



CONNECTIONS 2010

December 6th , 2010

Synthetic Biology and the Sustainable Chemistry Revolution

Synthetic Biology

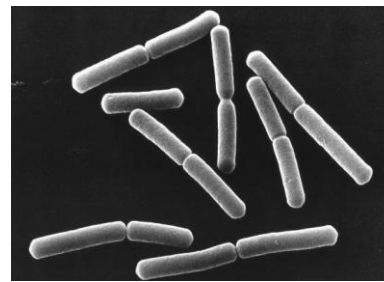
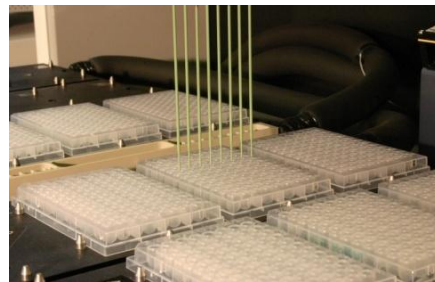
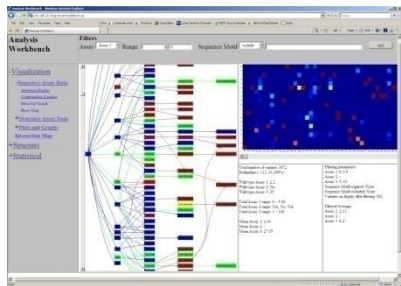
Software

Robotics

Biology

Manufacturing

Chemicals



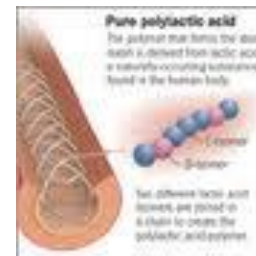
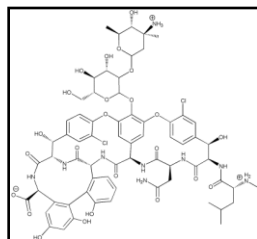
- 50,000 new chemical products
- \$1 trillion market opportunity

Natural Products

Specialty Chemicals

Commodity Chemicals

biopolymers



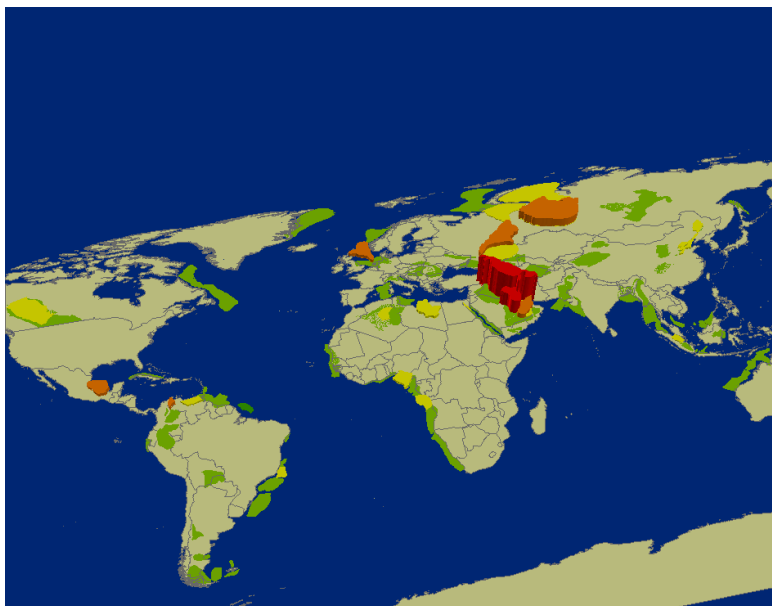
Sustainable Chemistry Opportunity for America

