



Energy Biosciences Institute Linking Biotechnology and Energy

March 25, 2010

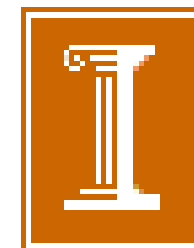
**Paul Willems, TVP Energy Biosciences
EBI Associate Director**



EBI Partners



This Extraordinary partnership builds upon and extends strengths in the area of alternative biofuels.

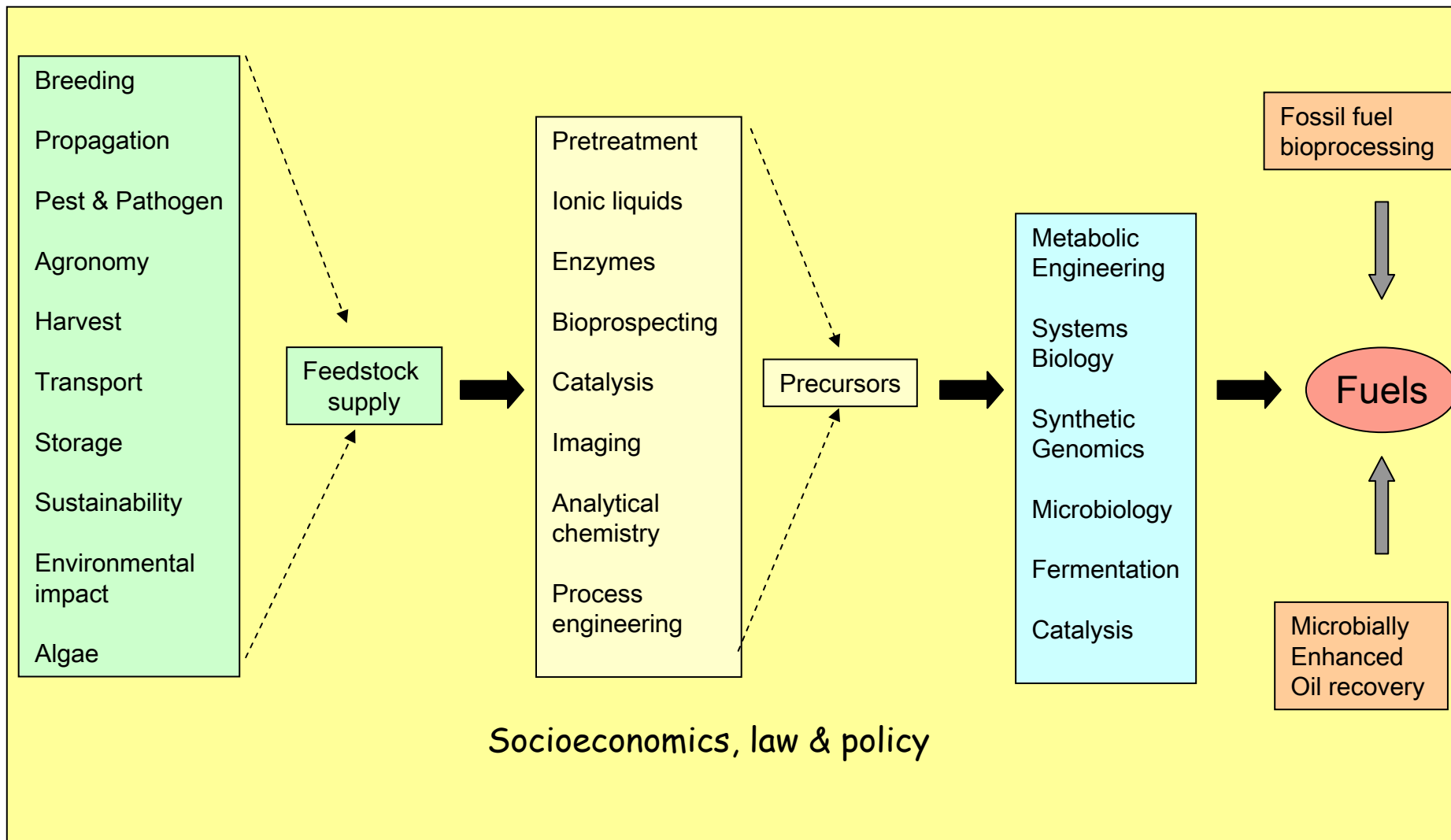


EBI design factors



- **A mission oriented multidisciplinary research institution**
- **Single organization doing open and proprietary work**
 - **Open work in Fundamental Energy Biosciences**
 - **Co-locate some BP researchers**
- **A substantial and long-term commitment to engage quality researchers (\$500m over 10 years)**
- **Host at a world-class institution to maximize academic presence and interdisciplinary interaction.**

