Energy
Biosciences
Institute

Development of Cellulosic Fuels

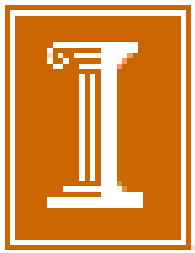
Chris Somerville

The Energy Biosciences Institute

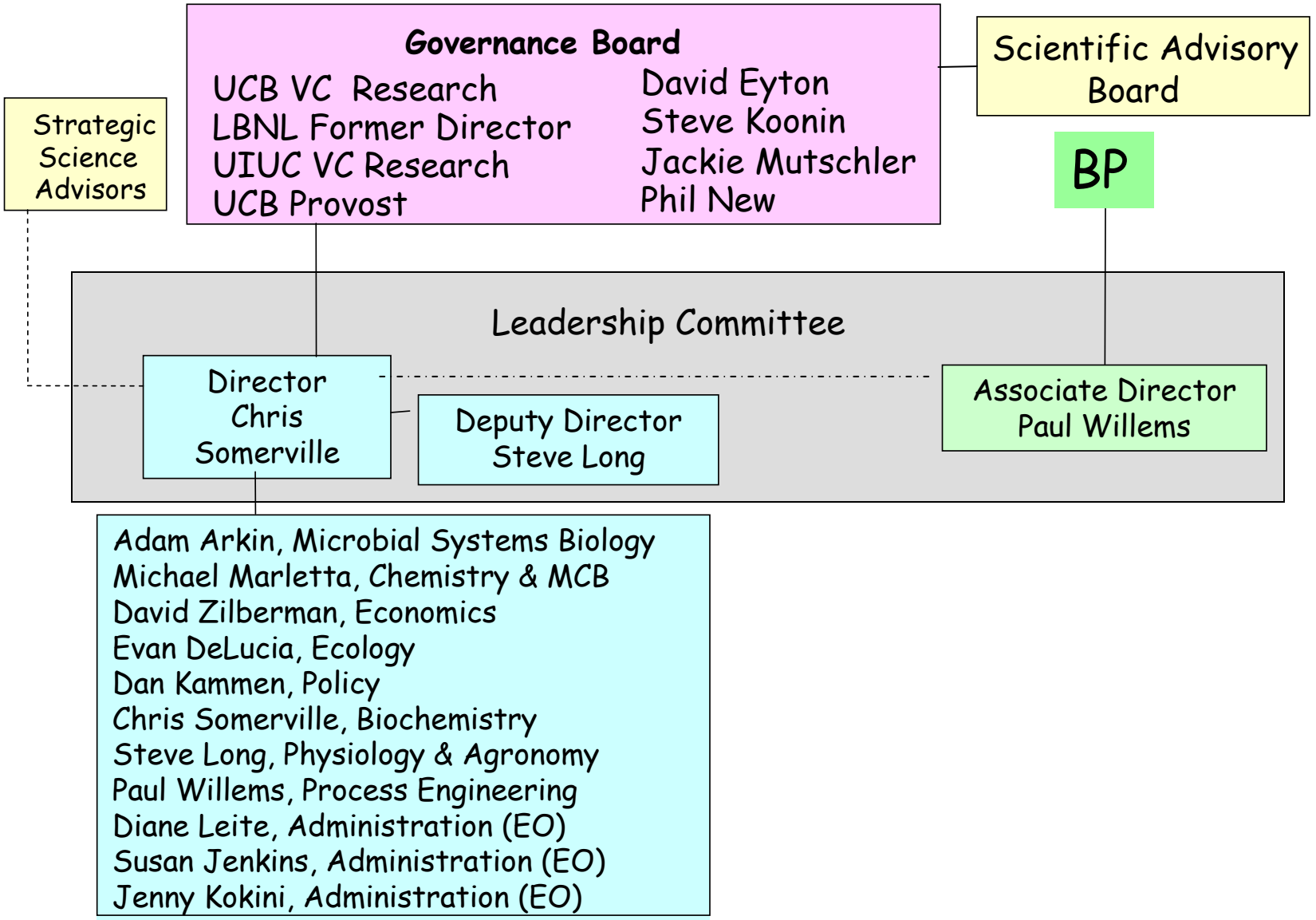
- Mandate to explore the application of modern biological knowledge to the energy sector
  - Cellulosic fuels
  - Improved fossil fuel recovery and processing
  - Other

