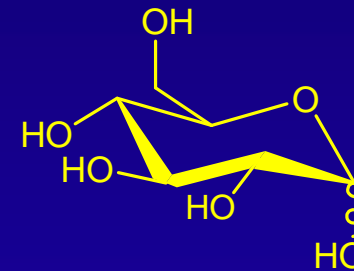
Biomass as Feedstock for a Bioenergy and Bioproducts Industry
The Technical Feasibility of a Billion-Ton Annual Supply

April 2005

Today



Saccharification



Fermentation



Ethanol

Breaking the Biological Barriers to Cellulosic Ethanol
A Joint Research Agenda

A Research Roadmap Resulting from the Biomass to Biofuels Workshop
December 7-9, 2005 • Rockville, Maryland
June 2006

U.S. Department of Energy
Office of Science
Office of Biological and Environmental Research
Genomics:GEL Program

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Office of the Biomass Program

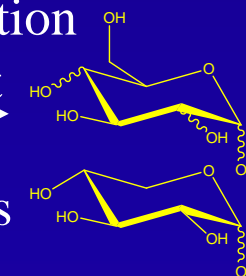
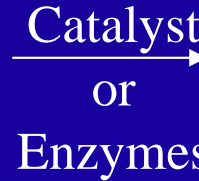
Future