Technical reach of the EBI

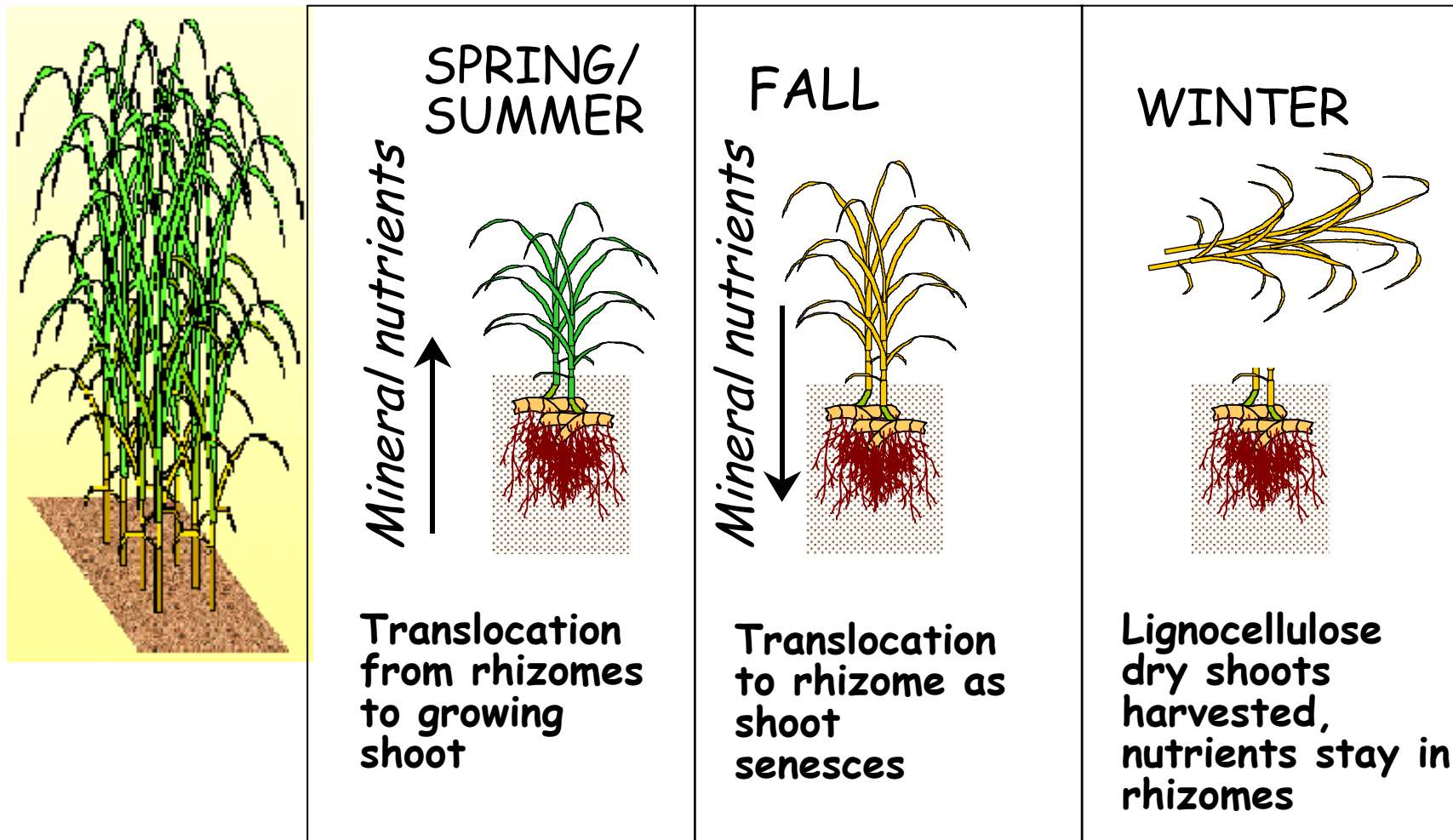


Summary of LC research priorities



- **Develop energy crops and associated agronomic practices**
- **Identify or create more active catalysts for conversion of biomass to sugars and sugars to fuels**
- **Develop improved industrial microorganisms**
- **Develop new types of microorganisms that produce and secrete hydrophobic compounds**
- **Understand the social, economic, and environmental implications**

