Replacing Petroleum with Renewable Fuels and Chemicals

UF | UNIVERSITY of FLORIDA

Buckeye Technologies

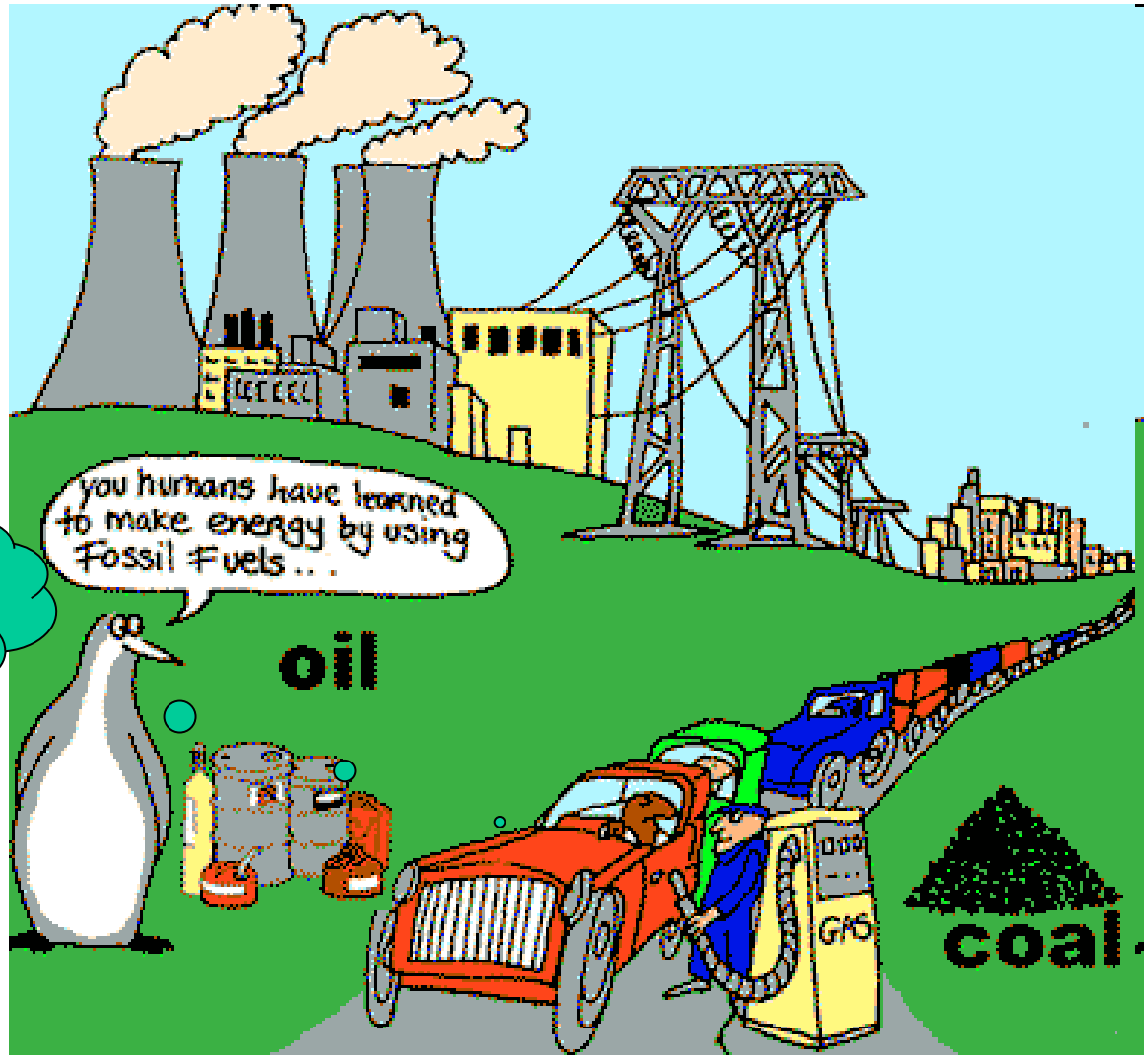
&

Florida Crystals

We have created an environmental problem.

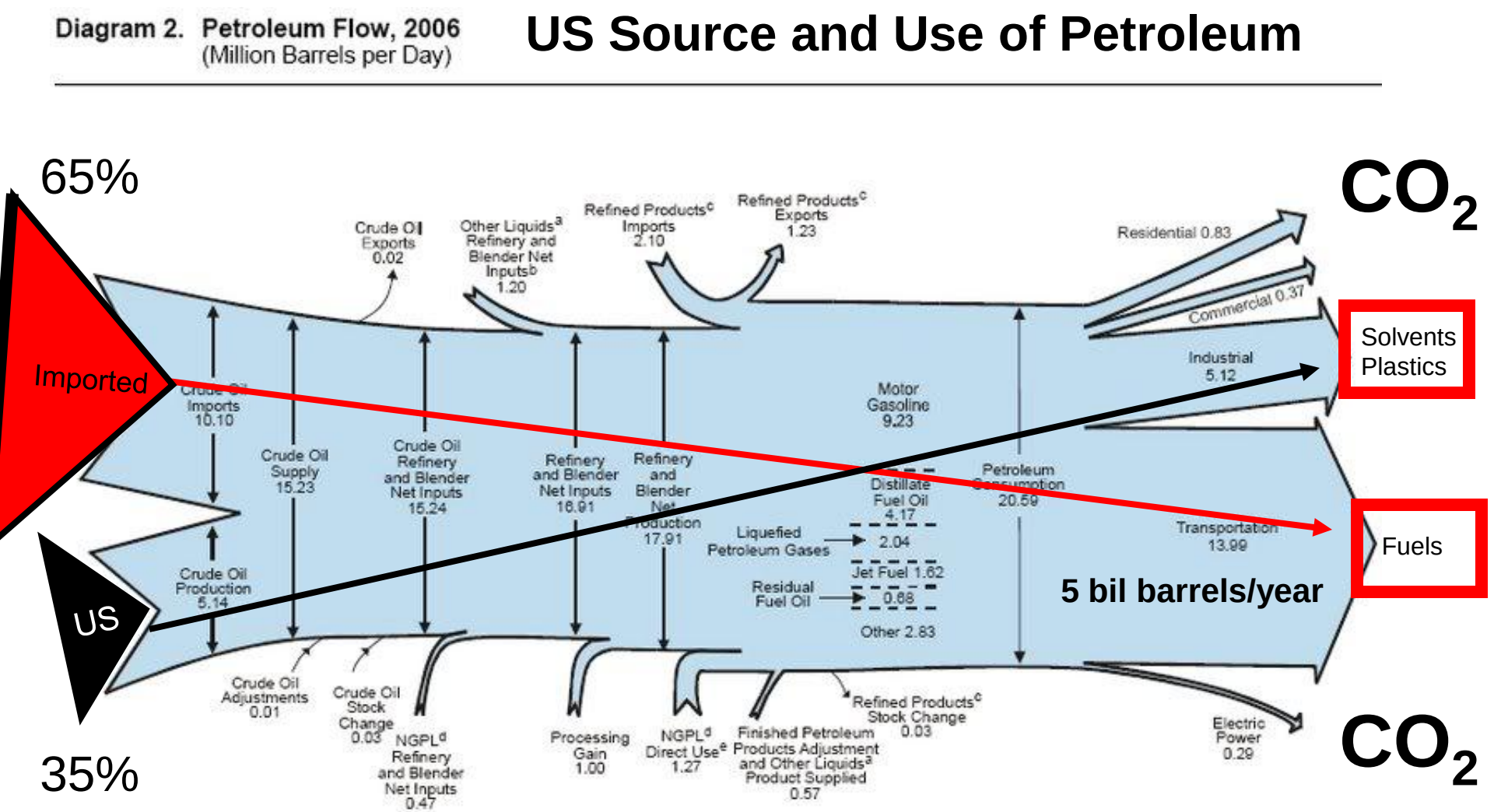
While US pundits turn climate change into a joke,

China turns this opportunity into jobs.
(T. Friedman, 2010)



Burning fossil biomass fuels releases fossil CO_2.

We have created a strategic vulnerability.



Fossil Biomass

Replace Fossil Biomass with Modern Biomass

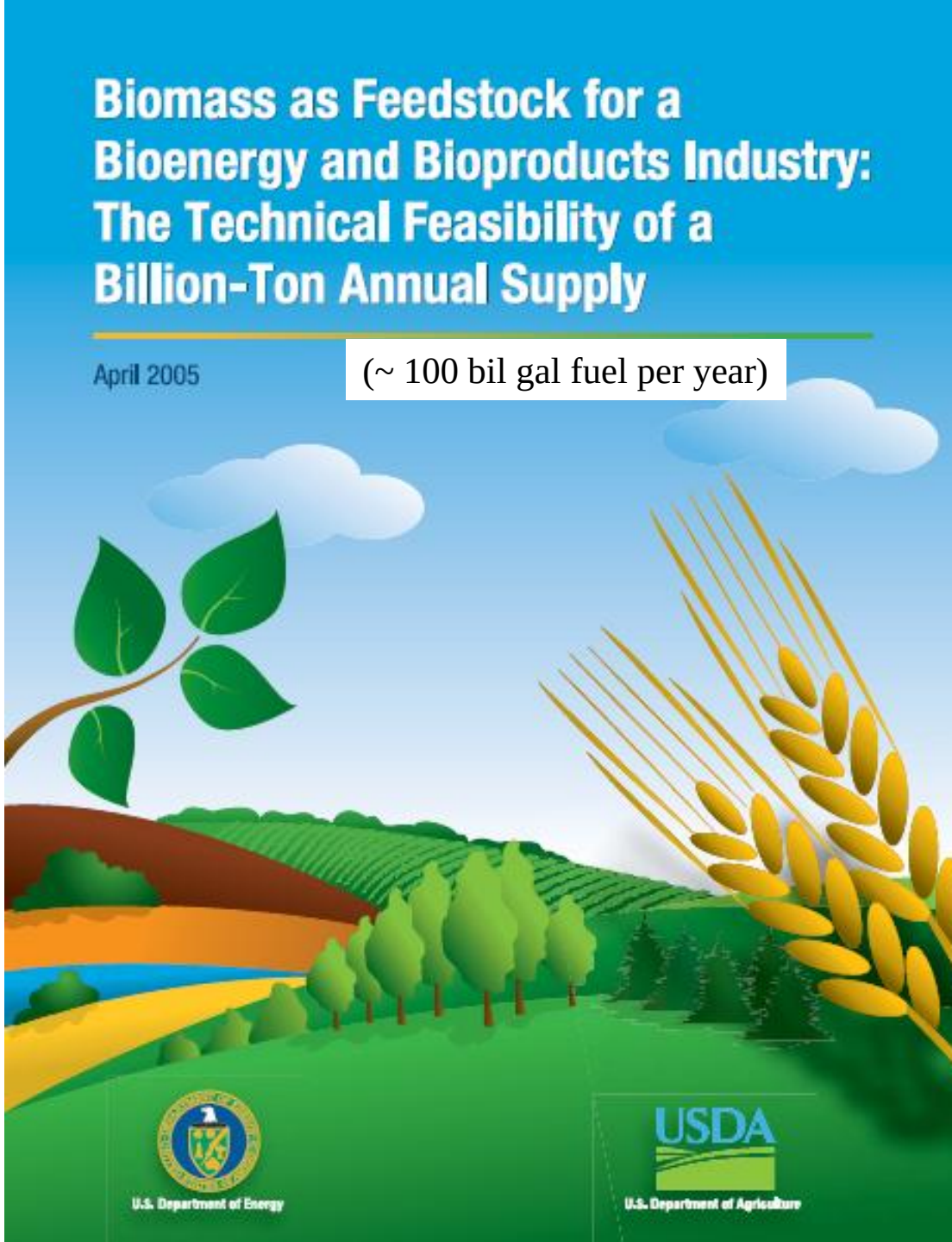
Nature's solar energy!