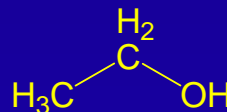
Biomass

Deconstruction

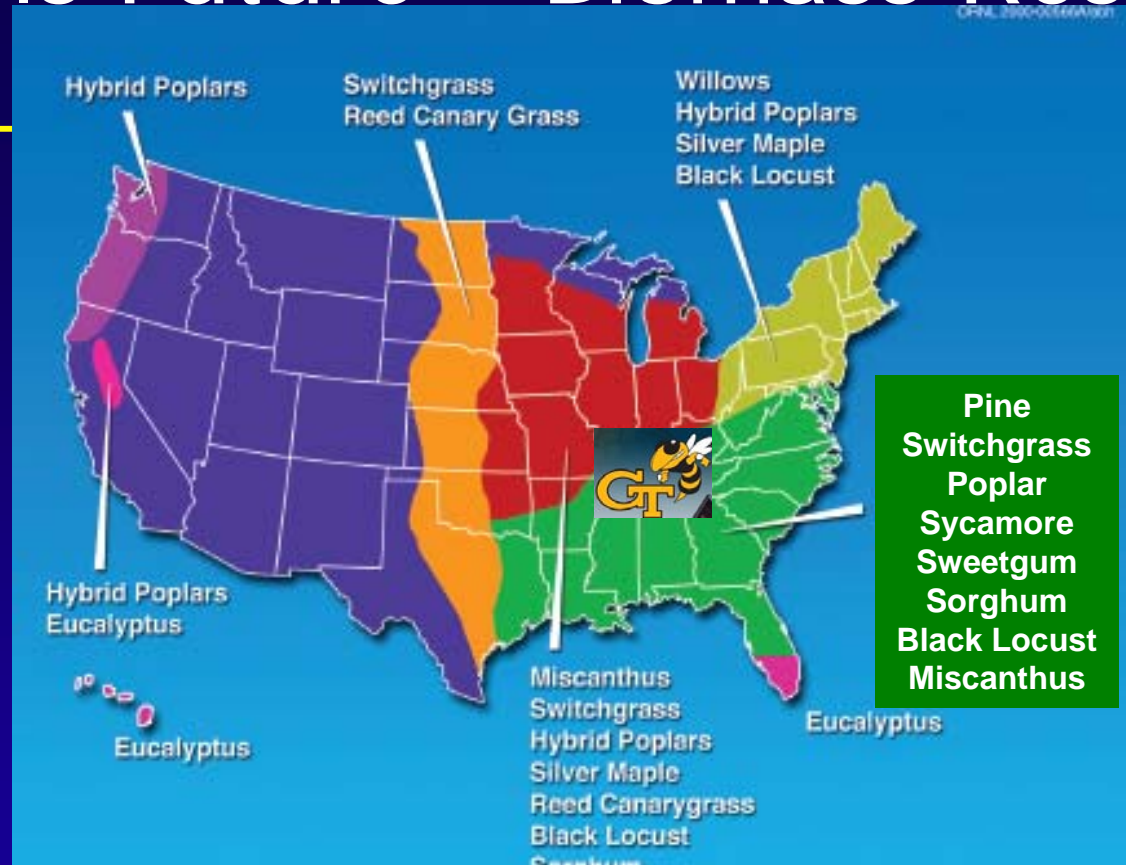
Catalyst
or
Enzymes



Fermentation



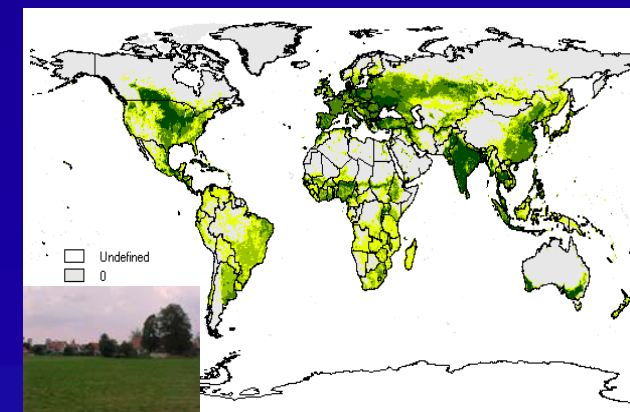
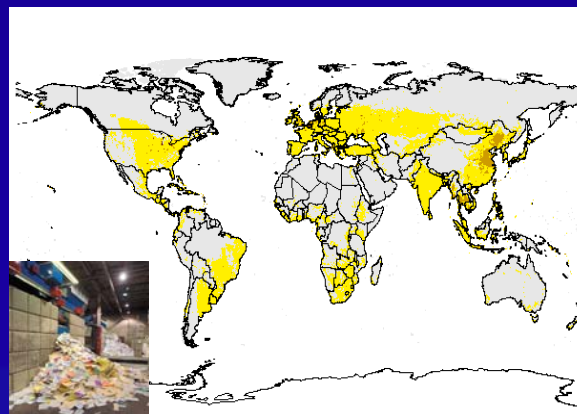
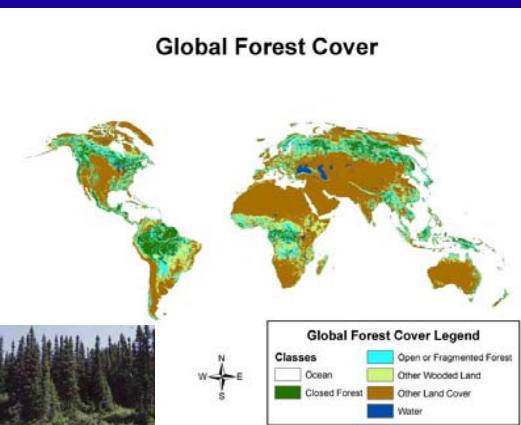
Biofuels Future – Biomass Resources