Nitrogen use efficiency



Courtesy of Steve Long et al

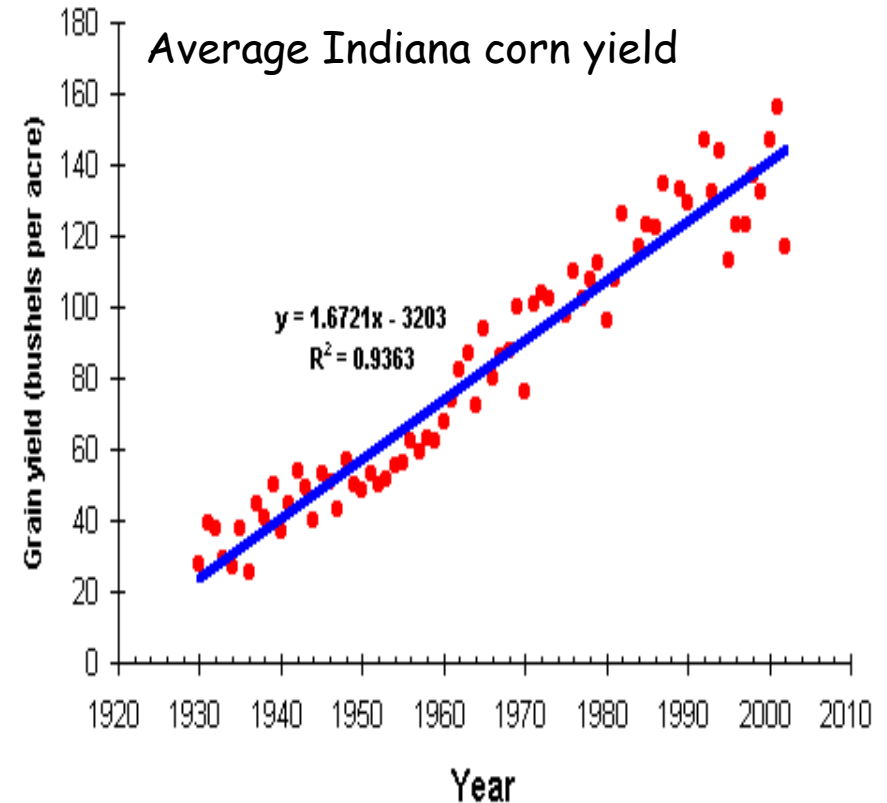
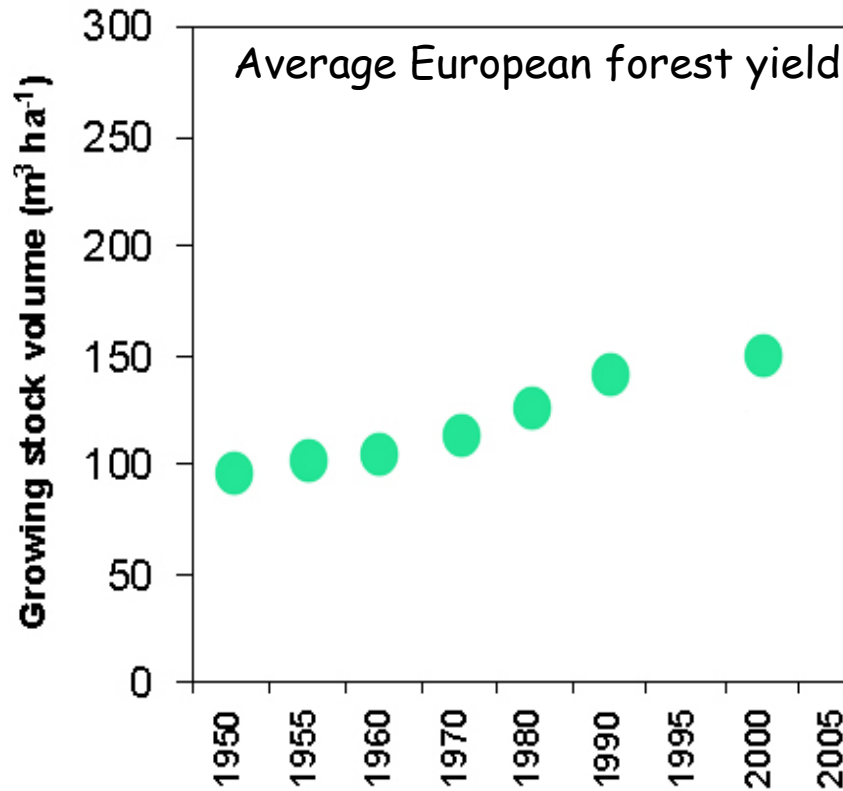
Miscanthus giganteus

Yield of 26.5 tons/acre observed by Long & colleagues
in Illinois, without irrigation