Renewable fuels and chemicals

To replace 1 lb petroleum:

2 lb Carbs → 1 lb ethanol + 1b CO_2

1 lb Carbs → 1 lb organic (plastics) acid polymer***



What role can Florida play?

1. Florida has the market, >9 bil gal/yr fuel.
2. Florida has farmers and families that need jobs.
3. Florida has natural resources to grow biomass.
4. Florida needs to invest in energy research for biomass production – (plant breeding & best practices).
5. Florida needs to invest in research to develop new bioproducts -- new biocatalysts & novel processes.
5. Florida will need to provide competitive incentives for new industries to locate here.
6. States that are winning are states that are

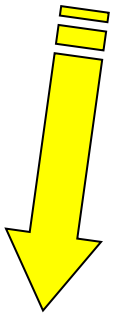
Making Big Investments!

Modern Biomass

All parts: stems, leaves, roots, etc.

Can this be done at $ 50 / dry ton?

CO_2



Plant Biomass

N,P,K,Mg,Fe

Water & Nutrients

- Ammonia
- Phosphorus
- Potassium
- Magnesium
- Sulfate
- Iron and trace metals

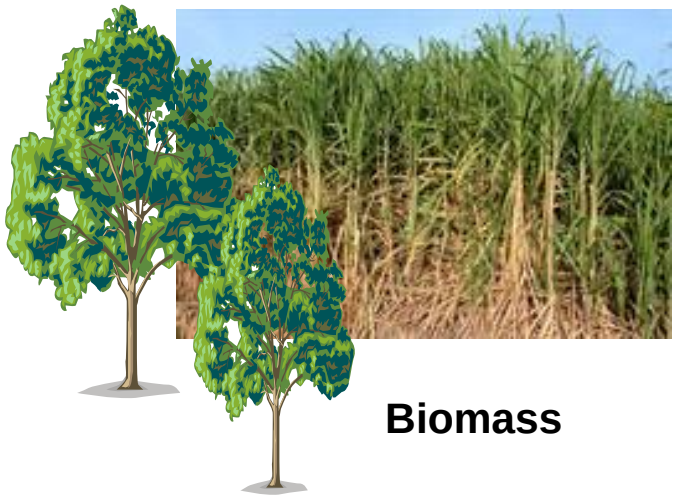
IFAS – Crop Production

Short rotation trees

New plants, new diseases, new practices

Energy crops must use water and nutrients efficiently!

Biomass Biorefinery -- Renewable Cycle



Biomass

CO_2

Use More Wood!

No Net Greenhouse Gas Emissions

Bio-Refinery

Liquid Fuels

Plastic & Solvents

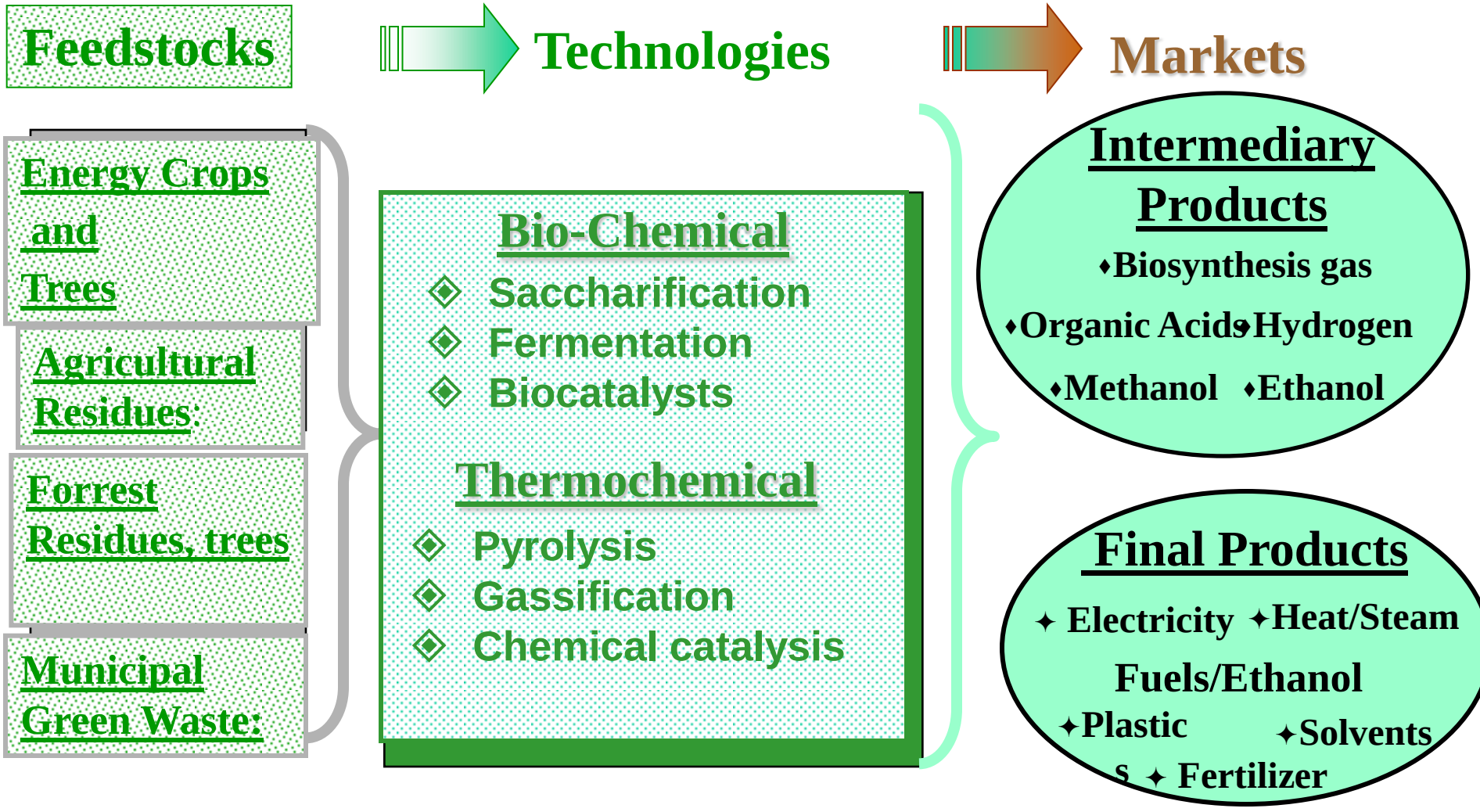
$C_xH_y + (X + \frac{y}{4})O_2 \rightarrow CO_2 + (\frac{y}{2})H_2O$

Cars, Trucks, and Planes

Lignin, composites, biomaterials, fertilizer, biogas, and other products

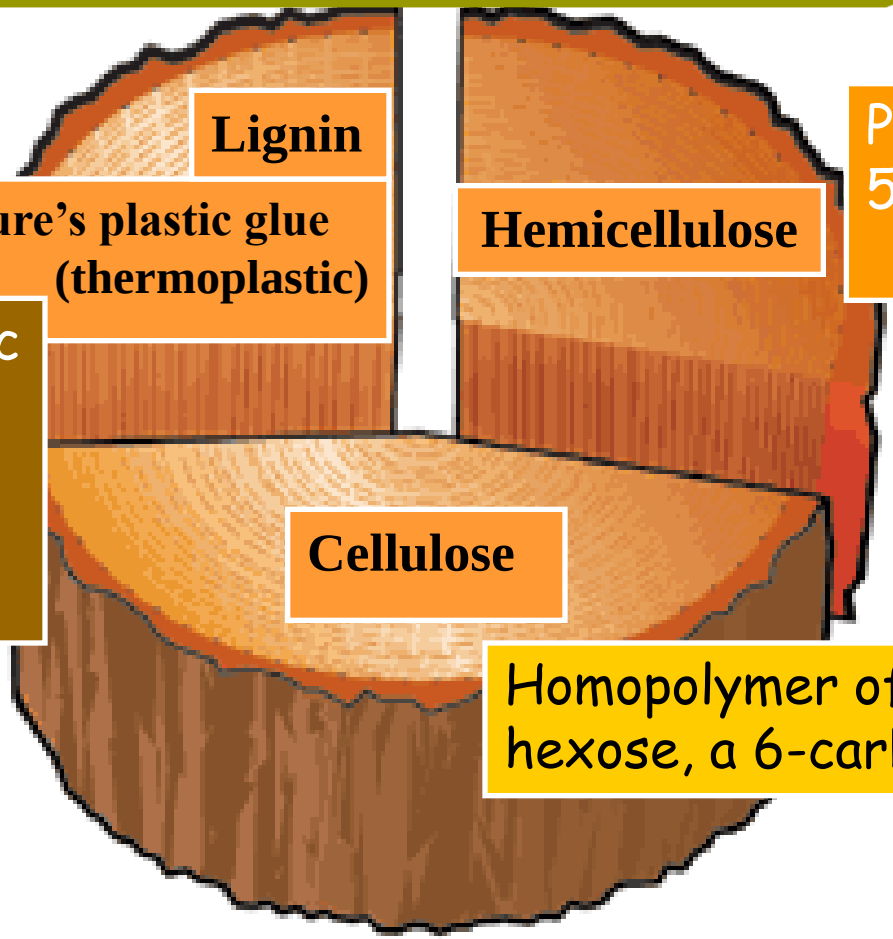
DOE

Replace a Petroleum Refinery with a Bio-Refinery



(Modified from DOE, 2002)