Lower Cost

Higher Availability

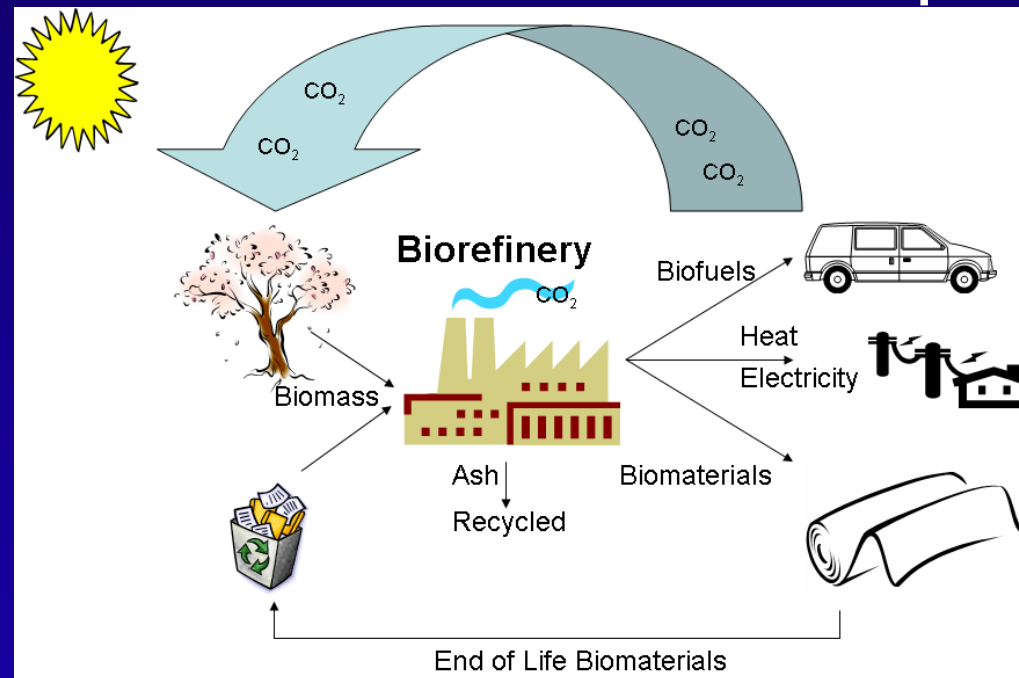
No Competition with Food Demand



Biofuels Future

Integrated Biorefinery

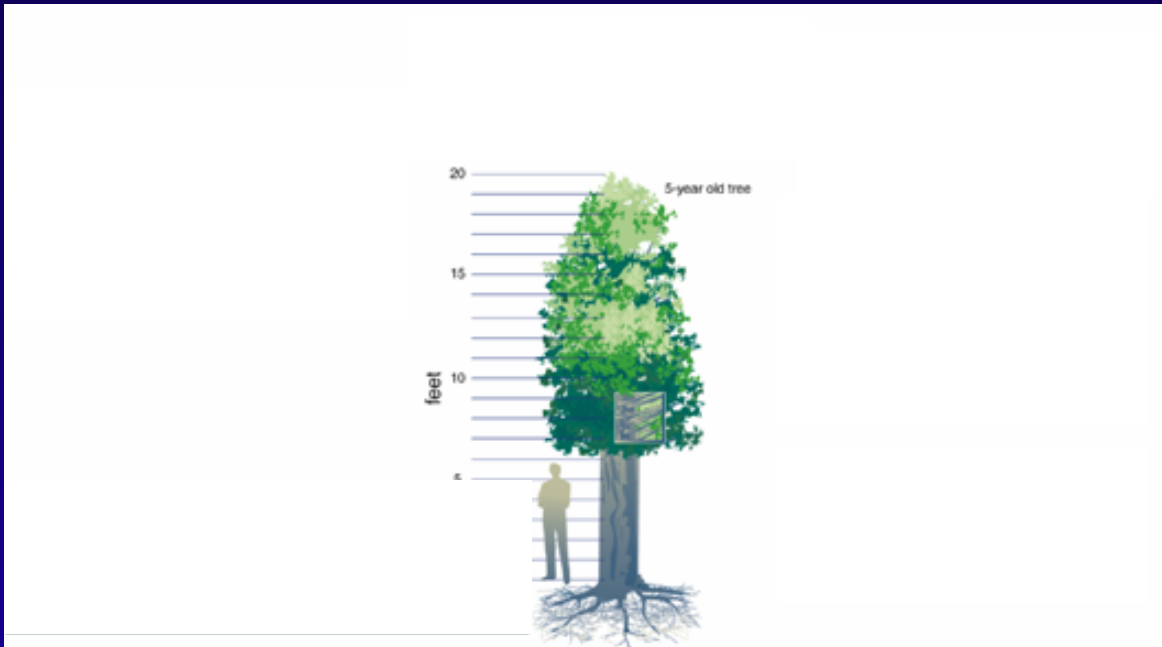
The integrated biorefinery is a facility that fully integrates biomass production and conversion to produce fuels, power, and chemicals from biomass. It fully utilizes all components of biomass to make a range of foods, fuels, chemicals, feeds, materials, heat and power in proportions that maximize sustainable economic development.