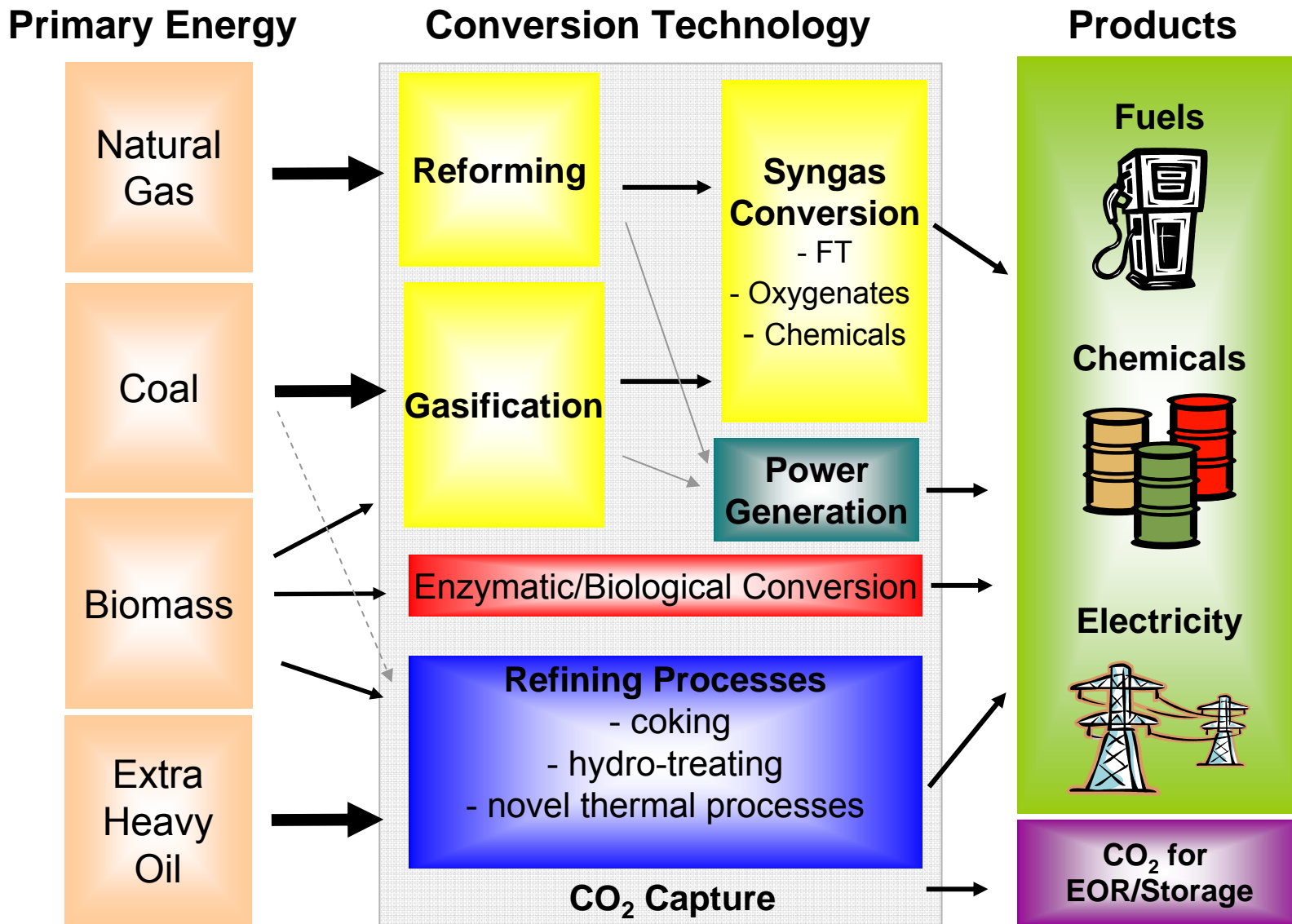
Courtesy of Steve Long et al

Crop yields have been strongly increased but biomass yields have not



Source: European Forest Institute (www.efi.fi)
Indiana Agricultural Statistics Service