Opportunity to combine three areas of US strength

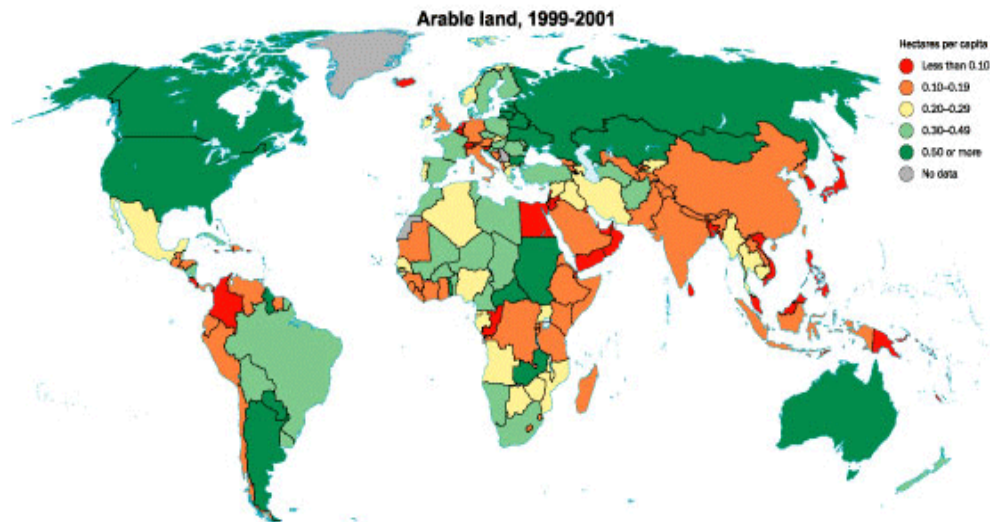
- World's largest amount of arable land, 174,448,000 hectares in 2005
- Most advanced biotechnology industry
- Largest national chemical industry

- Potential to create 237,000 direct U.S. jobs and 1.3 million indirect U.S. jobs
- Potential for domestic revenue generation of about \$200 billion
- Inherently safer production methods
- Lower carbon footprint
- Safer biodegradable chemicals
- Chemical production can enable the operation of profitable biorefineries that produce chemicals and bio-fuels

Proven oil reserves



Arable Land



The Efficient Biorefinery

Renewable Feedstocks

Crude glycerol

Soy meal

Soy molasses



Biorefinery

- One uniform standard fermentation process
- A variety of engineered strains
 - All strains are grown under the same conditions
 - Each strain produces a different chemical product