The Energy Biosciences Institute

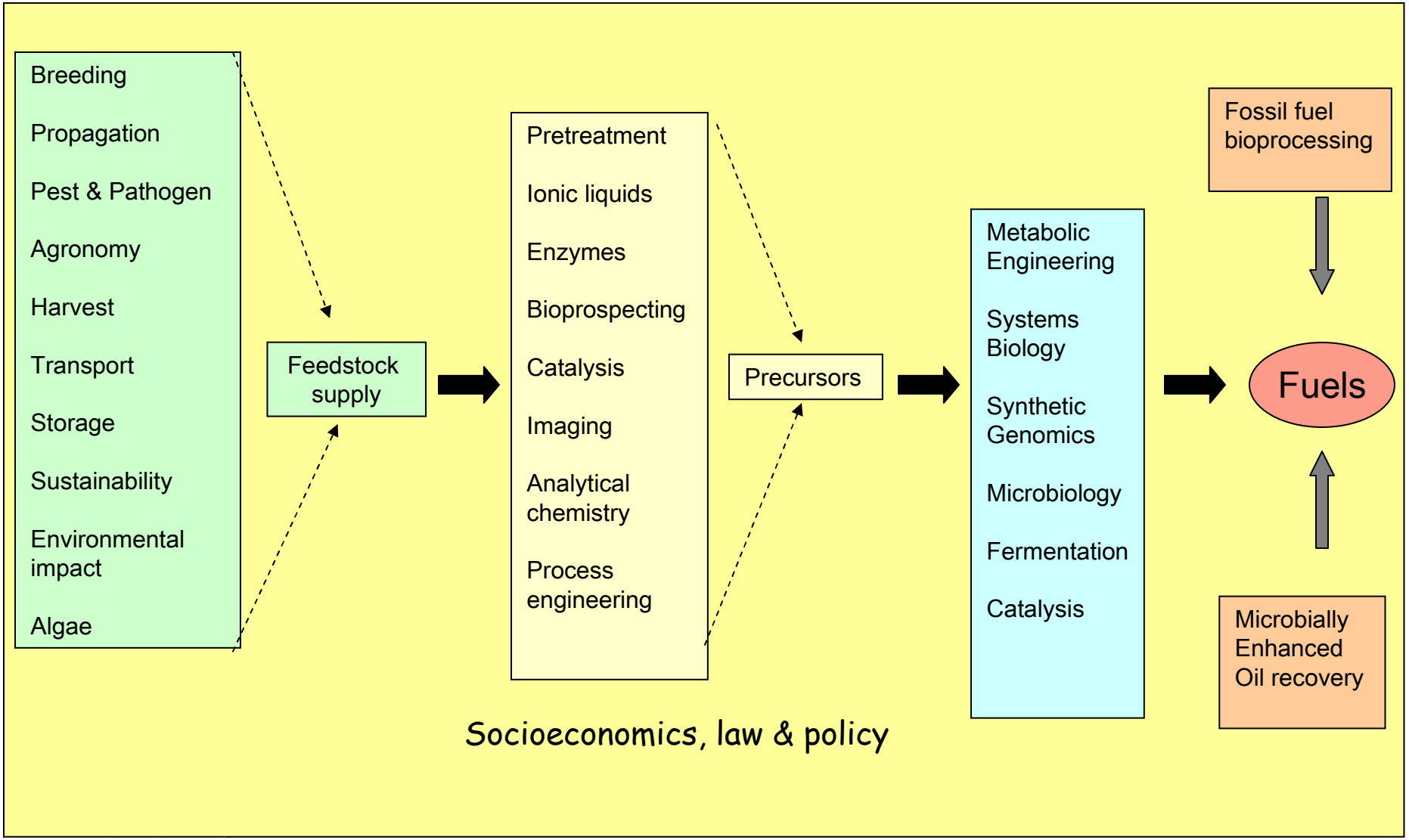
- Value to the partners
  - Develop comprehensive understanding of the opportunities in selected areas
  - Identify or create enabling technologies



EBI Governance and Oversight



Technical reach of the EBI



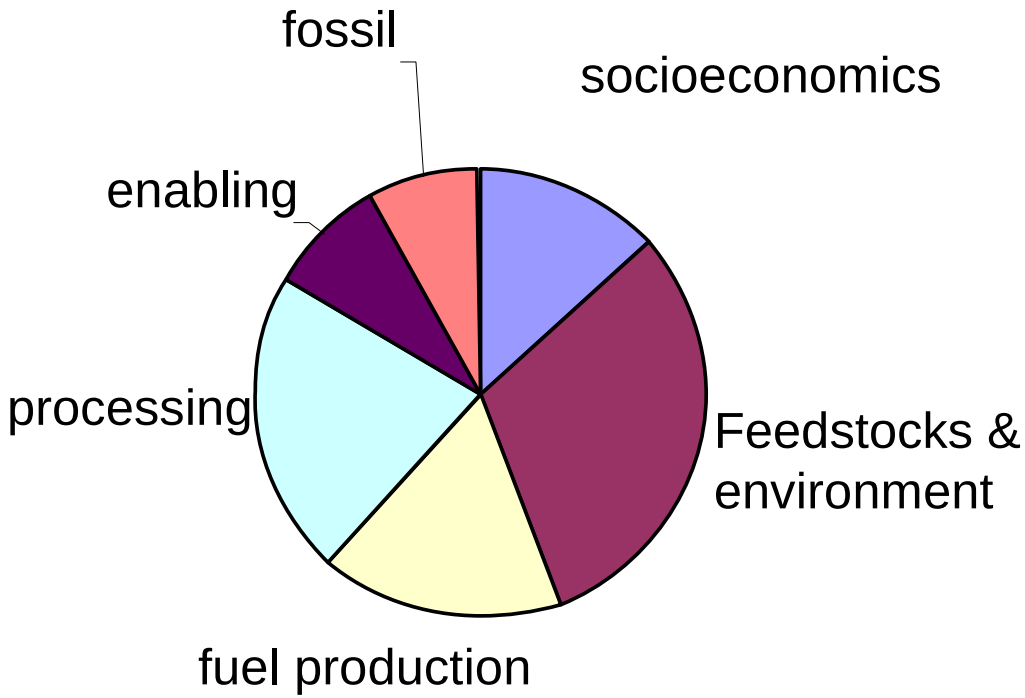
General Research Strategies

- Startup phase is exploratory: we are investing broadly across the complete spectrum of issues to create capability
- Where opportunities are not well defined we are investing in workshops and reports
- Multidisciplinary to facilitate comprehensive view
- Colocated research groups to facilitate horizontal integration
- Projects for small exploratory activities, programs for core activities