The fungibility of carbon



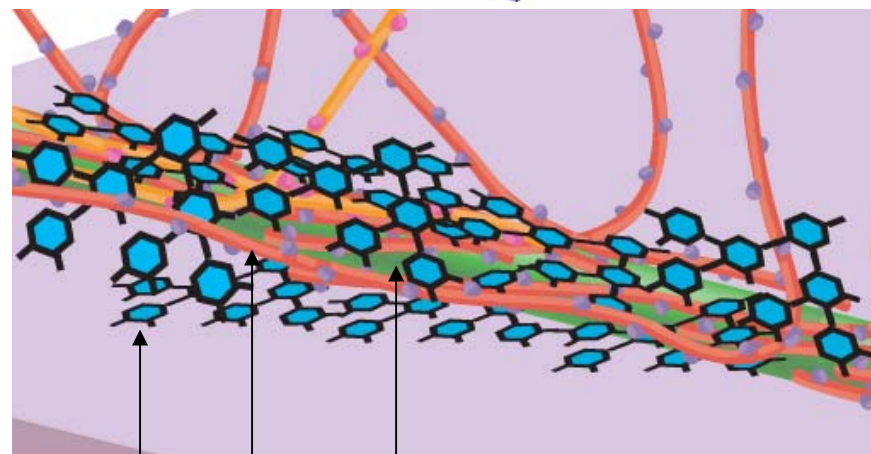
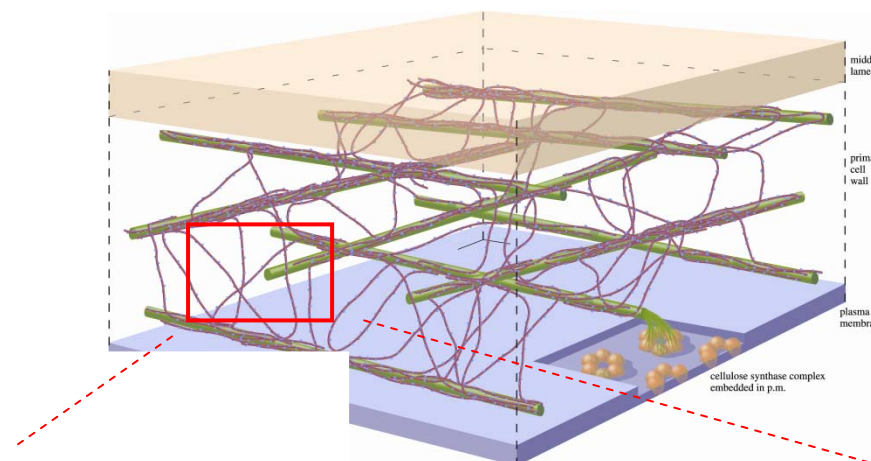
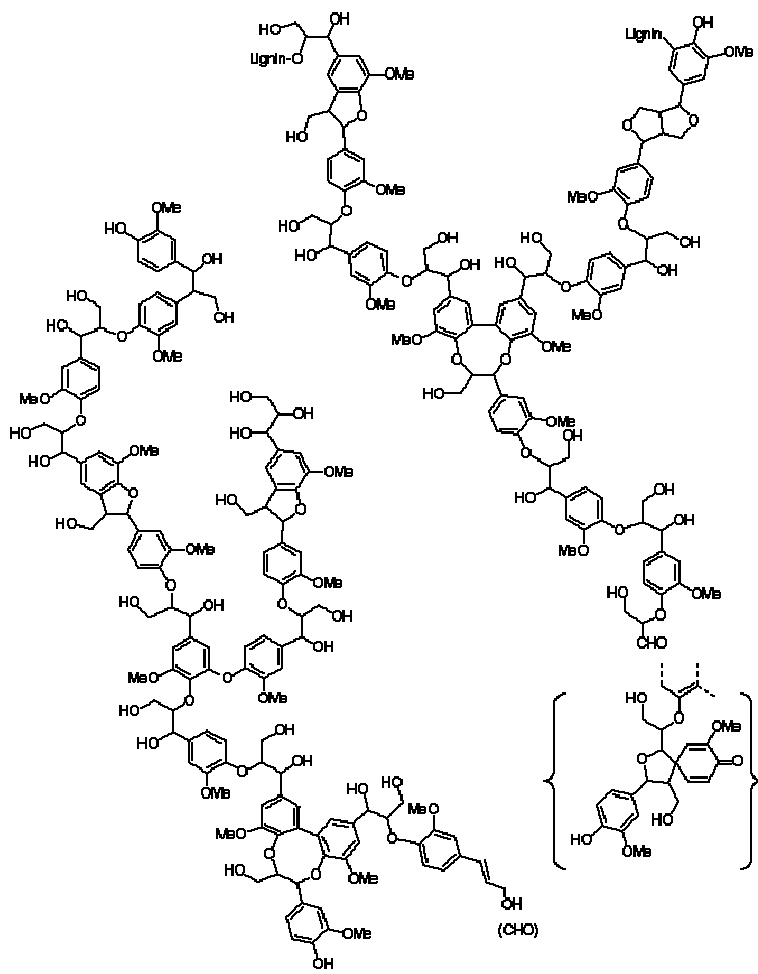
Key Challenges

LC conversion technology



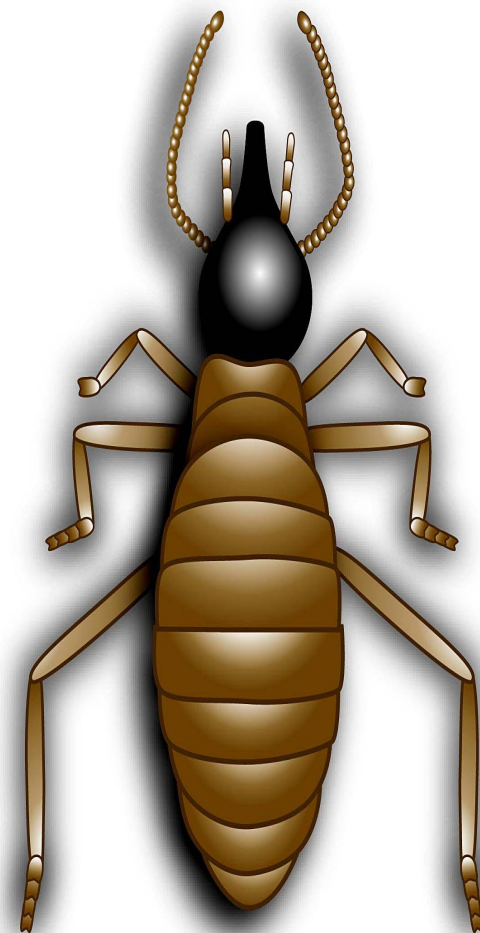
- **Overcoming the recalcitrans of LC biomass**
- **Efficiently utilizing all sugars**
- **Producing better fuel molecules beyond ethanol**
- **Creating a highly productive, stable host organism**