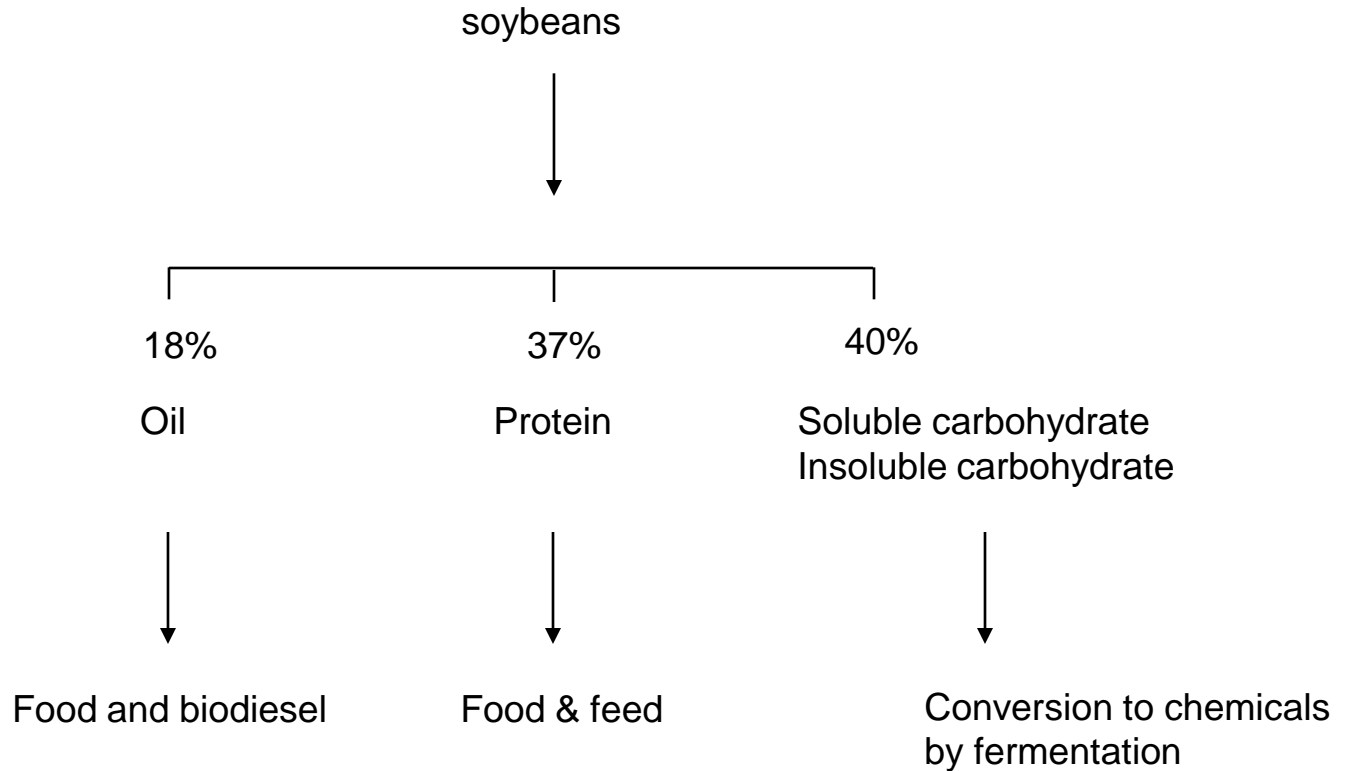
surfactants

dispersants

other products



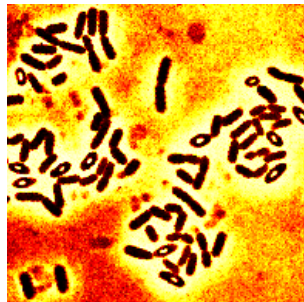
Soybean Processing for Chemical Production



Soy Molasses

- 50% total soluble solids
- Solids are: carbohydrates (60%), proteins and other nitrogenous substances (10%), minerals (10%), fats and lipids (20%)
- Carbohydrates are sugars that include oligosaccharides ([stachyose](#) and [raffinose](#)), disaccharides (sucrose) and minor amounts of monosaccharides (fructose and glucose)

[stachyose](#)
[raffinose](#)



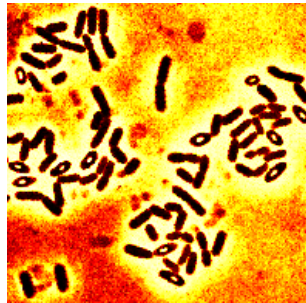
Specialty Chemicals

Soy Hulls

cellulose	25%
hemicellulose	20%
pectin	12%
protein	12%
uronic acid	11%
ash	5%
lignin	4%

cellulose

hemicellulose



Specialty Chemicals

What are surfactants?

Foaming agents—they suspend gas in a liquid (Bubbles!)

Emulsifiers—they suspend an immiscible liquid in a liquid

Dispersants—they suspend a solid in water



- The surfactant market was \$23.9 billion in 2008
- Annual global production of 13 million metric tons

Green Manufacturing

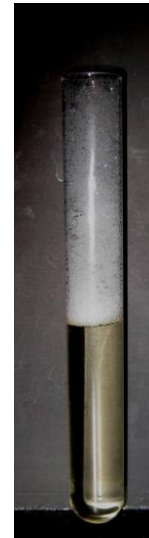
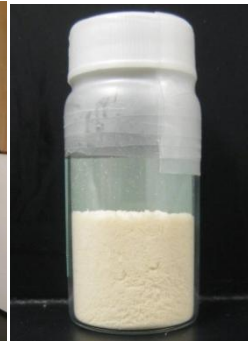
Surfactant Manufacturing Today

- 32 billion kg CO₂ annually
- Equal to burning 3.6 billion gallons of gasoline annually