Woody Biomass ~60-70% Carbohydrate
Corn ~70% starch



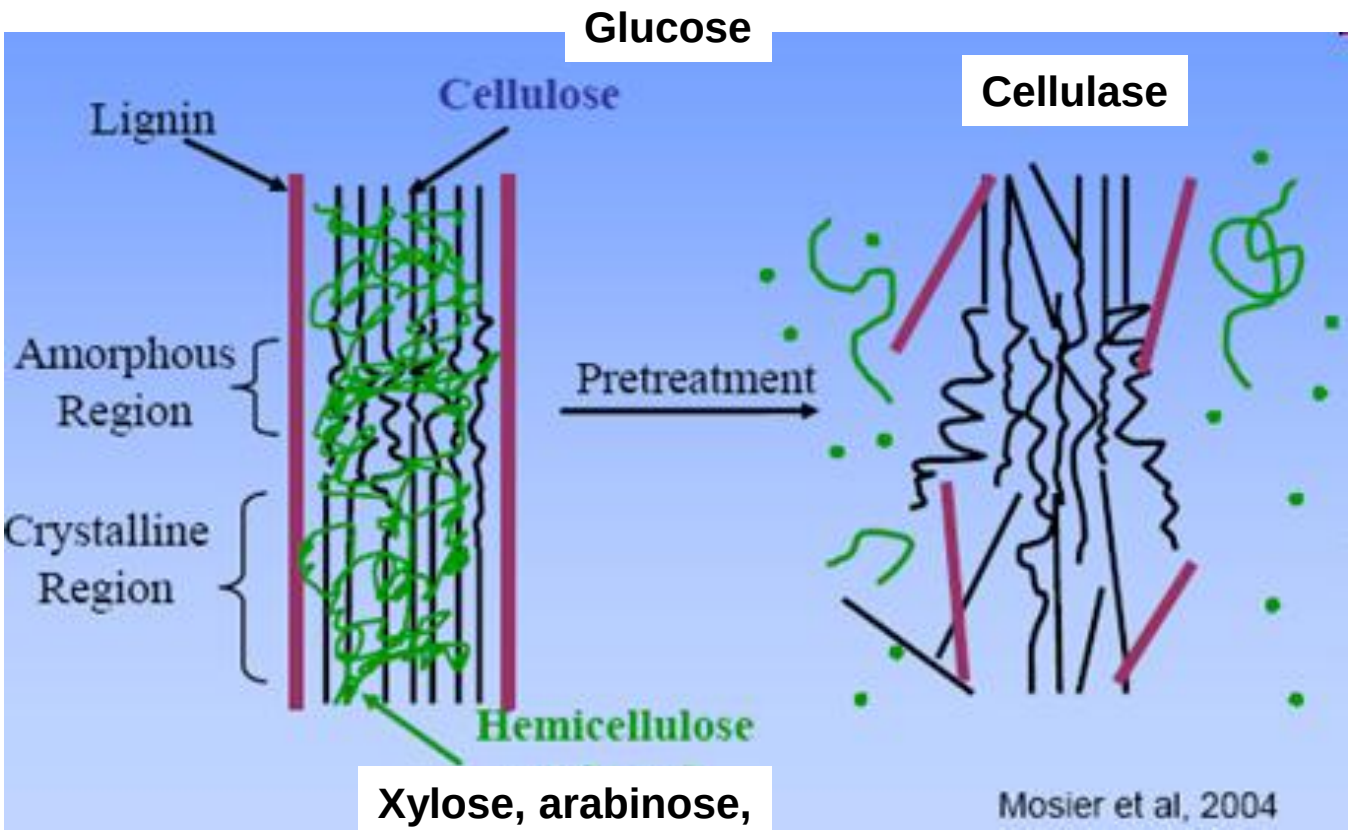
Primarily pentoses, 5-carbon sugars also 6-C sugars

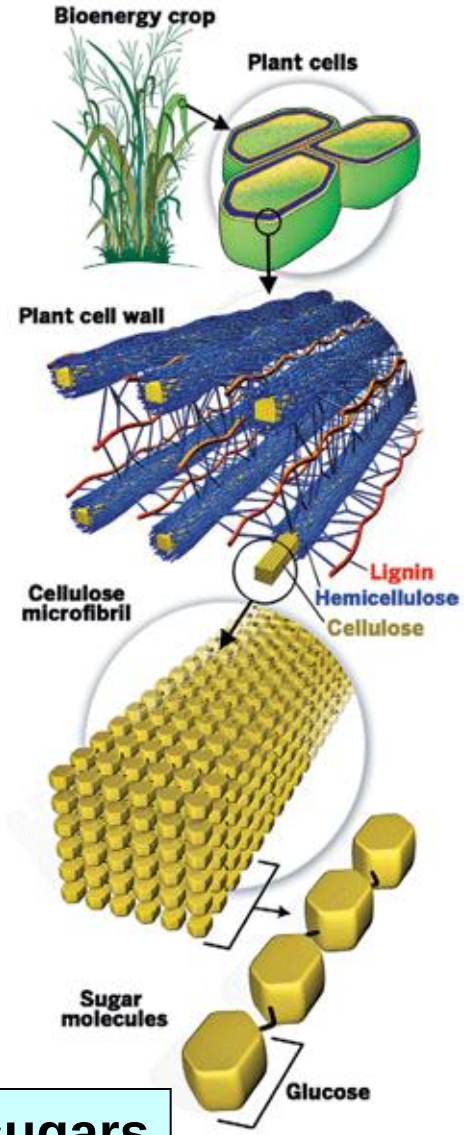
Black thermoplastic that can be burned to provide energy for ethanol production.

Homopolymer of glucose, hexose, a 6-carbon sugar.

Composition of Lignocellulosic Biomass

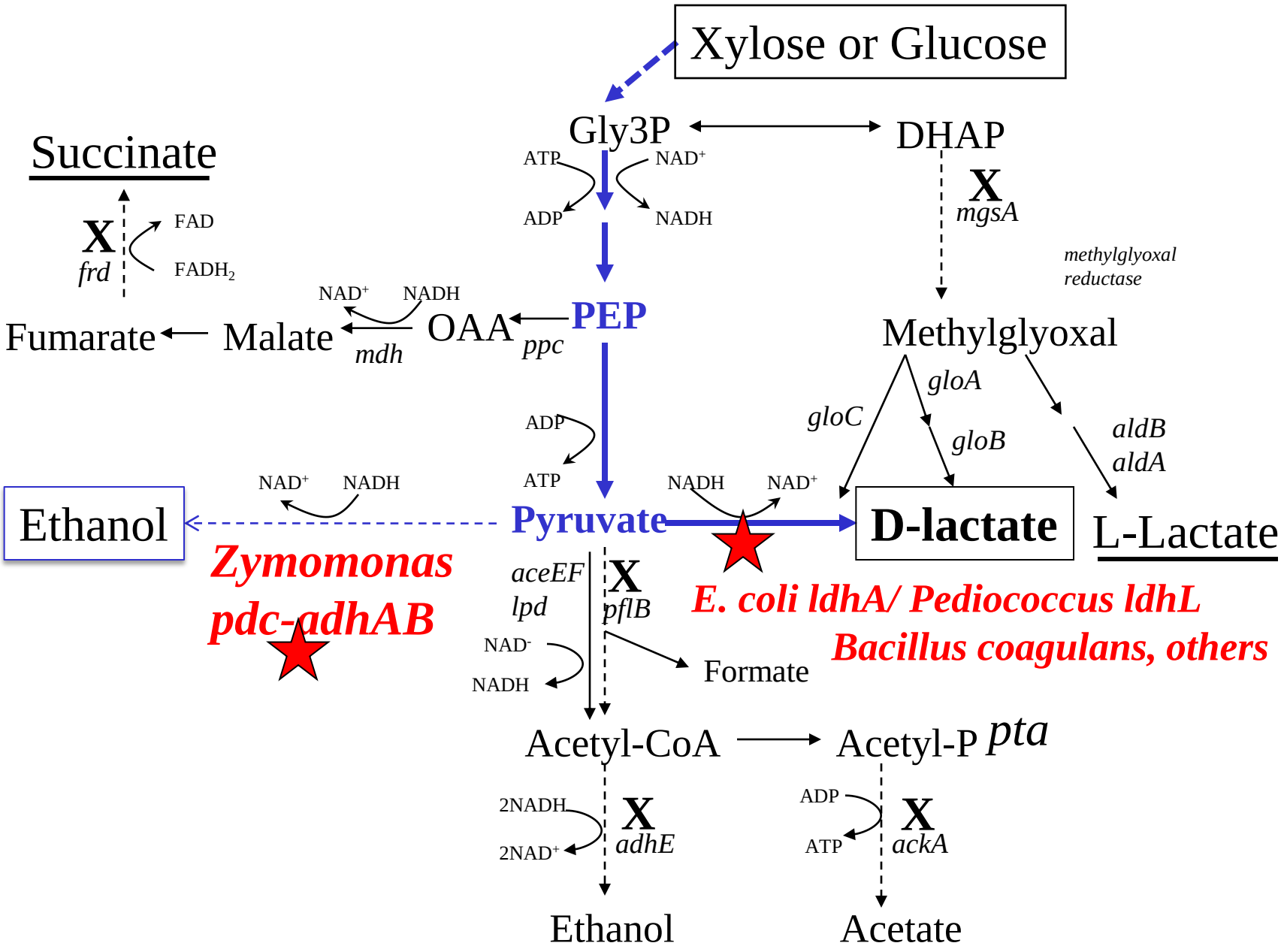
Acid or Base pretreatment is essential for deconstruction of lignocellose.



