

*Distinguished Lecture Series in Biological  
Engineering*



**The Evolving Paradigm  
of Agriculture and  
Forestry as a Supplier of  
Energy and Industrial  
Raw Materials**



*Dr. Larry P. Walker  
Professor  
Department of Biological and  
Environmental Engineering  
Cornell University*

# The Big Question



How do we meet the energy and material needs of a sustainable global community?

**The  
Economist**

OCTOBER 25TH-31ST 2003

www.economist.com

**Don't blame China**

PAGE 65

**The Democrats' economic ideas**

PAGE 25

**Iran's last chance**

PAGE 12

**A SURVEY OF CORPORATE LEADERSHIP**

AFTER PAGE 50

# The end of the Oil Age



Biomass is the only renewable that directly reduces our dependency on liquid fuels.

# Father of Biobased Industry



*"I believe the Great Creator has put ores and oil on this earth to give us a breathing spell.....As we exhaust them, we must be prepared to fall back on our farms, which are God's true storehouse and can never be exhausted. For we can learn to synthesize materials for every human need from the things that grow."*

Dr. George Washington Carver  
(1864-1943)

# Plant Based Resources



- Plants are effective in sequestering and recycling carbon.
- Plant resources are genetically and chemically diverse.
- Plants are renewable resources.

# Feedstock Development Issues and Needs

- Expand breeding program to improve biomass and plant quality for biofuel production.
- Develop a response to potential disease problems on perennial grasses such as smuts, rusts and virus diseases, all of which may be intensified in a monocultural production system.