Palm and coconut plantation expansion threatens rainforest

Surfactant Manufacturing Tomorrow





Scale Up and Process Optimization

50 liter fermentation using inexpensive capital equipment



Engineering the microorganism for increased feedstock utilization



Testing pre-treatment processes to increase yield feedstock utilization



Determining the nutritional content of the fermented hulls



Natto beans



Natto

Bio-dispersant Project Timeline

BP Oil Spill

April 20th, 2010

Professor Somasundaran attends meeting in Louisiana to discuss spill management

June 4th, 2010

COREXIT ingredients made public

June 8th, 2010

Assembly of team of collaborators

June 16th, 2010

Approached NSF regarding RAPID funding

June 18th, 2010

RAPID Response grant awarded

August 18th, 2010

Project Plan teleconference

September 1st, 2010

Design of novel compounds

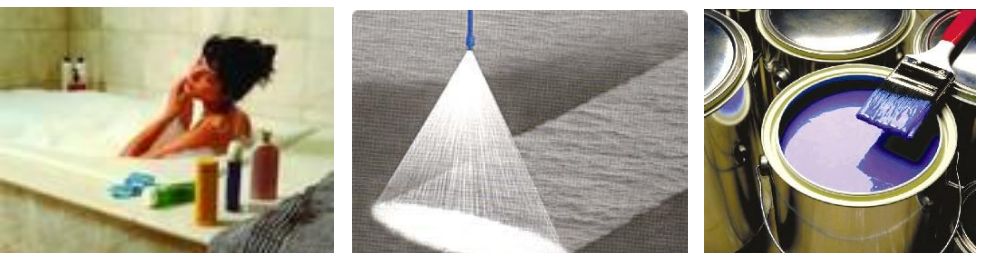
September 28th, 2010

Fermentation and separations

November 10th, 2010

Oil dispersion assays

December 2nd, 2010



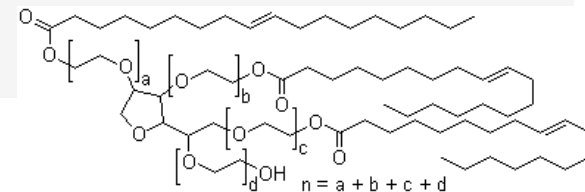
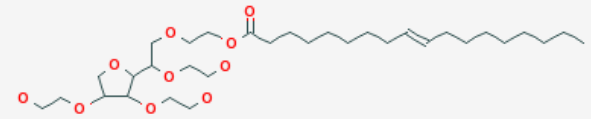
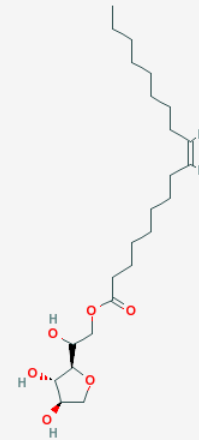
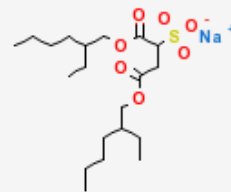
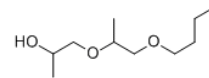
A functional bio-alternative to COREXIT (oil dispersant)

NSF RAPID Response Grant



Components in COREXIT

- sorbitan monooleate
- Polysorbate 80
- Sodium 1,4-bis(2-ethylhexoxy)-1,4-dioxobutane-2-sulfonate
- Dipropylene Glycol Monobutyl Ether
- Hydrotreated kerosene
- 2-butoxyethanol



Sufficient Soy Carbohydrate is generated to produce all U.S. **specialty surfactants** by fermentation

If the technology can be developed to convert soy carbohydrate into chemicals by fermentation the U.S. chemical industry is large enough to utilize all U.S. soy carbohydrate.

The U.S. produced 1.23 billion tons of chemicals in 2007.

The U.S. produce 32 million tons of soy carbohydrate in 2008.

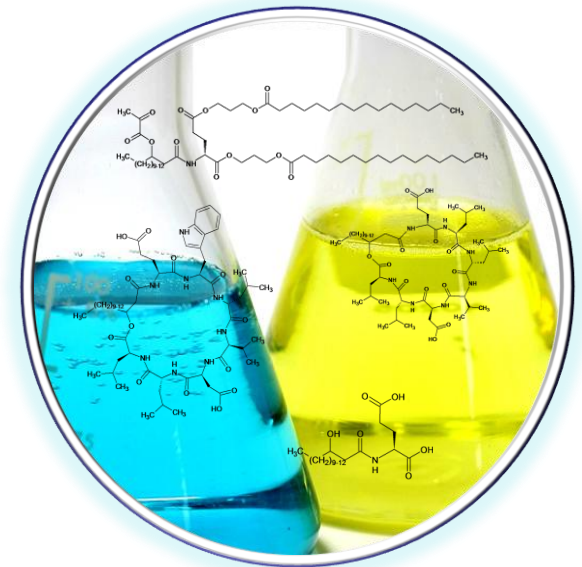
Assuming 50% conversion of carbohydrate to chemicals, soy carbohydrate could be used to manufacture 2.6% of the total U.S. chemical output



Example: **Specialty surfactants**

Annual U.S. production of specialty surfactants is about 1 million tons

The U.S. produces 16 times more soy carbohydrate than is needed to produce all U.S. specialty surfactants.





Thank you for your support!

We Appreciate it!



Fermentation of Soybean Hulls