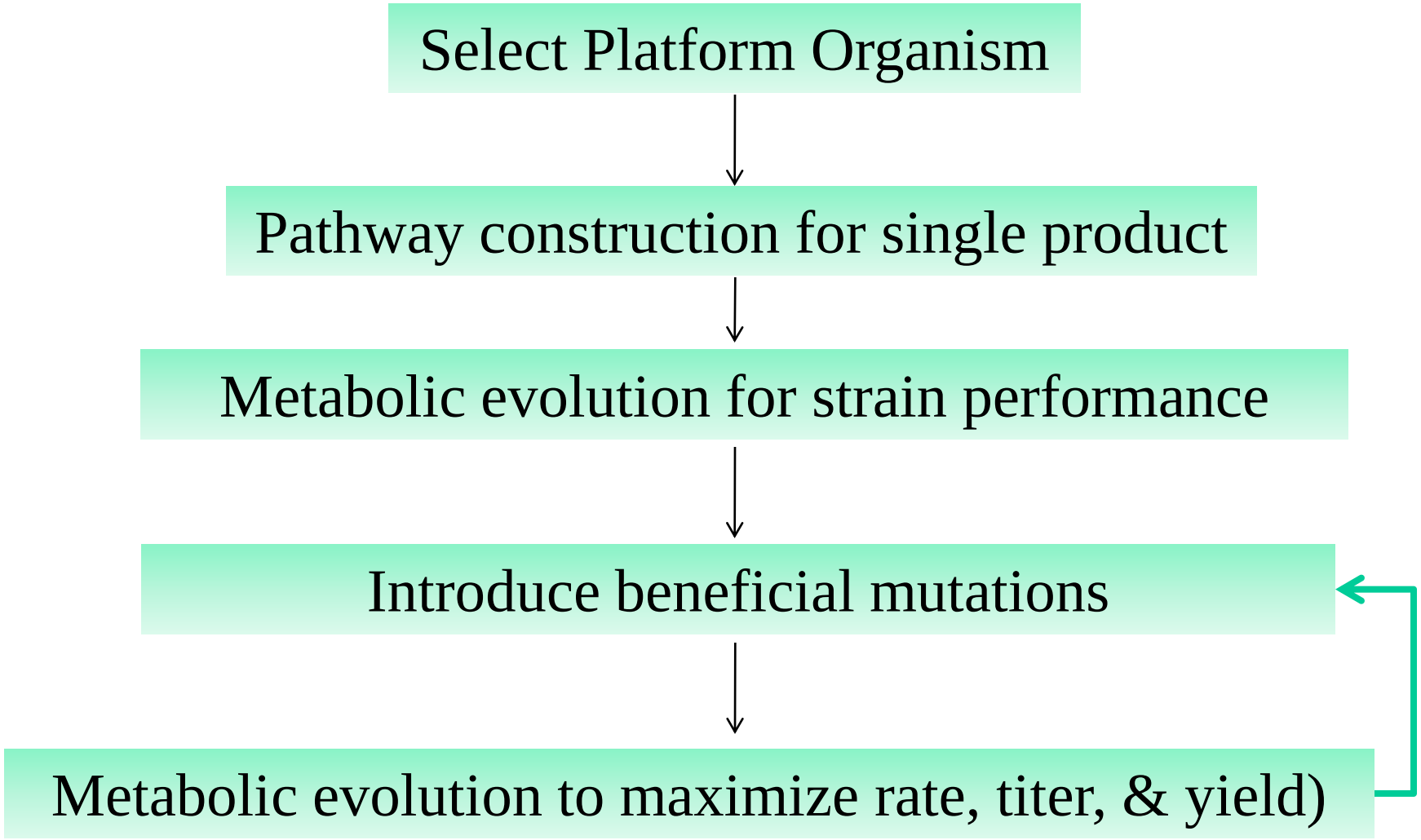


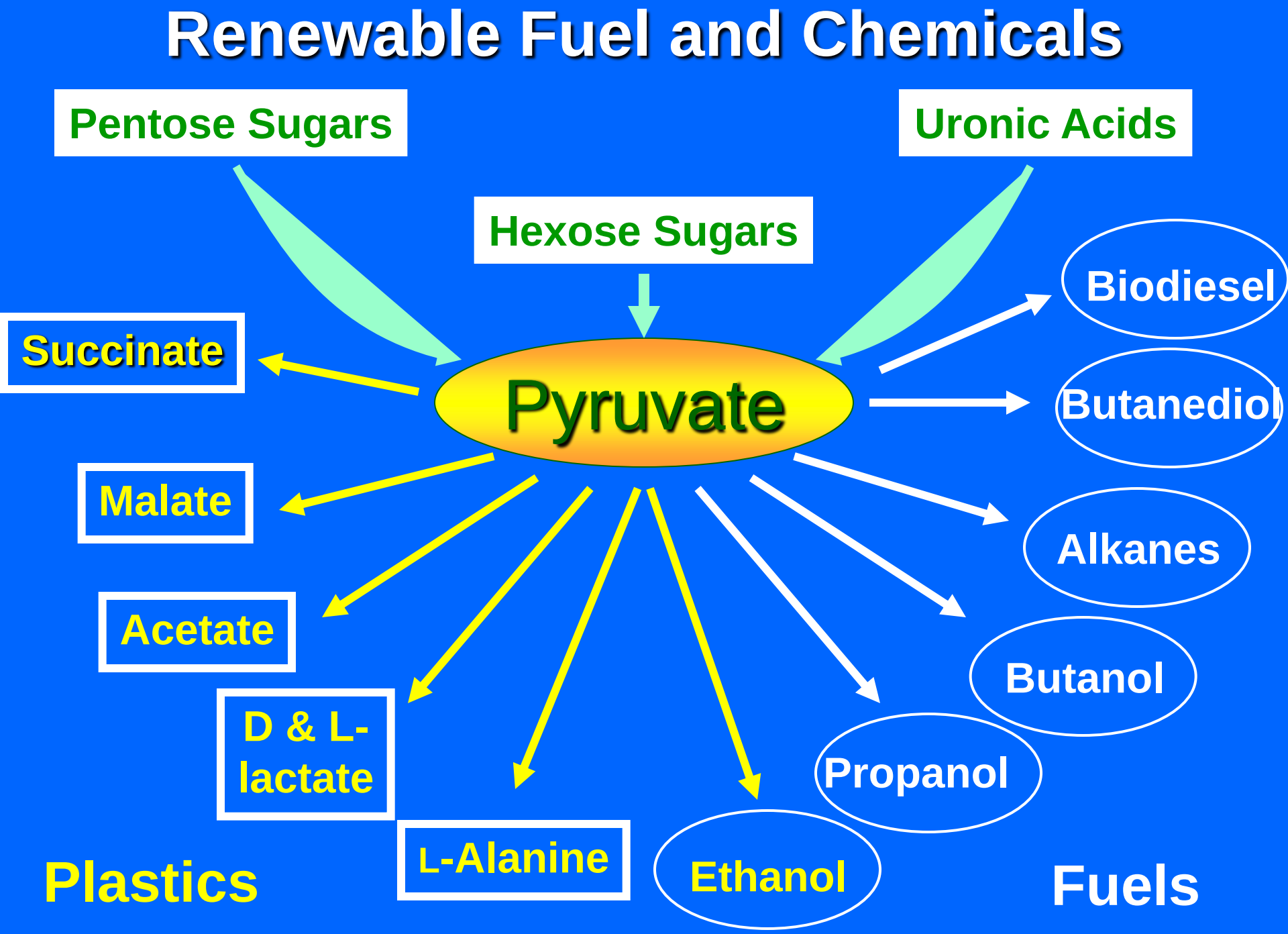
1. Dilute acid pretreatment → syrup of hemicellulose sugars
2. Enzymes to convert cellulose → glucose syrup

Examples of pathway construction to make biocatalysts



Engineering Strategy




Renewable Fuel and Chemicals
Pentose Sugars
Uronic Acids
Hexose Sugars
Biodiesel
Succinate
Pyruvate
Butanediol
Malate
Alkanes
Acetate
Butanol
D & L-
lactate
Propanol
L-Alanine
Ethanol
Plastics
Fuels

Cellulosic Sugars → Commercial D-lactic acid

PURAC

BIOPLASTIC

PURAC PDLA

BENEFITS

PLA plastics with HDT B (0.45MPa) values >100°C possible

New applications with better heat stability possible

More efficient in injection molded PLA

Bulk density of PLA unchanged

IMPROVING HEAT-RESISTANCE OF PLA USING POLY(D-LACTIDE)

PLA (Poly L-Lactide) is a bioplastic derived from annually renewable carbohydrate resources. PLA has conquered a promising market volume and is growing fast. The semi-crystalline biopolymer has mechanical properties comparable to polystyrene and is being used as an eco-friendly packaging material. However, the adoption and growth of PLA is currently limited by a number of technical challenges. The most prominent material property of PLA that needs improvement is the poor heat resistance. Heat-deformation of PLA already takes place at temperatures below 50°C. This poses major issues in storage, transport and use of pallets and finished articles. A solution for the low heat-stability while maintaining transparency would accelerate the acceptance of PLA and widen the application window.