The Path Forward for Biofuels and Biomaterials. Ragauskas, A.J.; Williams, C.K.; Davison, B.H.; Britovsek, G.; Cairney, J.; Eckert, C.A.; Frederick, W.J., Jr.; Hallett, J.P.; Leak, D.J.; Liotta, C. L.; Mielenz, J.R.; Murphy, R.; Templer, R.; Tschaplinski, T. Science (2006), 311(5760), 484-489

BioFuels

Research Challenges: Plant Science



Research Objective

“More, Bigger, Better;” the mantra of modern consumerism, ironically, summarizes the goals of research aimed at modifying plants for use in sustainable biomass production

Georgia – GA Tech Challenges

- Can we Tailor Georgia’s Wood Resources for Biofuels
 - Reduced lignin – Increased carbohydrates
 - Faster growing Loblolly Pine – Poplar/Hardwoods
 - Improved Switchgrass

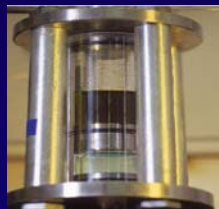
• GA Tech

School of Biology/Forest Biology/Systems Biology
School of Chemistry/Biochemistry

Society Issues: “If we build it – Will they come?”

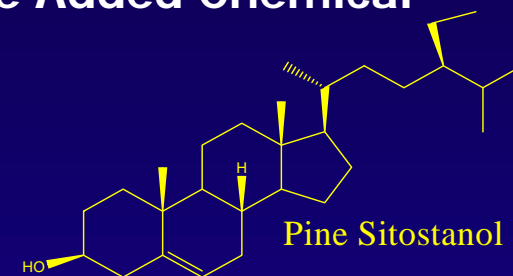
Biofuels

Research Challenges: Separations



Extraction of Value Added Chemical

- Nutraceuticals
- Bioactive agents

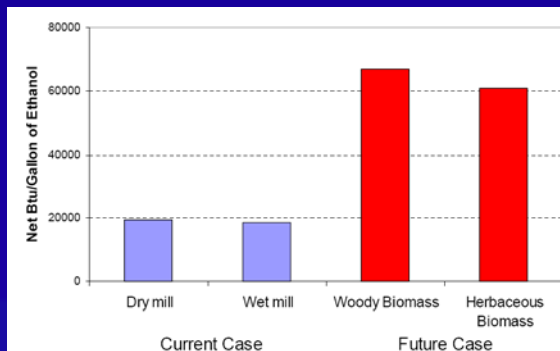
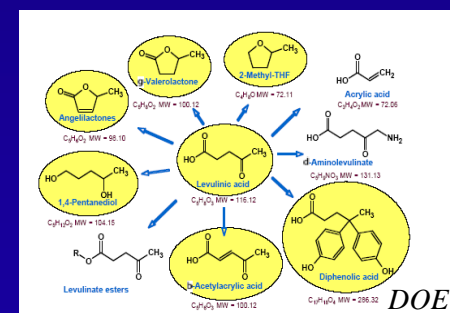


Value Added Materials

- Nanocellulose/hemicellulose
- Lignin for carbon fibers

BioFuels

- Ethanol
- Dimethyl ether
- Biodiesel
- Biogasoline



Wang et al.
Argonne 1999

Societal Issue:
How much does
Society value
Renewables

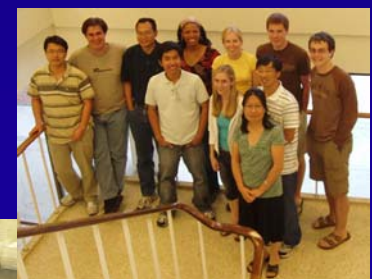
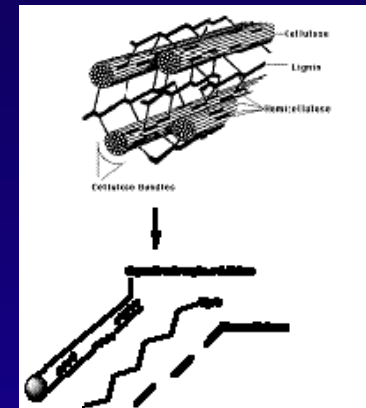
BioFuels