Lignin occludes polysaccharides

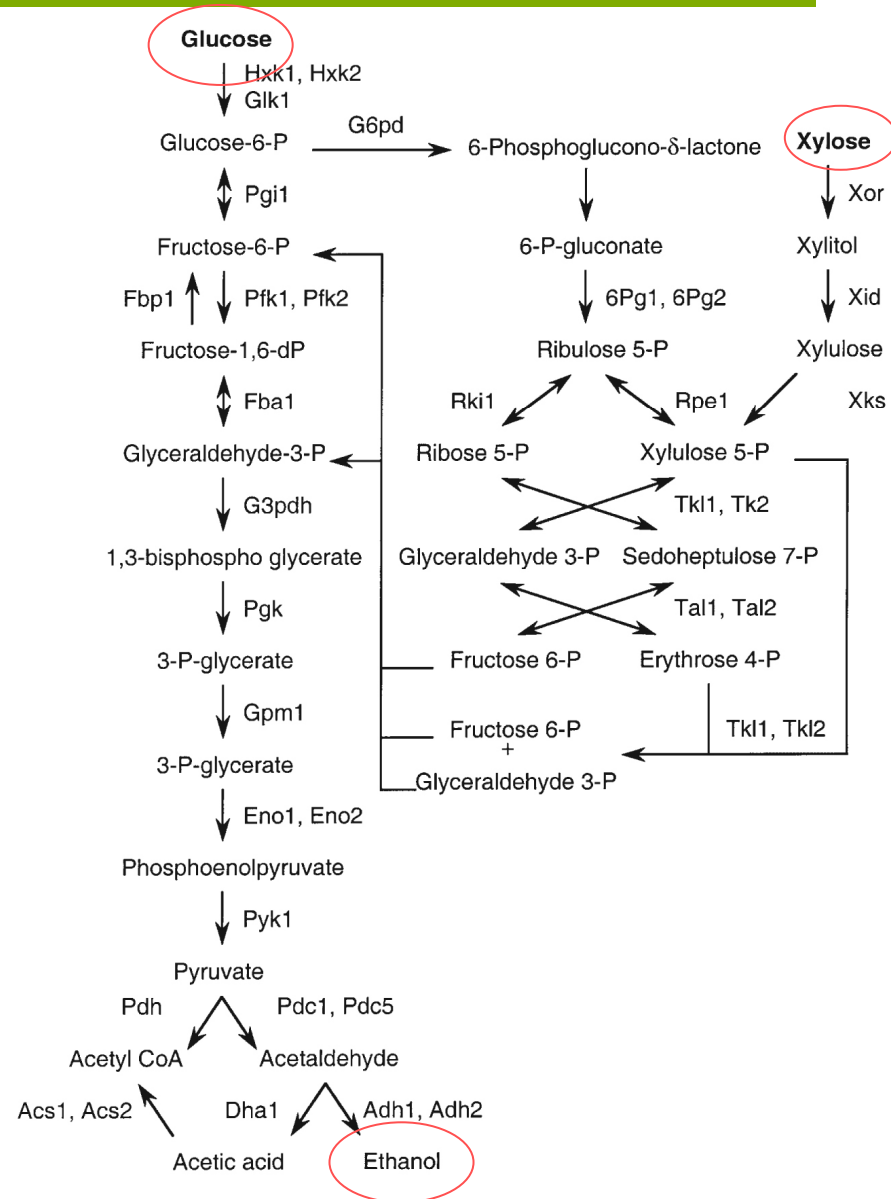
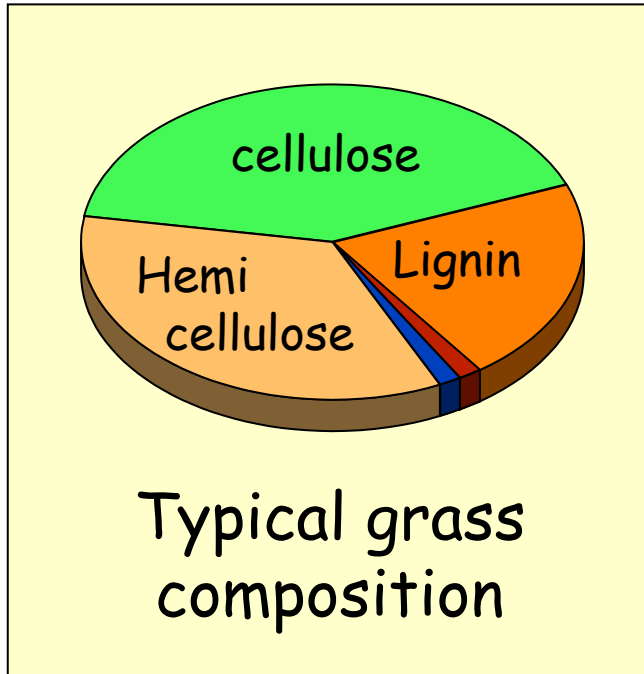