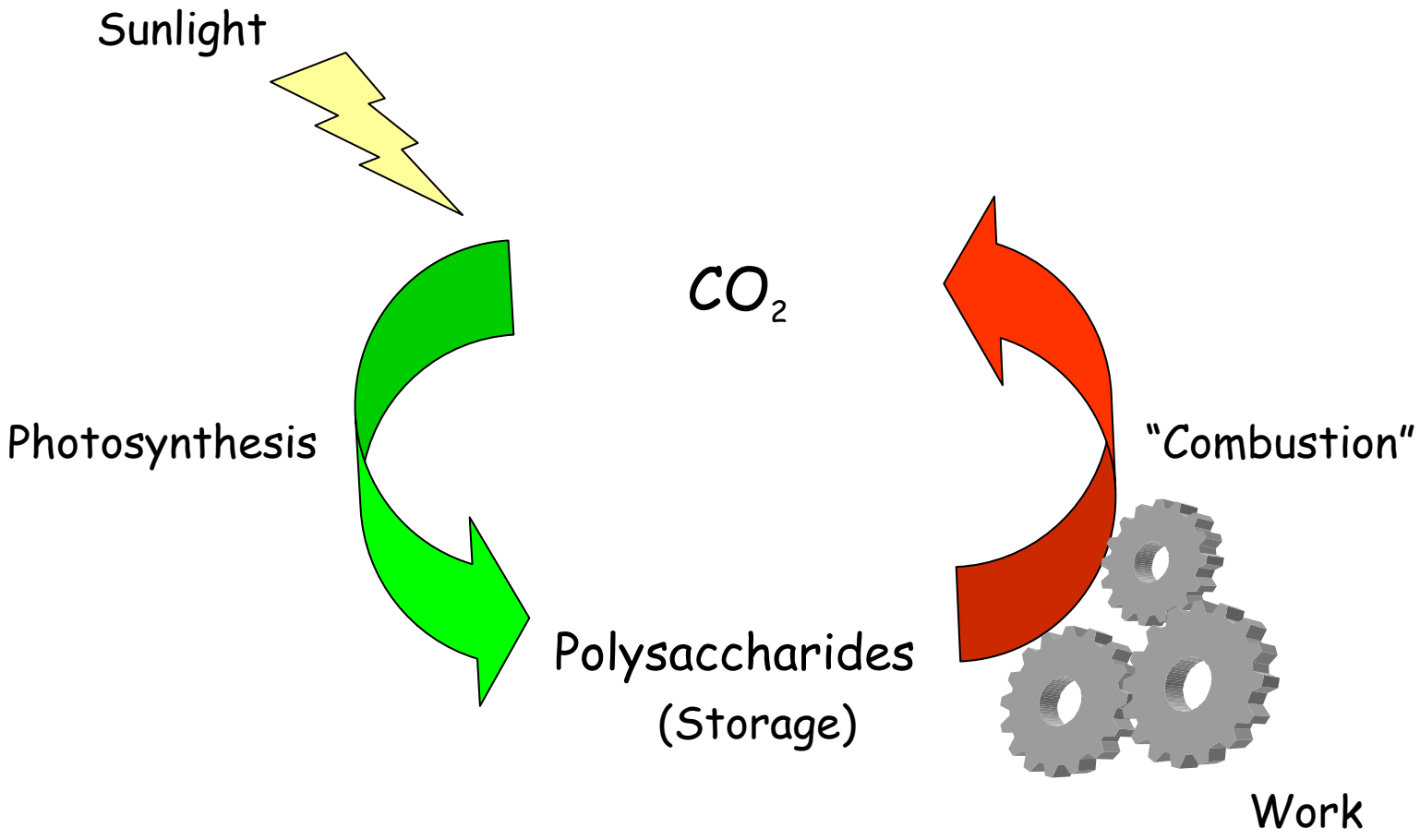
Summary of priorities

- Enable feedstock availability
- Identify or create more active catalysts for conversion of biomass to sugars and sugars to fuels, or biomass to fuels with minimal preprocessing
- Develop microorganisms that use all sugars and thrive in hydrolysate
- Develop strains that produce and secrete hydrophobic fuels
- Understand the social, economic, and environmental implications
- Explore new ideas in fossil fuel recovery and processing

Current budget allocation



Combustion of biomass *can* provide carbon neutral energy



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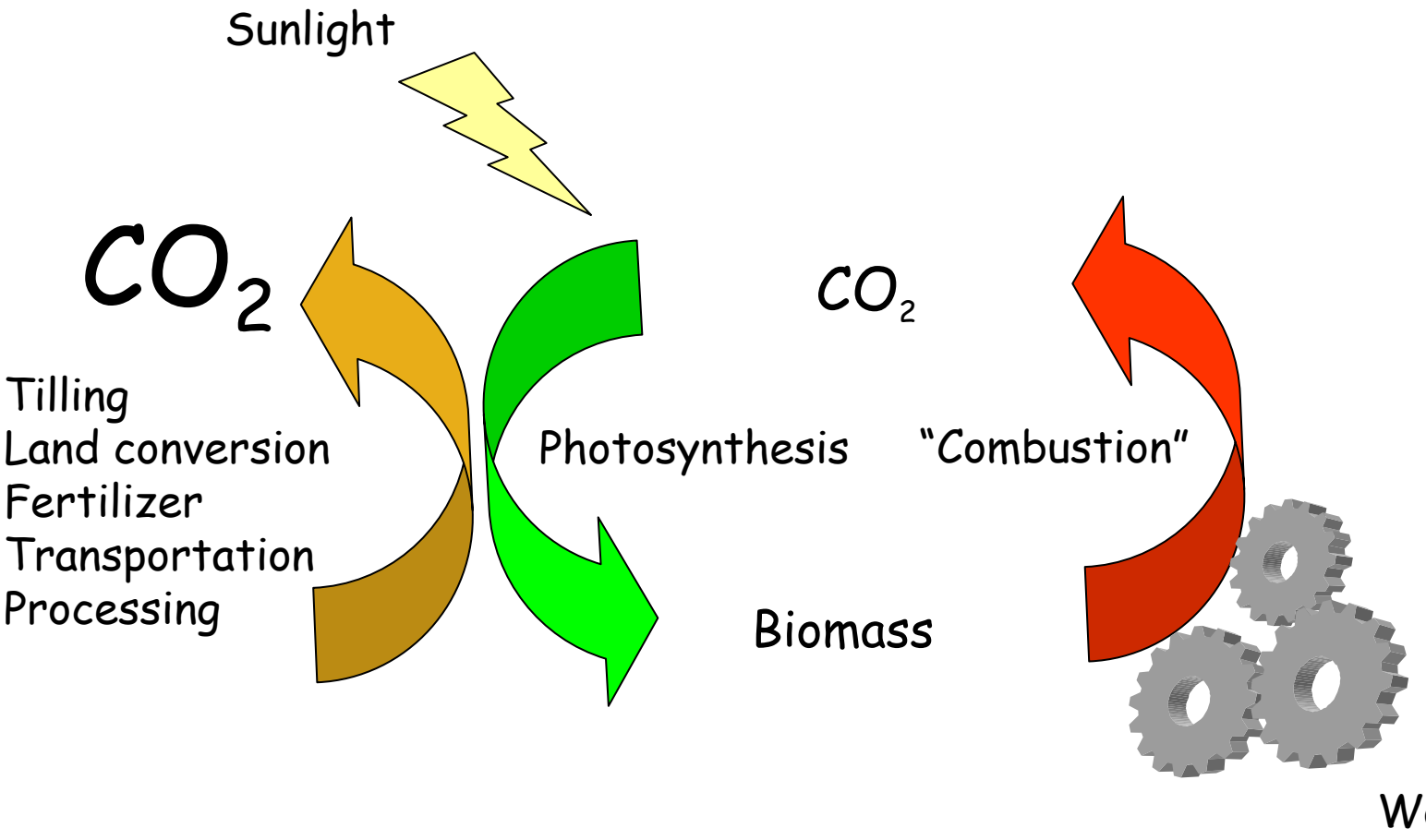