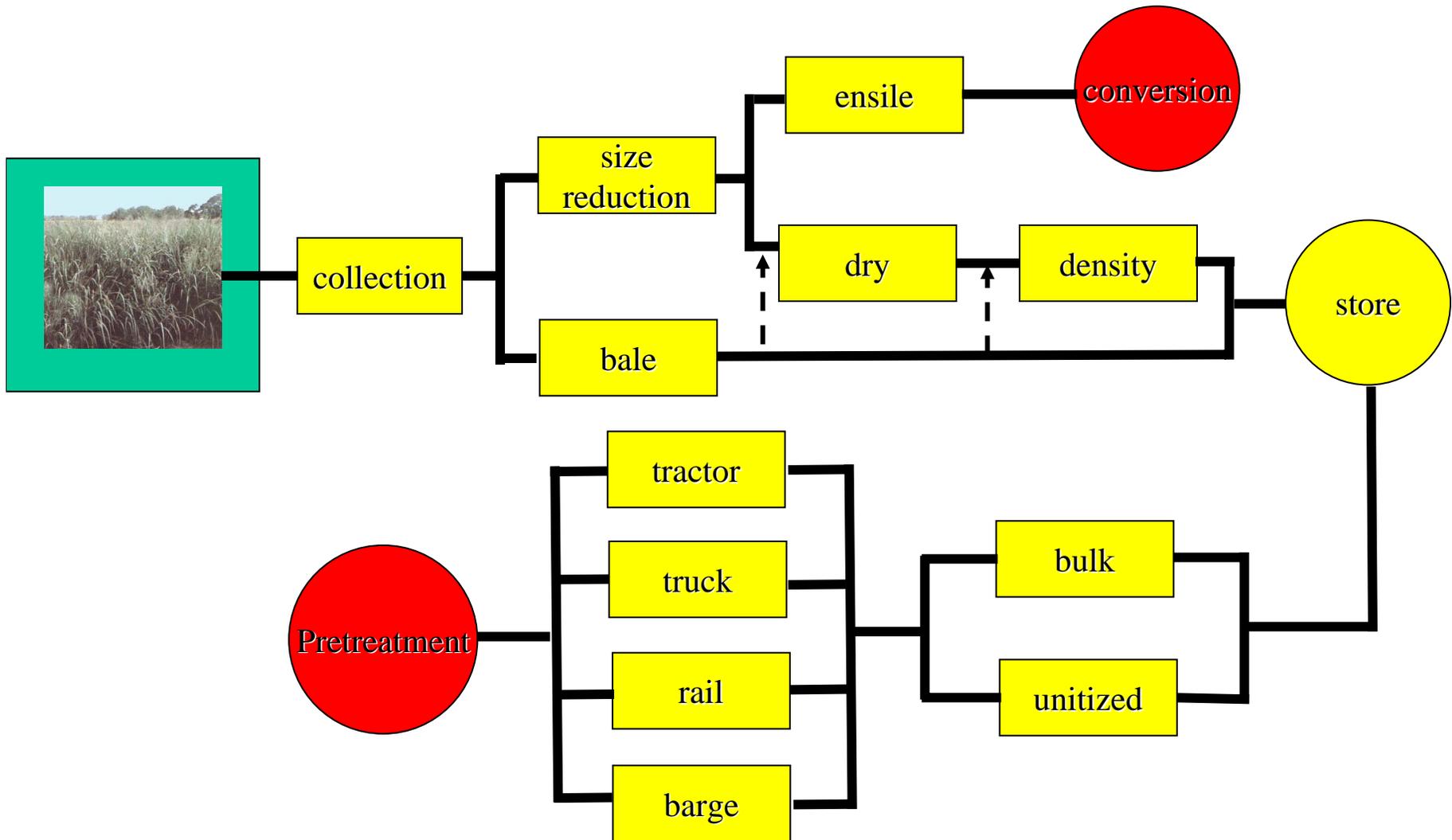


# Feedstock Development Issues and Needs

- Research is needed to determine the best species in mixtures for biomass production and pretreatment enzyme activity to convert cellulose into sugars.
- Explore using manure to meet nutrient requirements for crops that could be suitable for biofuel



# Feedstock Supply System

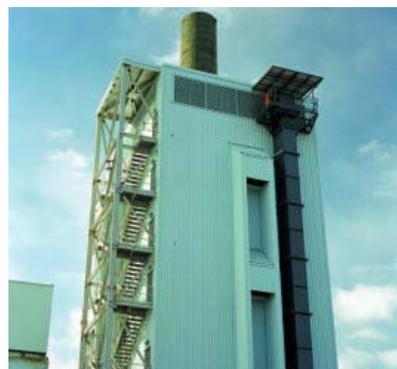


Source: USDOE

# Pathways for Biomass Conversion



Industrial  
Biotechnology



Thermochemical

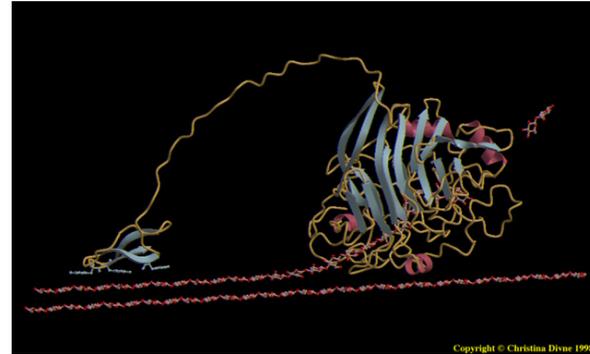
# Microbial Sources

*Shipworm bacterium*  
*Cellulomonas fimi*  
*Clostridium thermocellum*  
*Acetivibrio cellulolyticus*  
*Trichoderma reesei*  
*Thermobifida fusca*  
Plants



Environmental  
Sample

# Biocatalysts: Cellulases



## Cellulase Engineering

- Site directed mutagenesis
- Directed Evolution
- Enzyme discovery
- Developing novel cellulase cocktails