Lignin
Hemicellulose
Cellulose

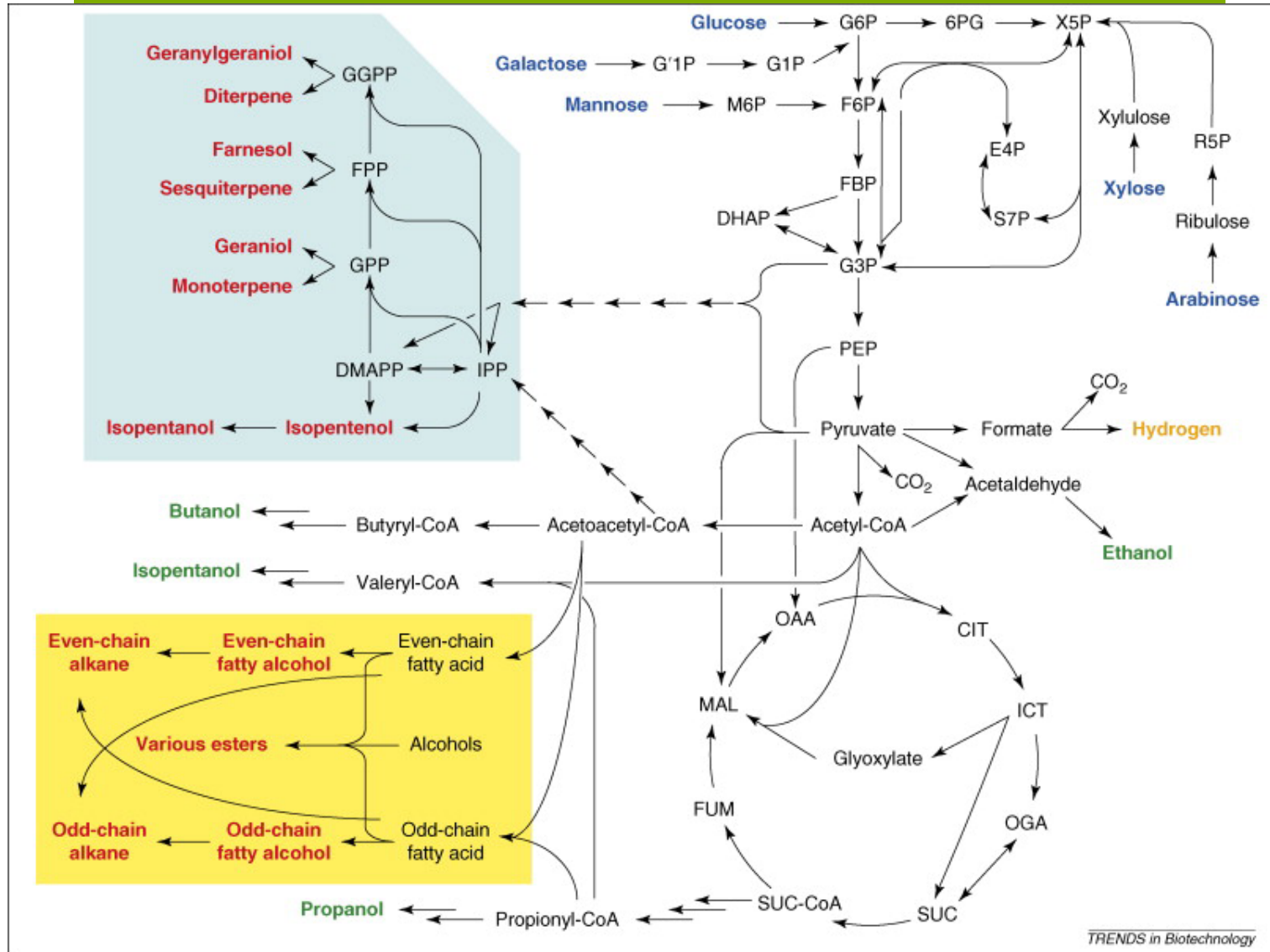
- Explore the enzyme systems used by termites for digesting lignocellulosic material
- Same for ruminants
- Compost heaps and forest floors are poorly explored
- In vitro protein engineering of promising enzymes
- Develop synthetic organic catalysts (for polysaccharides and lignin)