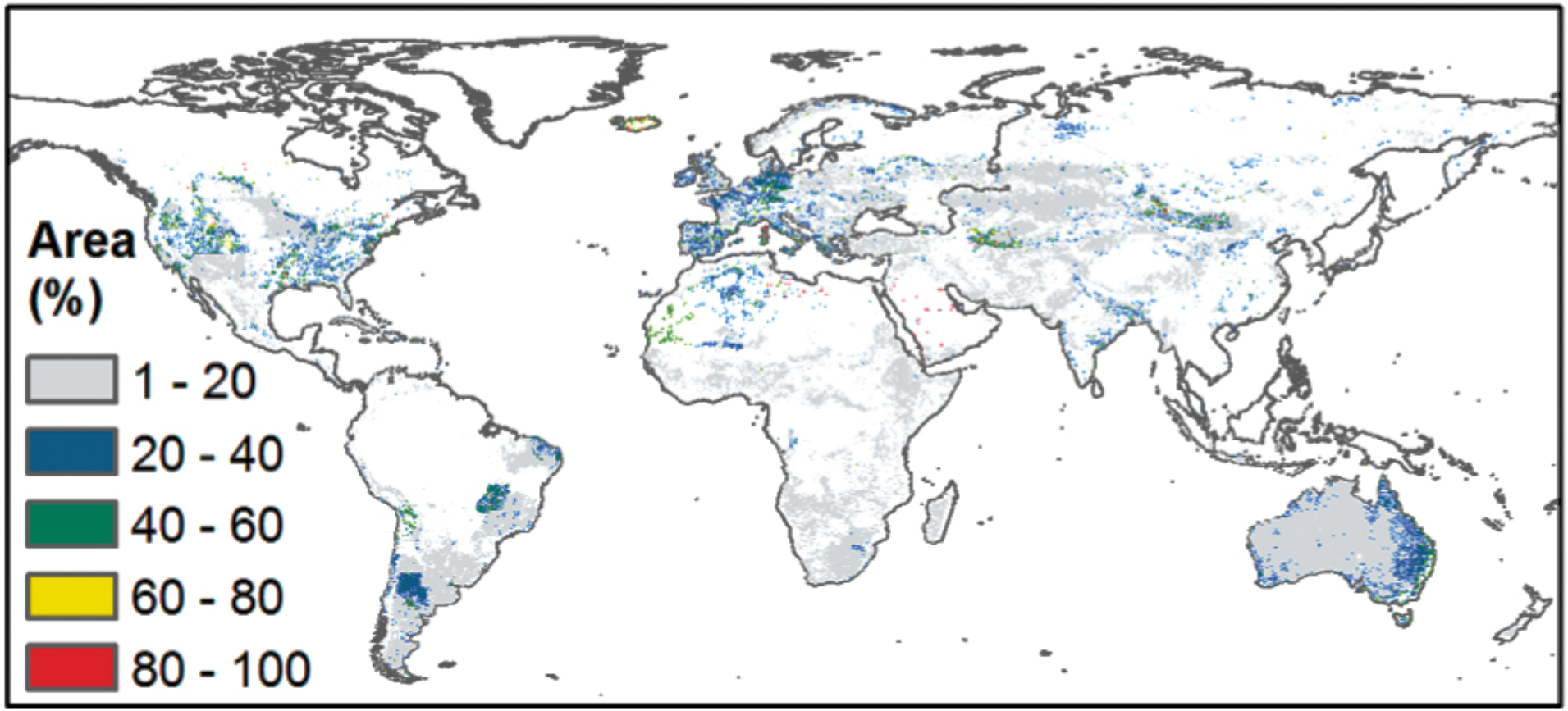
But it depends on how the biomass is produced and processed

Responsible Biofuels

- No conversion of undeveloped land
- No erosion, runoff, nitrous oxide emissions
- Net GHG benefits based on full lifecycle accounting
- No effect on food production

Corn Prices
(Chicago Board of Trade)