Research Challenges Conversion

Bioethanol <<<< Sugars <<<< Hemi/Cellulose << Biomass

Efficient Depolymerization of Cellulose

- Biomass Pretreatments
 - Conventional, Organic Solvents
 - New Solvents, Gas Expanded Liquids
- Deconstruction Enzymes
 - Improved hydrolysis active
 - In-situ Expression – cellusomes
 - Fundamental biomass chemistry



Societal Issue: Leadership-Education

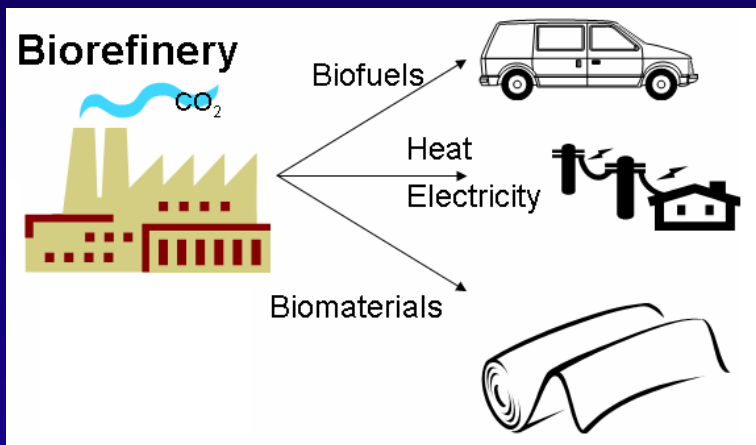
BioFuels

Research Challenges Conversion

Biomass

Biomaterials – Biochemicals

Biofuels

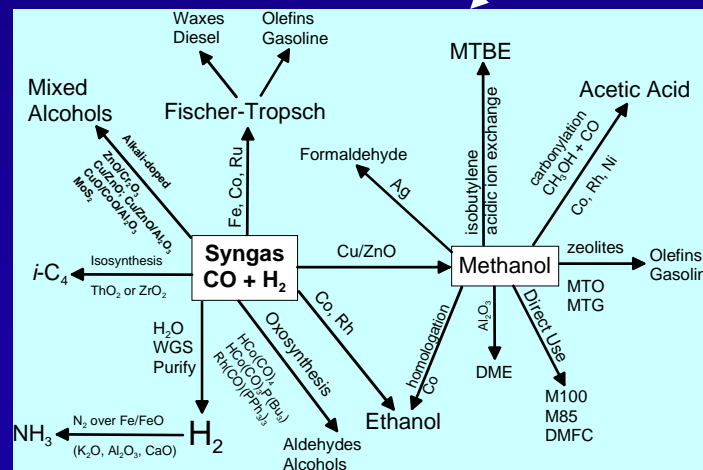


Gasification

*Power
Heat
Electricity*

Research Needs

- Gas cleanup/tars
- New catalyst
- Biological 'Fisher Tropsch' routes



BioFuels – Path Forward

GT Strengths



Georgia Institute of Technology

Strategic Energy Institute

SEI mission is to actively engage in and facilitate energy technology development, assessments, demonstration projects and policy guidance based on scientific facts, engineering principles and economic realities.

Several Programs

- **Woody Cellulose for Ethanol Transportation Fuel in Georgia**
 - *Energy Security – Rural Development – GA Advantage*

GA SW/HW



Performance/Policy

Distribution

Conversion

Today's Technological Needs

Tomorrow's Technological Breakthroughs

BioFuels - Challenge

**Grand Challenge for the New Millennium
Development of Practical, Renewable BioFuels
and BioMaterials Technologies For
GA – Nation - Mankind**

Equivalent

1961: J.F. Kennedy "The goal, before this decade is out, of landing, a man on the moon and returning him safely to the earth"

1990: Human Genome Grand Challenge