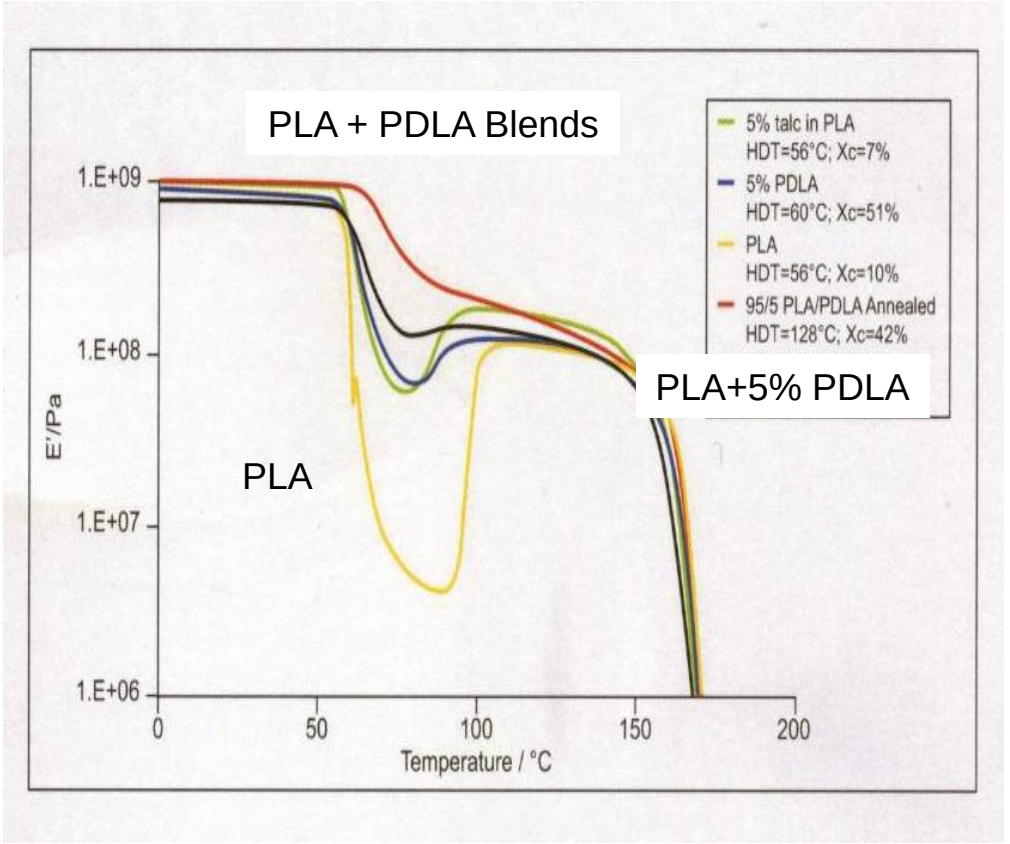
Six years of innovative research and development at PURAC have resulted in the commercial availability of D(-)-lactic acid and D-lactide, the monomer that enables large-scale utilization of PDLA (Poly D-Lactide). Melt-mixing PLA in the presence of PDLA produces in-situ sc-PLA crystallites, which act as heterogeneous nuclei for PLA, resulting in faster crystallization and higher crystallinity upon cooling from the melt. Consequently, the material exhibits better mechanical and thermal properties, like lower shrinkage and improved heat resistance (HDT). A 50/50 mixture of PLLA and PDLA, the homopolymers of L(+)- and D(-)-lactic acid, produces a semi-crystalline polymer with a melting temperature of 215-230°C, i.e., 50-80°C higher than PLA packaging grades. This sc-PLA (semi-crystalline PLA) is a suitable biopolymer for melt-spun fibers and biaxially stretched film.

About PURAC

- Global presence
- Efficient and secure supply chain
- Natural products with high quality standards
- Dedicated application expertise for customers

BioEnergy International, LLC
Now Myriant Technologies

Sublicensed to Purac



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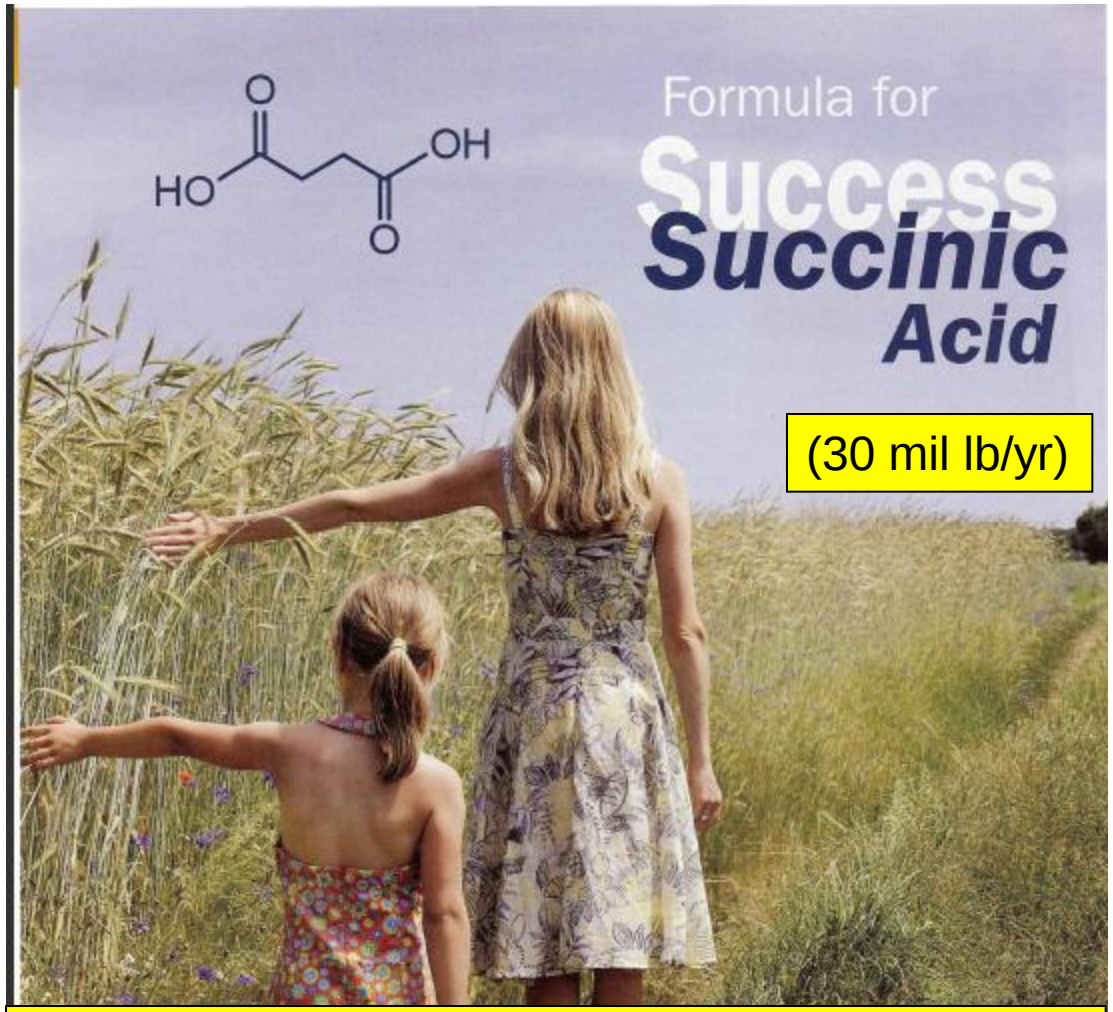
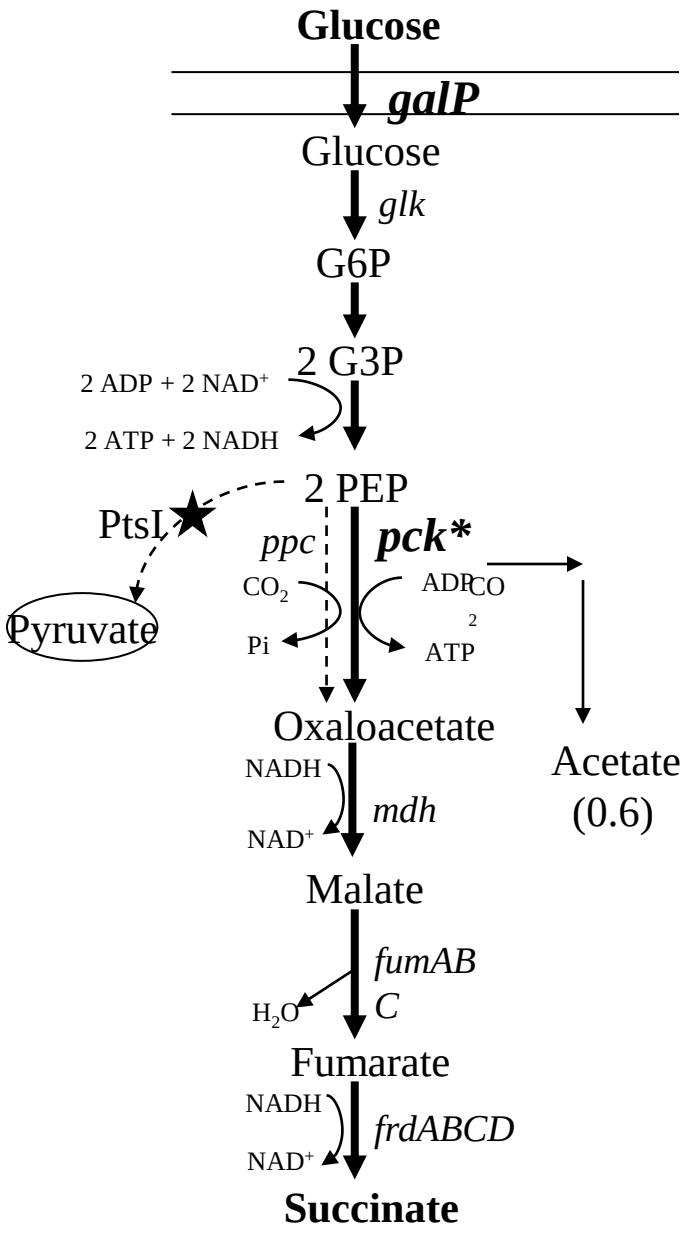
NatureWorks™