## Cellulase Production

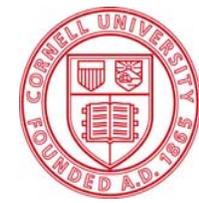
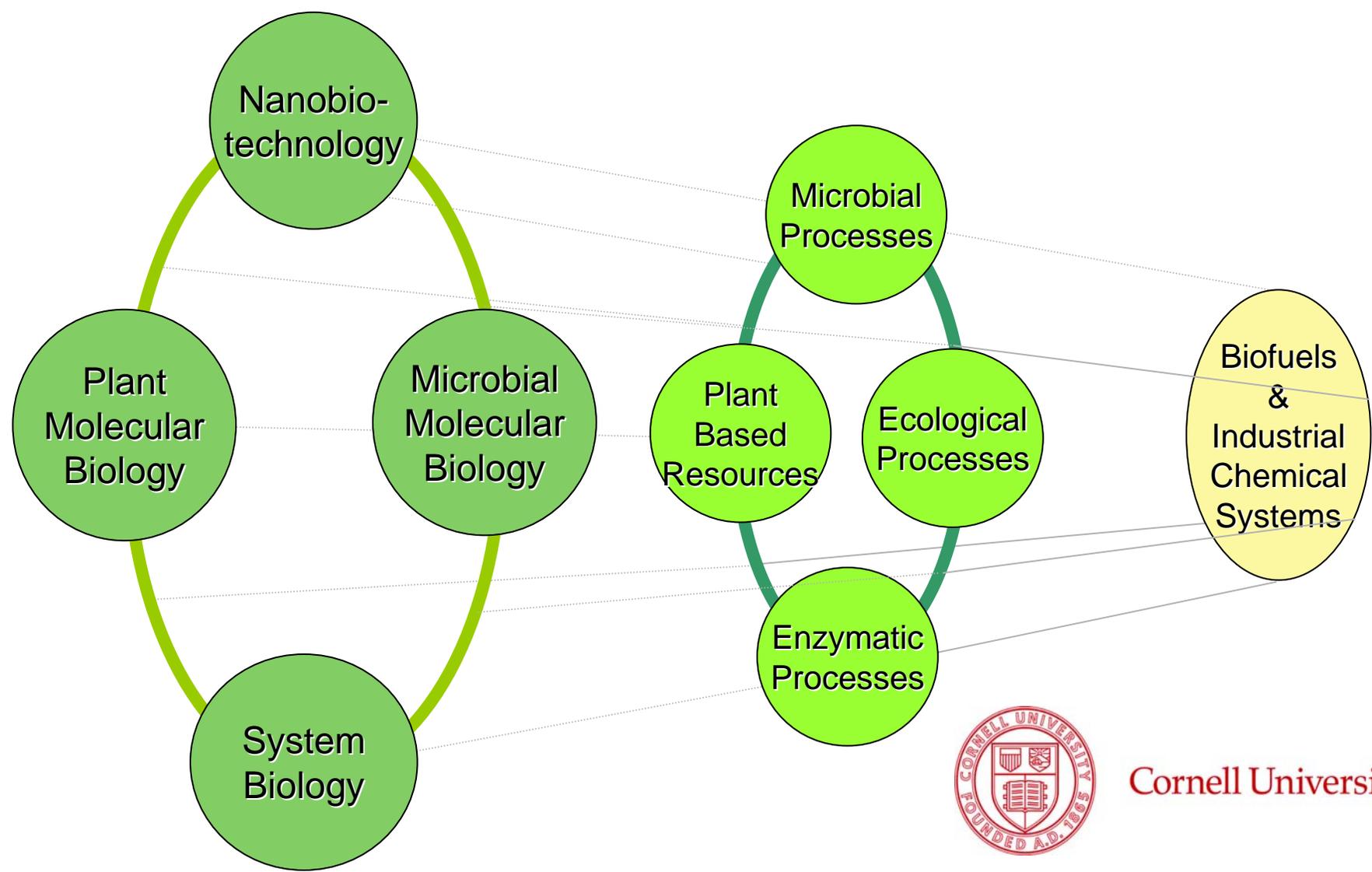