>>A billion acres of agricultural land have been abandoned



Campbell et al., Env. Sci. Technol. (2008) **ASAP Article**, 10.1021/es800052w

>1% yield is feasible

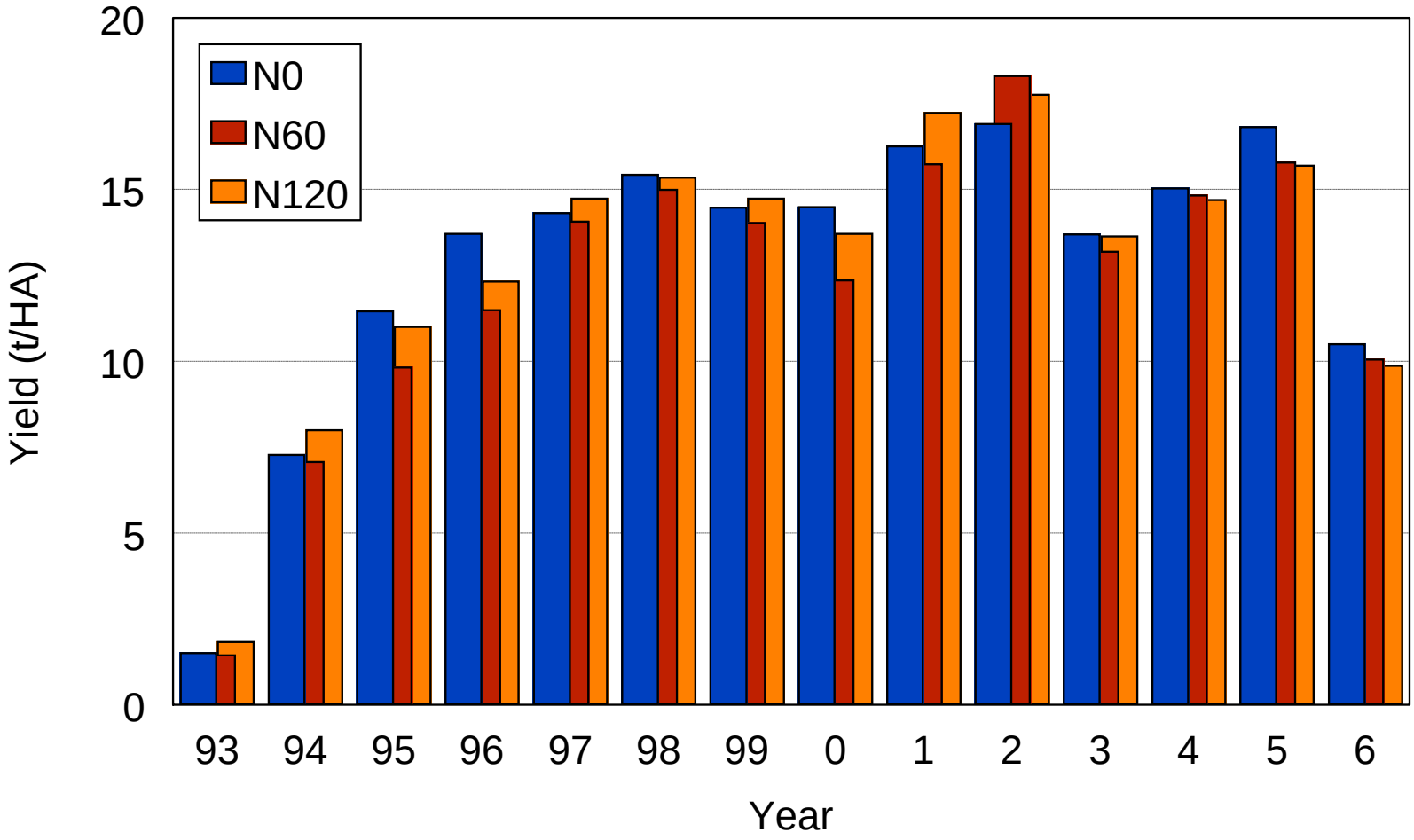
Yield of 26.5 tons/acre observed by Young & colleagues in Illinois, without irrigation

Courtesy of Steve Long et al

Harvesting Miscanthus

http://bioenergy.ornl.gov/gallery/index.html

Response of Miscanthus to nitrogen fertilizer



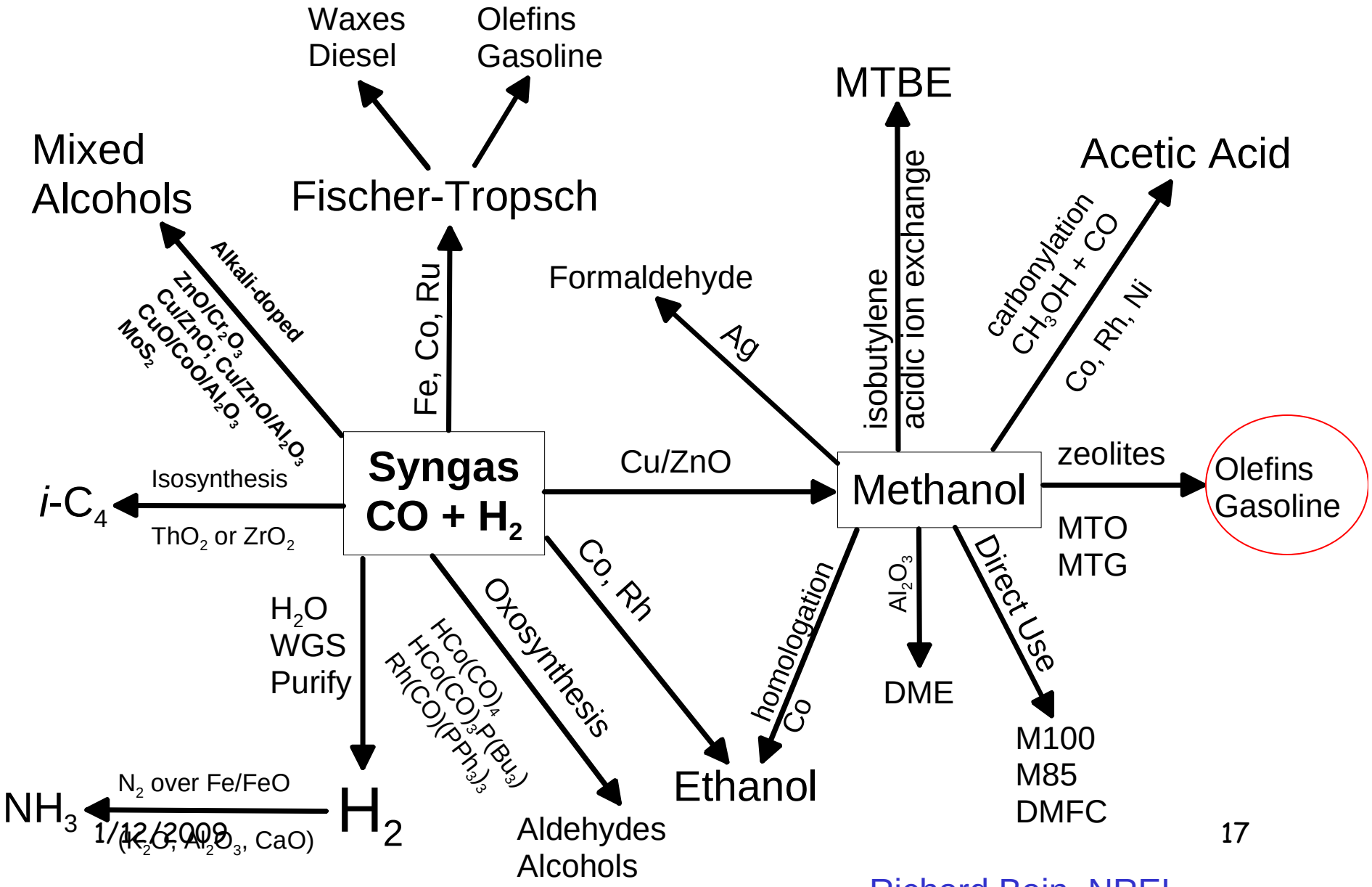
Christian, Riche & Yates Ind. Crops Prod. (2008)