Cargill Dow Polymers LLC

Polylactic Acid
PLA

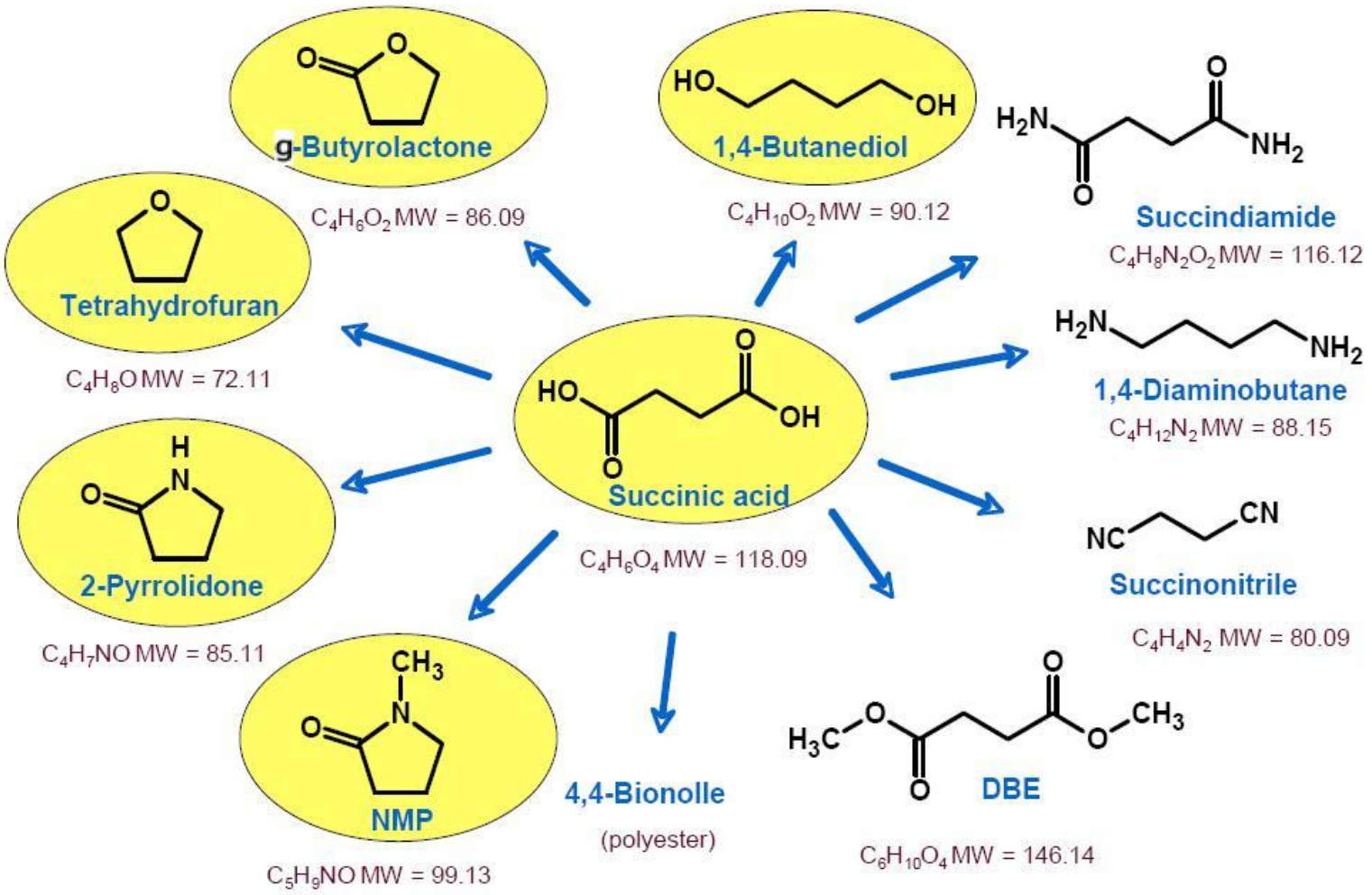

Formula for
Success
Succinic
Acid
HO
OH
O
O
(30 mil lb/yr)
Plant under construction in Louisiana
MYRIANT
TECHNOLOGIES
Chemistry refined...naturally!
In 1925, Henry Ford predicted that biochemistry would unite agriculture and industry. Myriant Technologies has realized that vision: next-generation biorefineries where pounds of sugar can replace barrels of crude.
Myriant biobased Succinic Acid lets you improve the environmental impact of your specialty chemical offerings.
Learn how at: www.myriant.com
Samples up to 1 ton available; call: 617-657-5221


Glucose
galP
Glucose
glk
G6P
2 G3P
2 ADP + 2 NAD+
2 ATP + 2 NADH
2 PEP
PtsI
Pyruvate
ppc
pck*
CO2
Pi
ADP
ATP
CO2
Oxaloacetate
NADH
NAD+
mdh
Acetate
(0.6)
Malate
fumAB
C
H2O
Fumarate
NADH
NAD+
frdABCD
Succinate

(1.4)

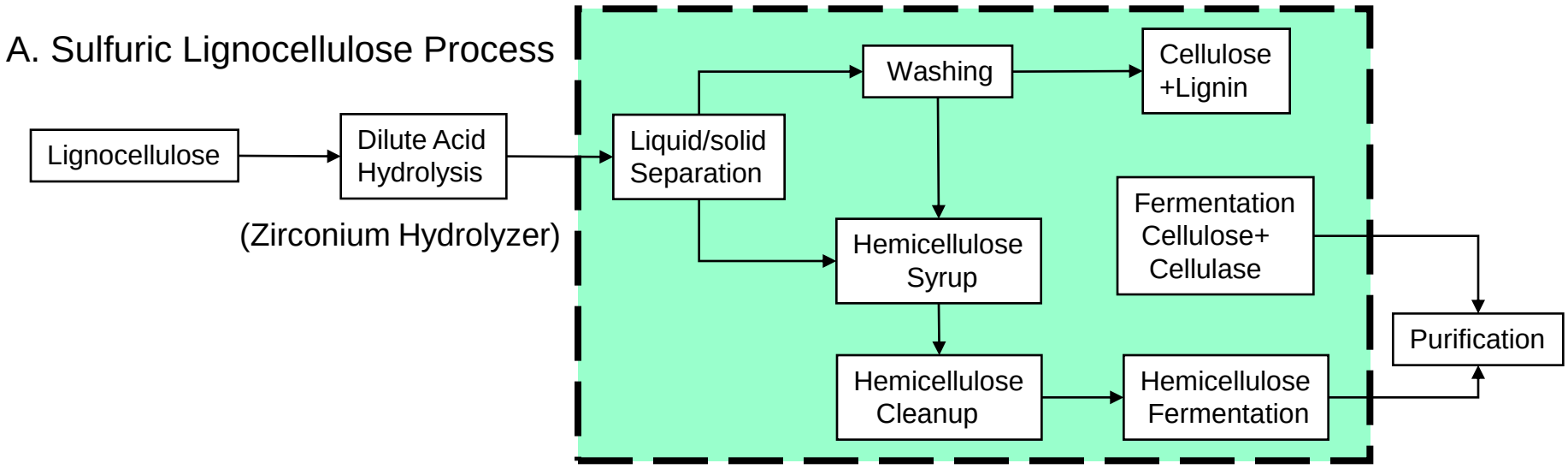
Succinate – a key building block with billon ton/year potential

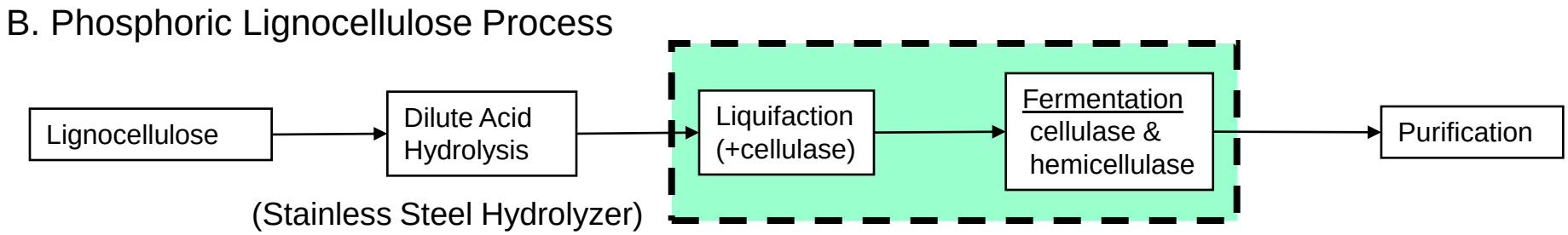
DOE Top 10 Building blocks

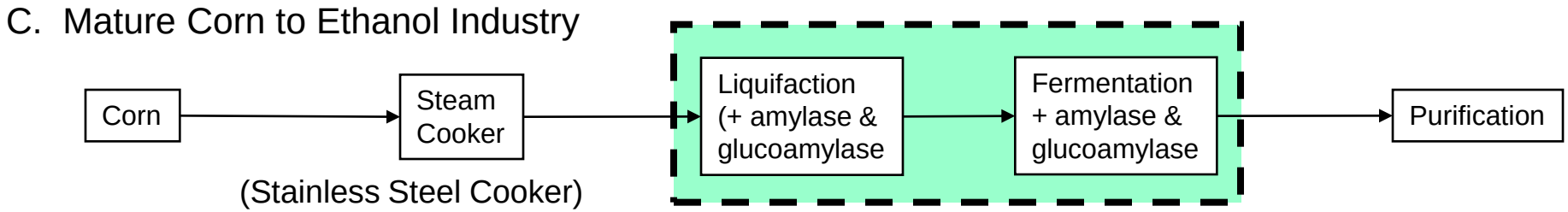


UF Biofuels Pilot Plant (unit ops)
BOG Center of Excellence (Frazier-RogersHall)