# Fermentation



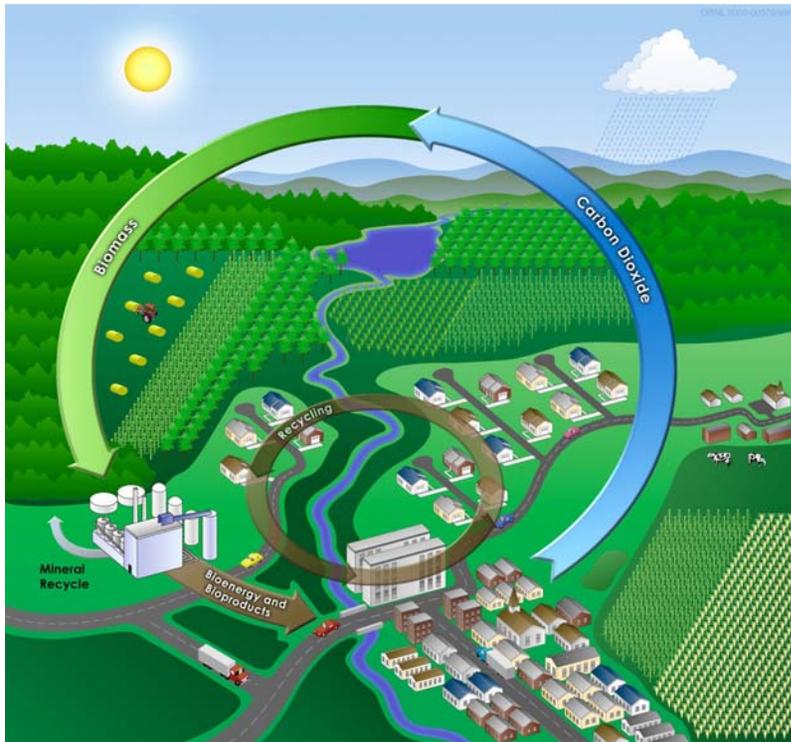
- Co-fermentation of mixed sugars streams;
- Increasing ethanol tolerance of *Saccharomyces cerevisiae*;
- Genetic engineering of yeast and other fermentative microorganisms, and
- Prospecting for new industrial microorganisms.

# Integrating Knowledge and Methods from Basic and Applied Sciences for a Mission



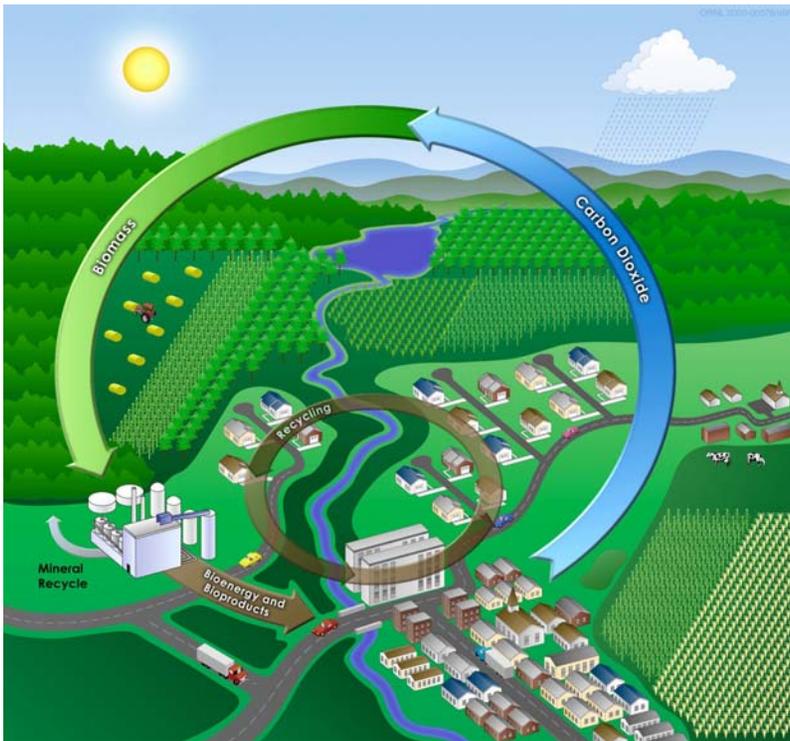
Cornell University

# Innovative in How We Network Transformation Processes



How do we integrate structural and dynamic aspects of natural ecology in our design of industrial ecology?