Energy Farm

A Core EBI Facility

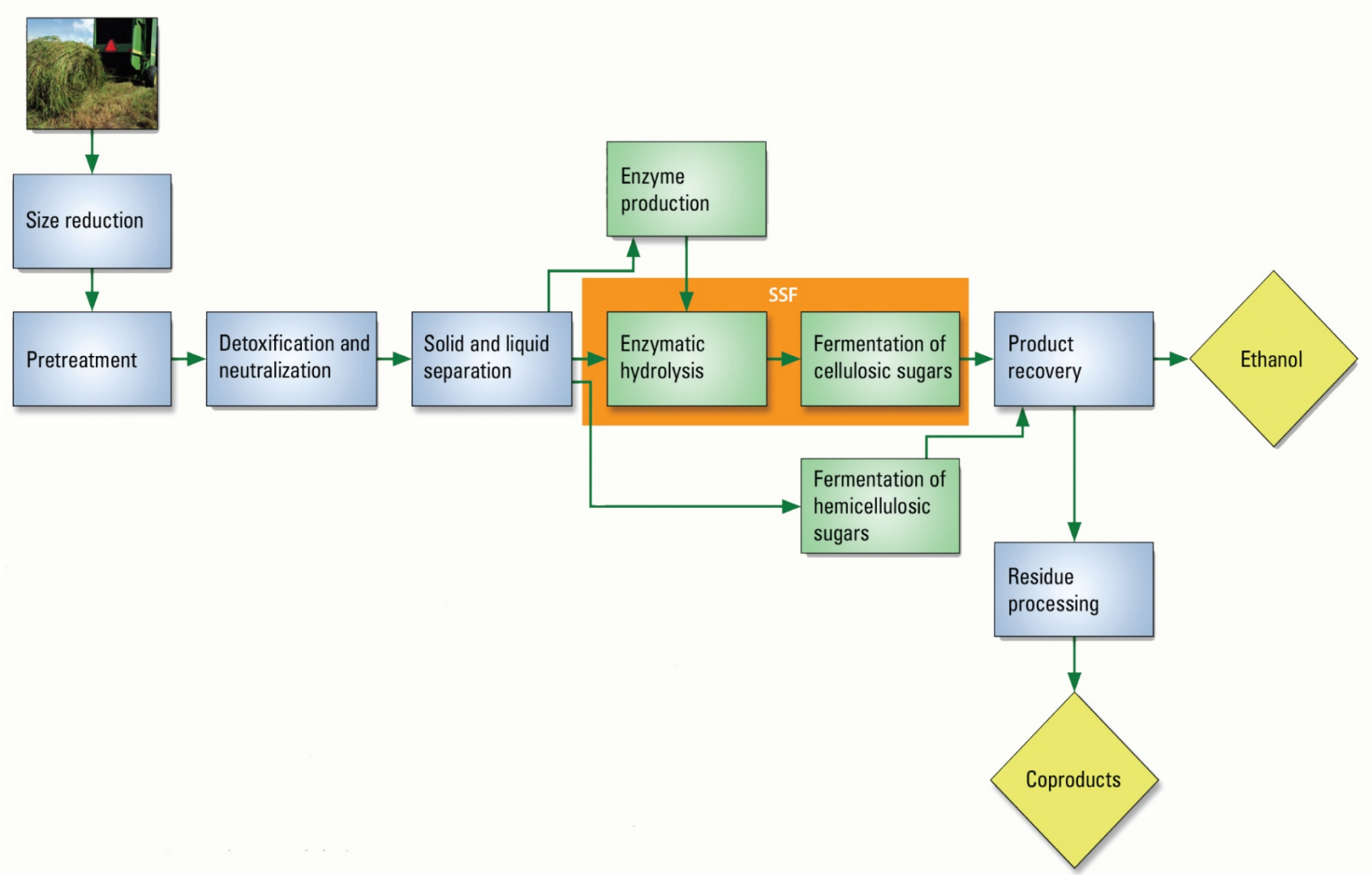
- 120 acres now in hand, 120 to be added in October and the final 80 in 2009.
- Will be a show-case for rural alternative energy, with a zero-energy house and 1.5 Mwh wind turbine (provided as separate additions by UIUC).
- State-of-the-art remote sensing of crop growth using unmanned aerial vehicle (mini-helicopter).
- Continuous greenhouse gas exchange monitoring (365 days/yr) installed over large scale trials of continuous corn, mixed prairie, switchgrass and Miscanthus feedstocks.
- Instrumented field drains installed below these crops.
- In use by five Programs, and providing test material to four Programs.
- Farm staff and machinery in place.
- Machine shed and feedstock storage space; start in November.
- Long-term objective would be to add a small interpretation and education facility, for student, farmer and lay groups.