Conversion of Biomass to Fuel Ethanol & Chemicals





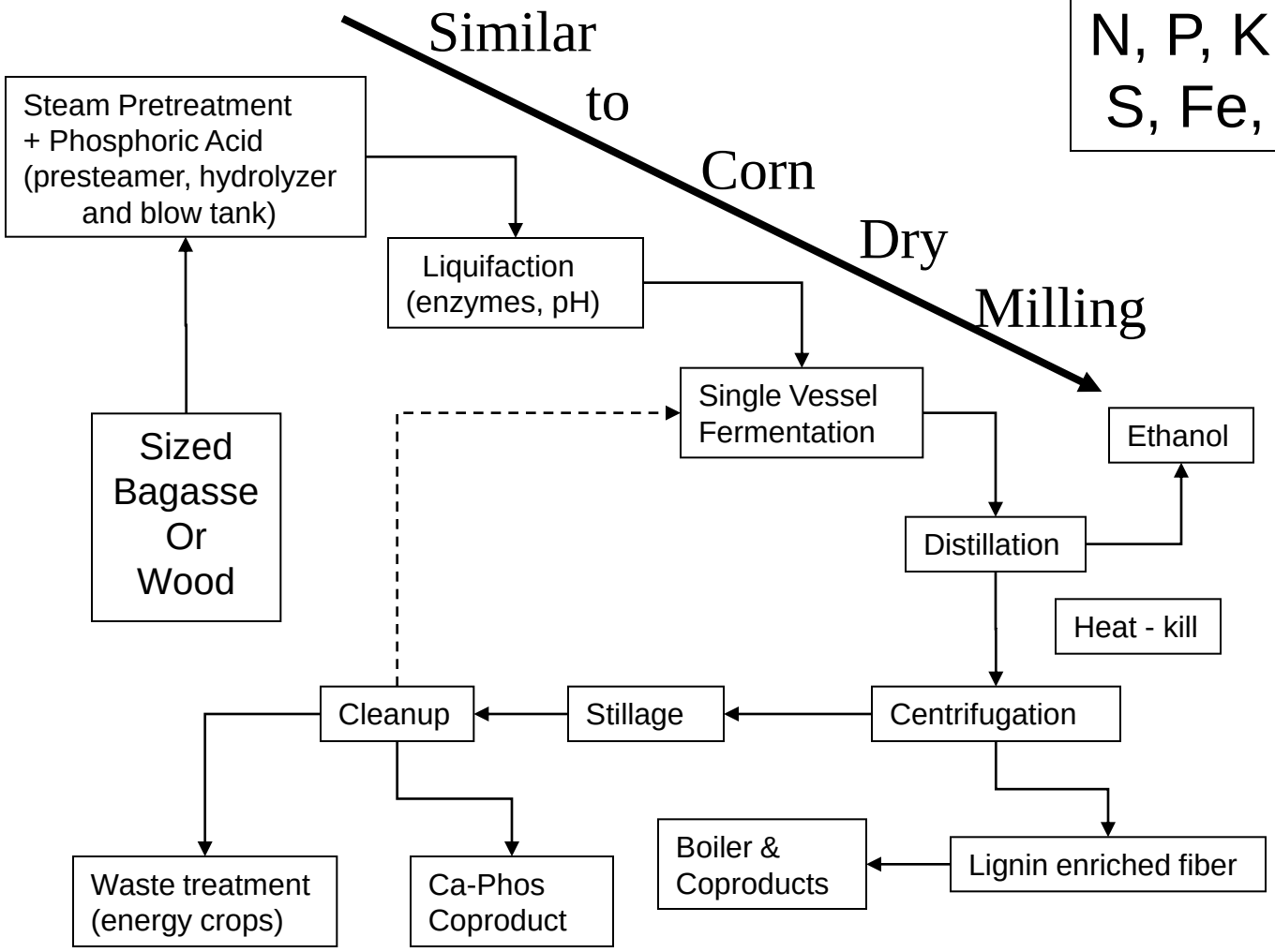


Process Development – Biofuels Pilot Plant

Process for Cellulosic Ethanol

"Borrowing water and nutrients"

N, P, K, Mg
S, Fe, Ca



Stan Mayfield Biorefinery Pilot Plant

with Buckeye Technologies, Perry FL

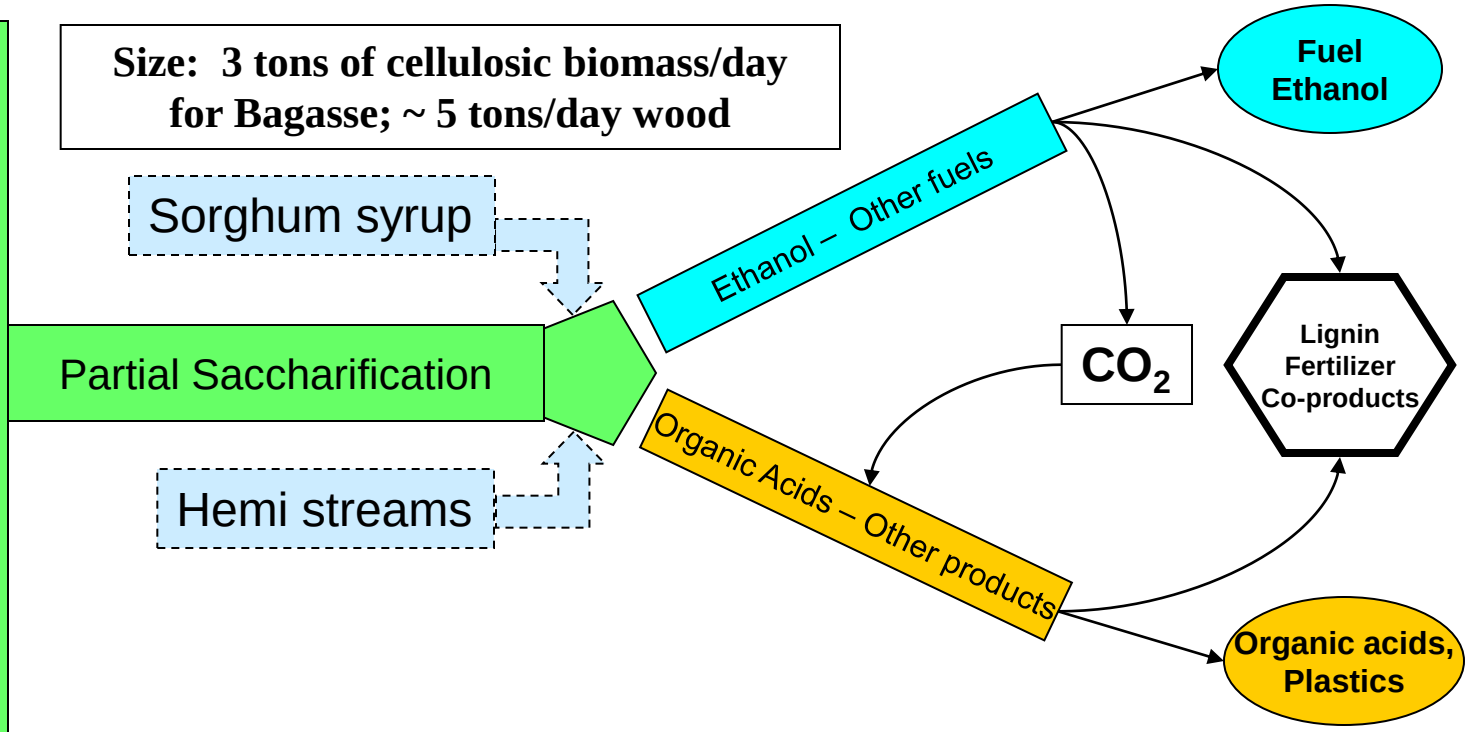
Woody Residues

Woody Crops and Trees

BKI materials

Sweet Sorghum and Related sugar crops

Size: 3 tons of cellulosic biomass/day for Bagasse; ~ 5 tons/day wood



Maximum Capacity per Day (lignocellulose)

400 gal ethanol/day or 5,000 lb of organic acids

Process borrows water and nutrients that are used to grow new energy crops.