# Some Elements of Industrial Ecology Design

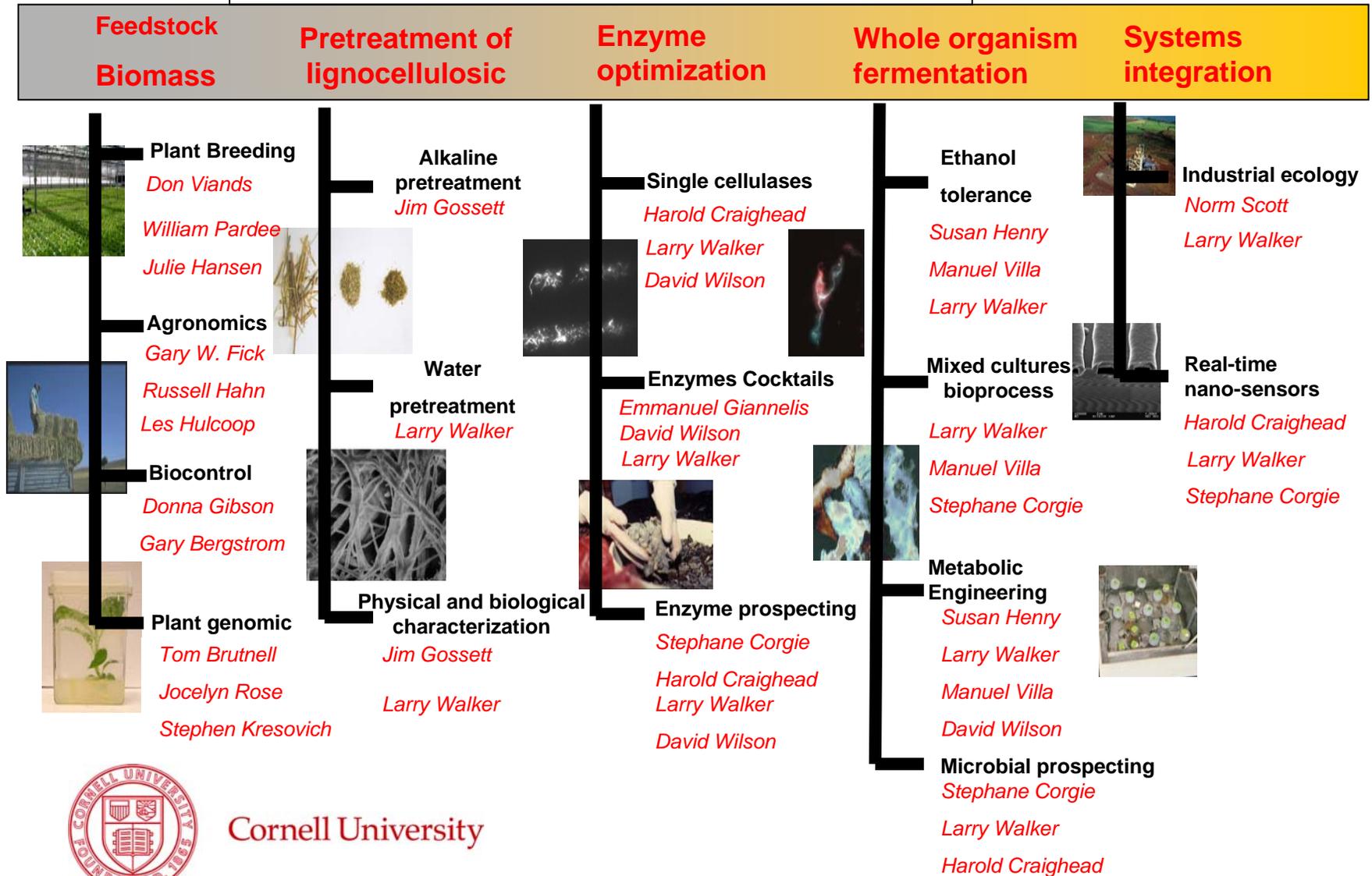


- Integrate an entire industrial process to determine maximal beneficial use of resources
- Optimize the utilization of the resource
- Minimize waste generation during obtaining and processing of the resource
- Minimize waste during manufacturing

*R. A. Frosch*



# Cross-matching with Cornell University Faculty Resources



Cornell University

# Educating the Next Generation of Scientists and Engineers



# Graduate Education and Training



USDA Multidisciplinary  
Graduate Education and  
Training (MGET) Fellows

The general goal of our program is to create a cadre of young engineers and scientists who can participate in the rational design of bio-based industries.