Summary of Syngas-Liquids Processes



Richard Bain. NREL

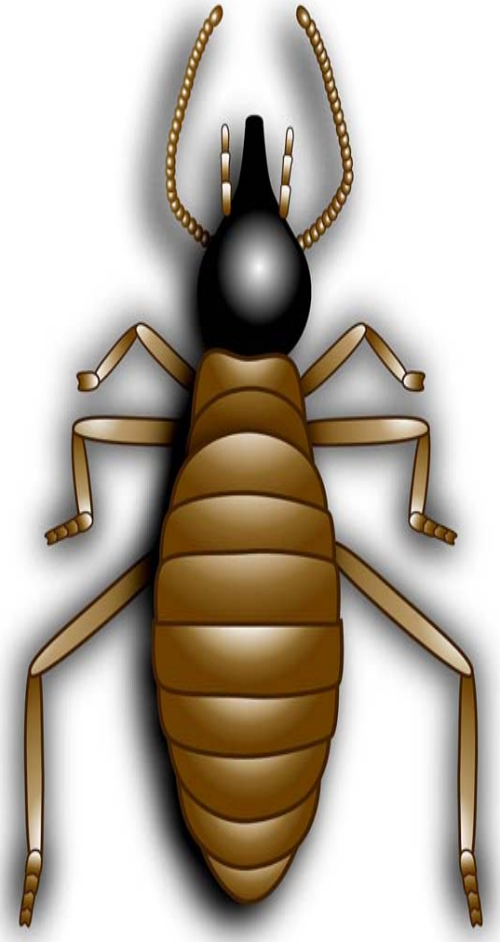
Steps in cellulosic ethanol production



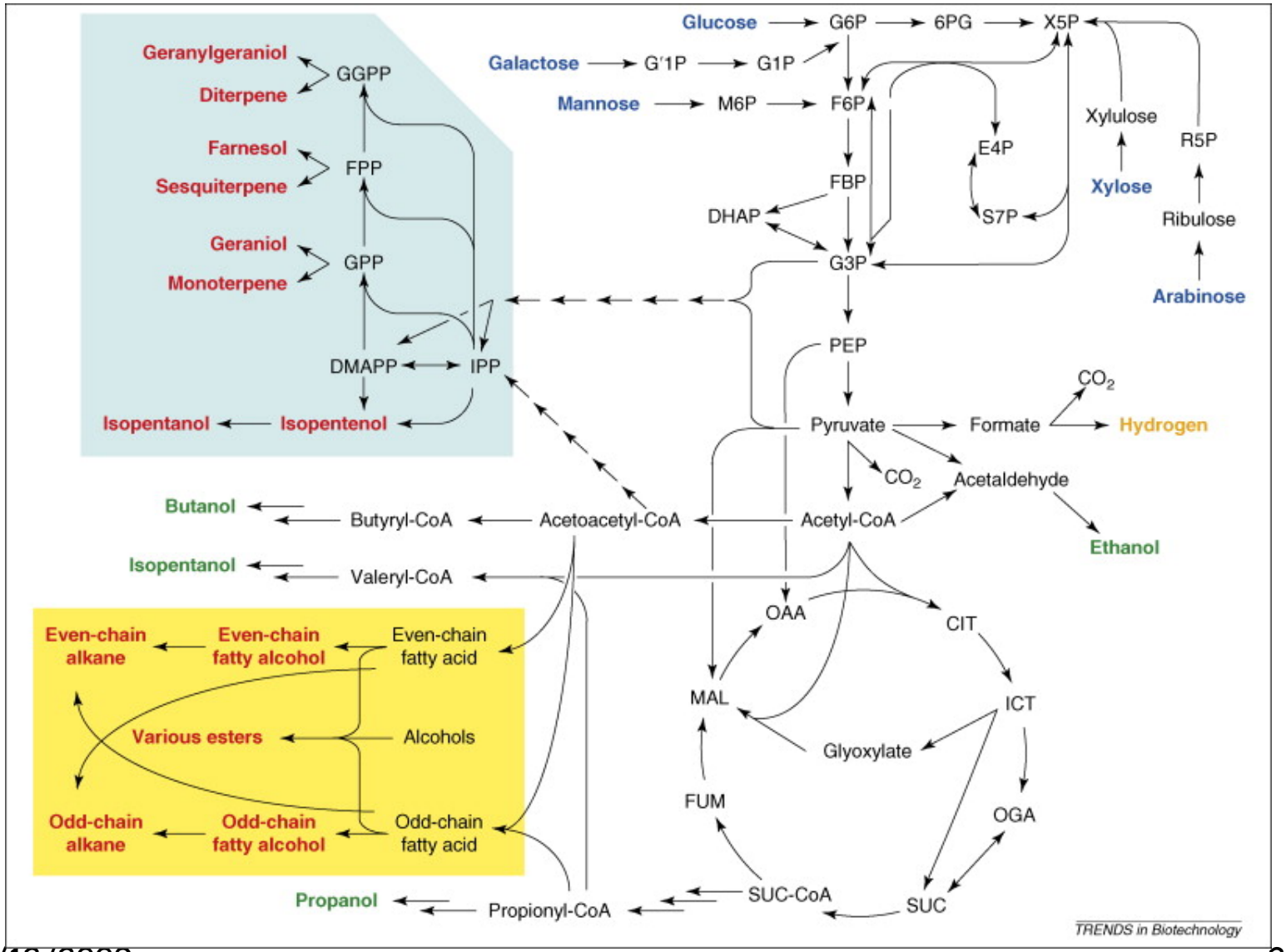
From: Breaking the Biological Barriers to Cellulosic Ethanol