Routes to fermentation of all sugars are known



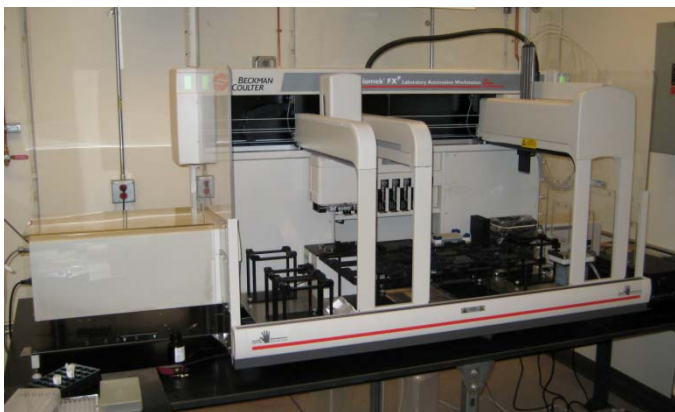
Routes to potential fuels



TRENDS in Biotechnology

Robotics have enabled high throughput assays

Automated Pre-screening of feedstock-derived inhibitors of bacterial growth

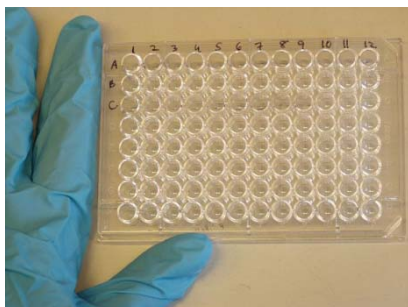


Biomek Robot

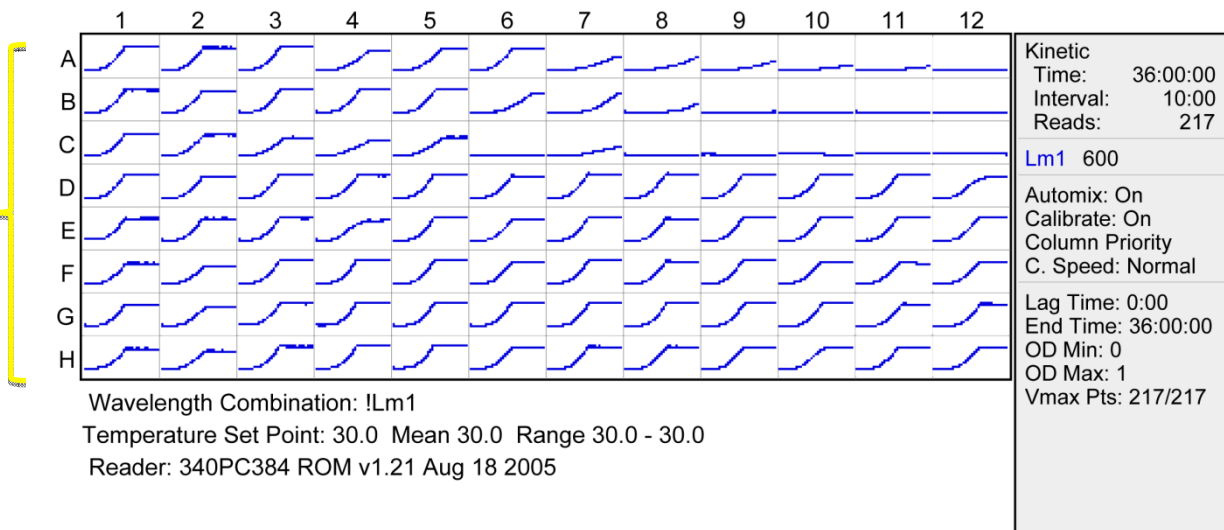
Inhibitor concentration



Inhibitors



96-well microtiter plate



State of the science



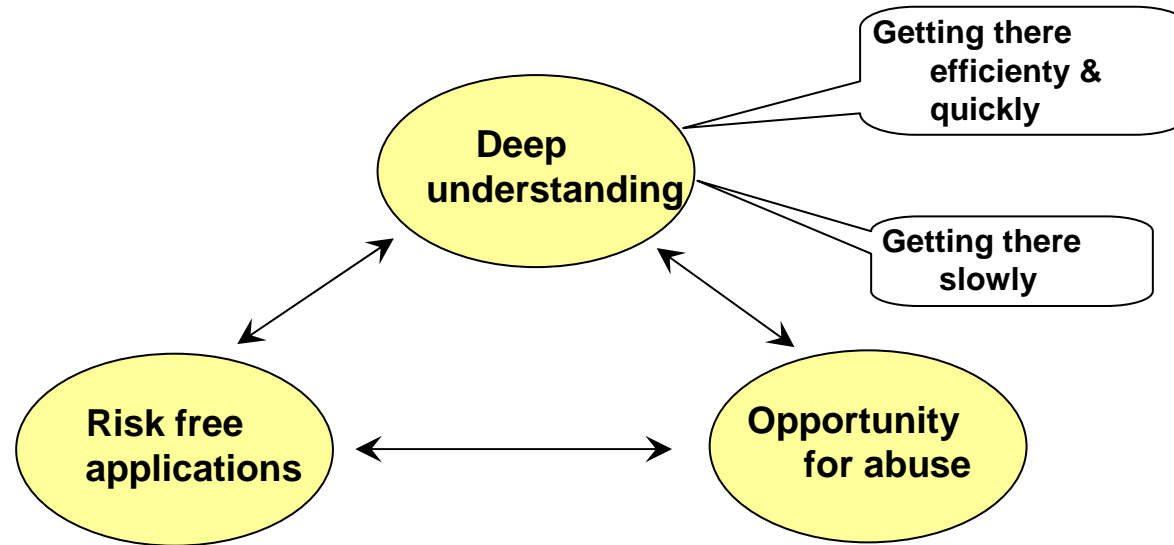
- Cheap sequencing
 - lots of new data
 - lots of unknown enzymes
 - even more poorly understood enzymes
- Various HighThroughput methods
 - analytics
 - “omics” profiling
 - biological selection
 - large amounts of empirical data to help inform genetics
- Creating deep understanding of biological systems
 - enzymes in context versus one off
 - signaling
 - regulation
- Demonstrating that we have really understood → SynBio
- Conducting efficient research

Definitions of SynBio vary



	Commercialization
• Building new organisms from the ground up	???
• Creating de novo solutions synthetically	5-10 years
• Use of gene synthesis products (e-mail genetic code → DNA in the mail)	Now
• Some degree of GM	Now
• Generation & application of systemic understanding	0-5 years

Governance and risks – a dilemma



Same dilemma with other technologies

- Nuclear
- Chemistry
- Electronics

→ **How to minimize the negatives while capturing the positives**

But

Infinite set of possibilities

Disclaimer



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