# MGET Activities



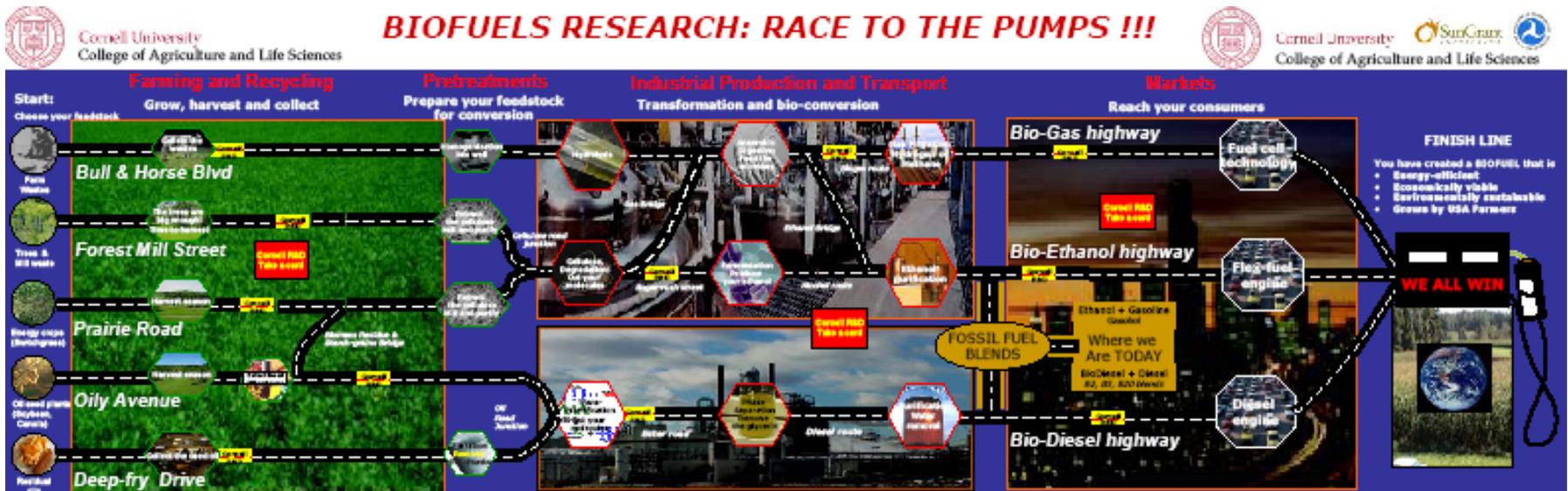
## A. Core Course Work:

1. Sustainable Development Seminar
2. The Science and Engineering Challenges to the Development of Sustainable Bio-based Industries
3. Biomass Conversion for Energy and Chemicals, and
4. Industrial Ecology of Bio-based Industries

## B. Multidisciplinary Special Committees

## C. Shared Office Facilities

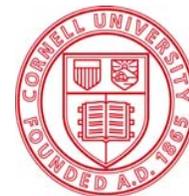
# Educating the Next Generation of Scientists and Engineers



Reaching out to { K-12 Students  
Communities and stakeholders

# Some key questions?

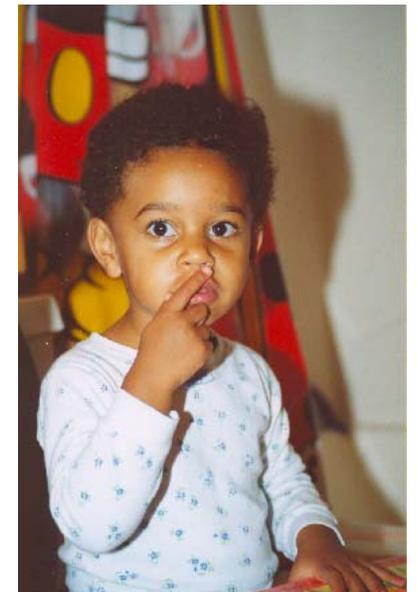
- What is driving the evolution of this paradigm?
- How do we manage the inherently disruptive nature of evolutionary processes?
- How do industry, government and universities work together to exploit opportunities and address challenges arising from this disruptive process?



# Innovative in Human Development



What a wonderful world!





“This only one world is  
our own to make and to  
keep.”

*Gerard Piel*

Thank You for your  
support and interest!