Possible routes to improved catalysts

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

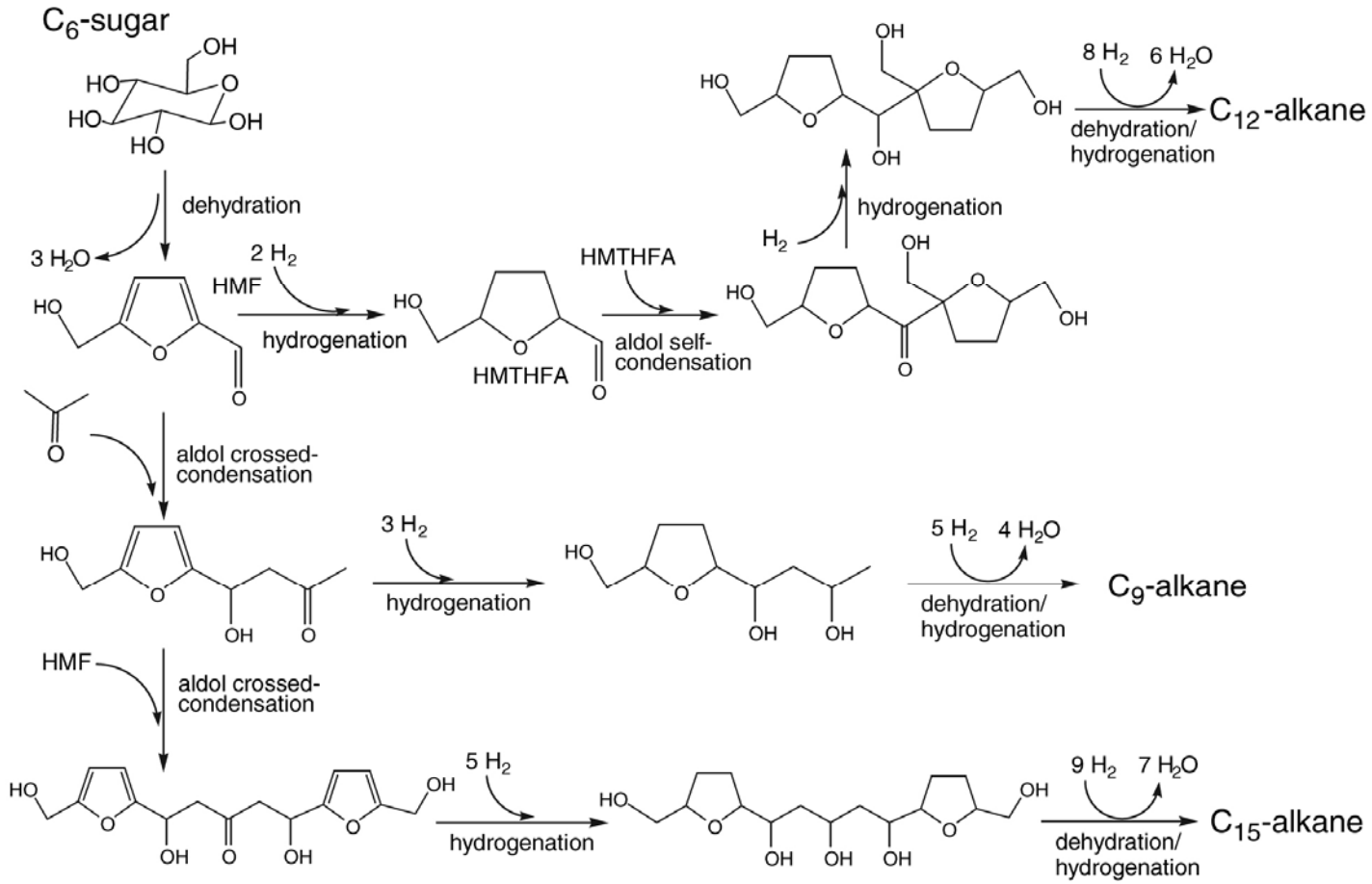


Routes to potential fuels



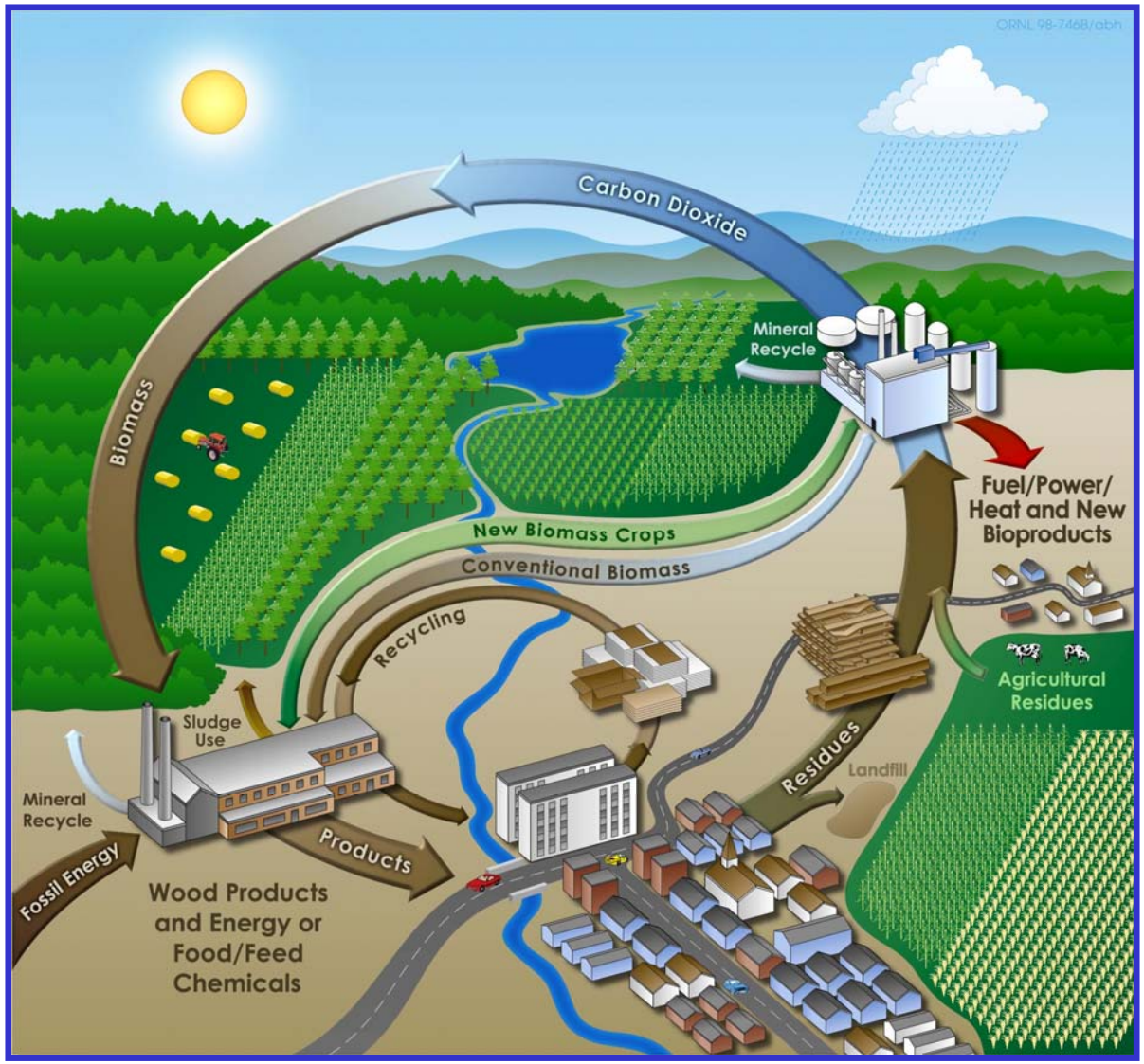
Fortman et al, Trends Biotechnology 26,375

Conversion of sugar to alkanes



Huber et al., (2005) Science 308,1446

The Future



http://genomicsgtl.energy.gov/biofuels/index.shtml