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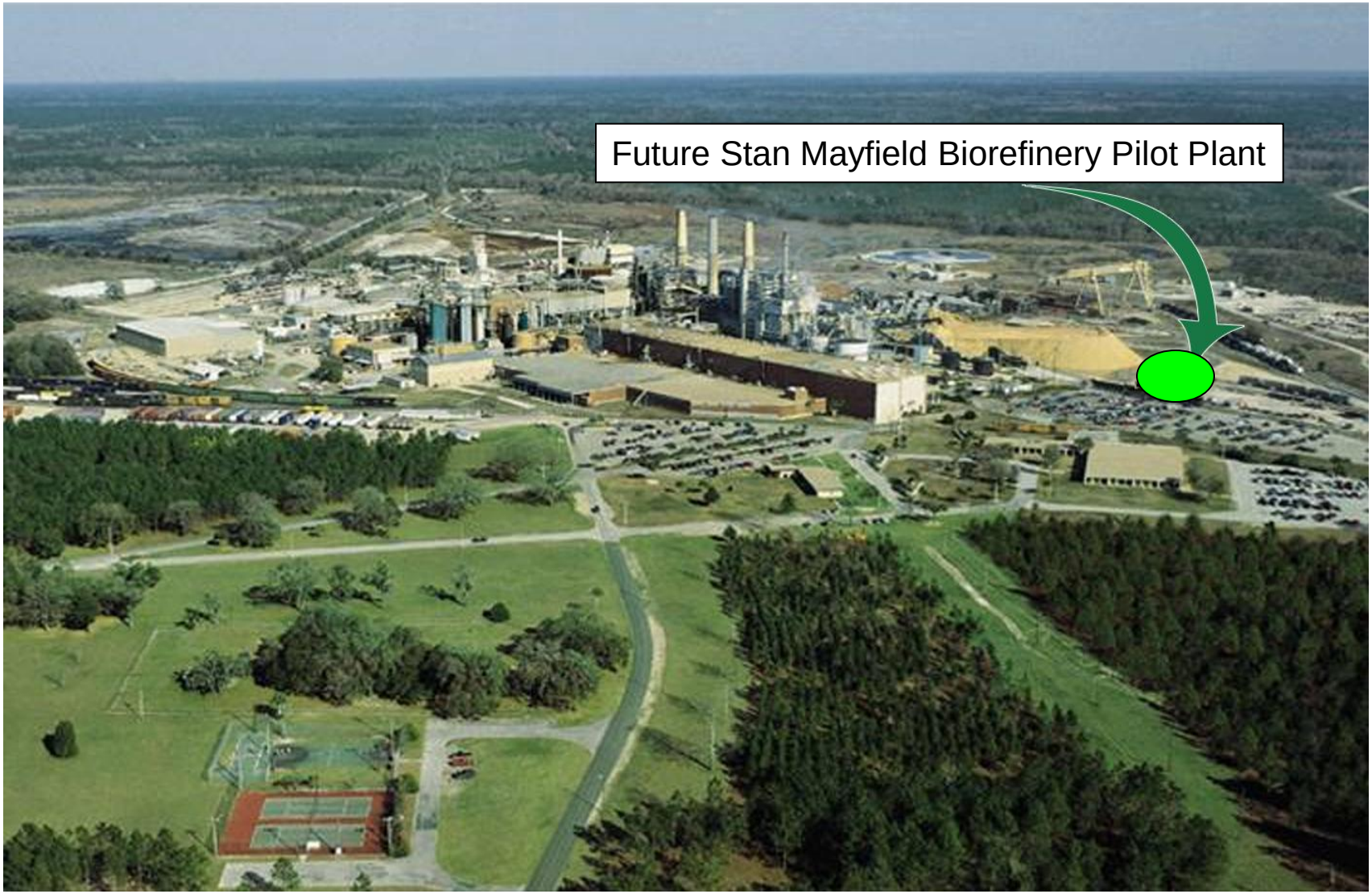
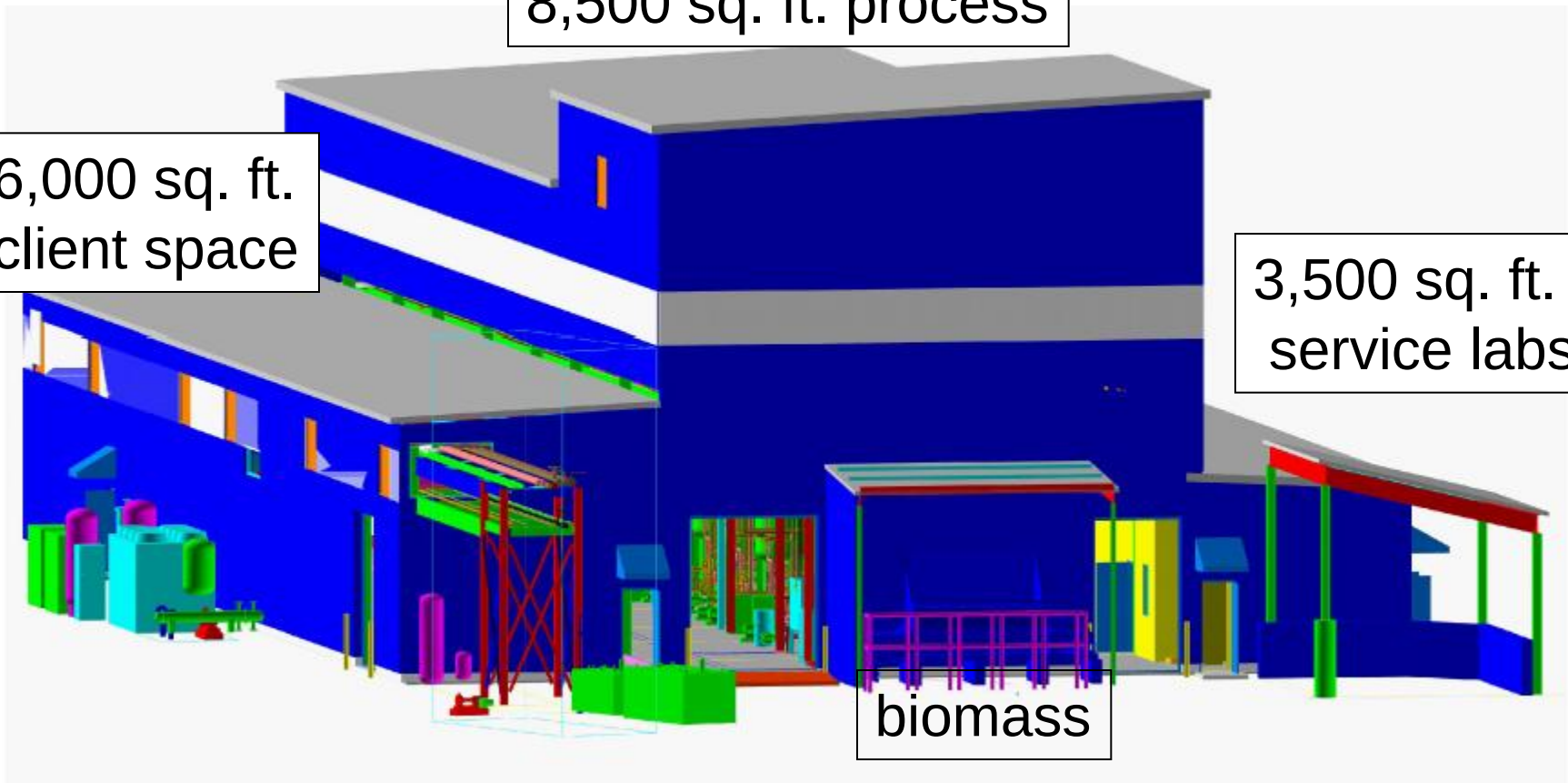
Buckeye Technologies, Inc., Perry Florida



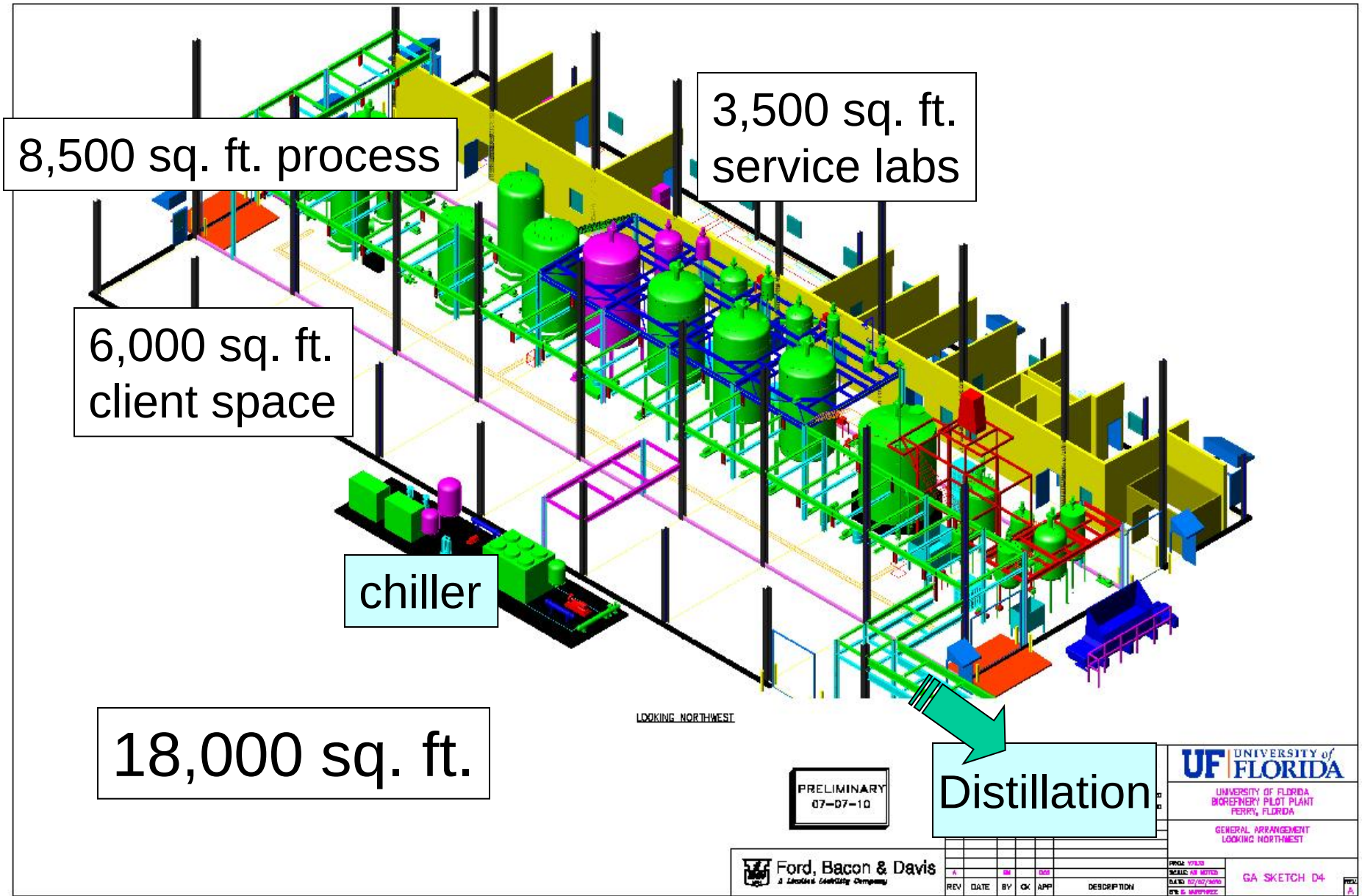
Stan Mayfield Biorefinery Pilot Plant



18,000 sq. ft.

Looking Northwest

Stan Mayfield Biorefinery Pilot Plant



Good things are already happening in Florida
(Replacing Petroleum with Renewable Fuels and Chemicals)

BP/Verenium/Lykes -- biofuel

Myriant Technologies (Purac)-- bioplastics

Licensees of UF technology for fuels and chemicals

Biodiesel: LS9 – bacterial oils from sugar

Seed oils – *Jatropha* **Petroalgae, oil from duckweed**

US Envirofuel – Ethanol from the juice of sweet sorghum

Buckeye Technologies & Florida Crystals
(power from woody residues; exploring fuels and chemicals)

Universities - Biofuels Pilot Plant (unit ops)
Stan Mayfield Biorefinery Pilot Plant/Buckeye
Florida Crystals/FIU Pilot Plant

Florida Center for Renewable Chemicals and Fuels (FCRC)

Thank you