CIAPR – Convención 2008

Overview of Bioethanol Production from Lignocellulosics

Lorenzo Saliceti-Piazza, *PhD, PE*

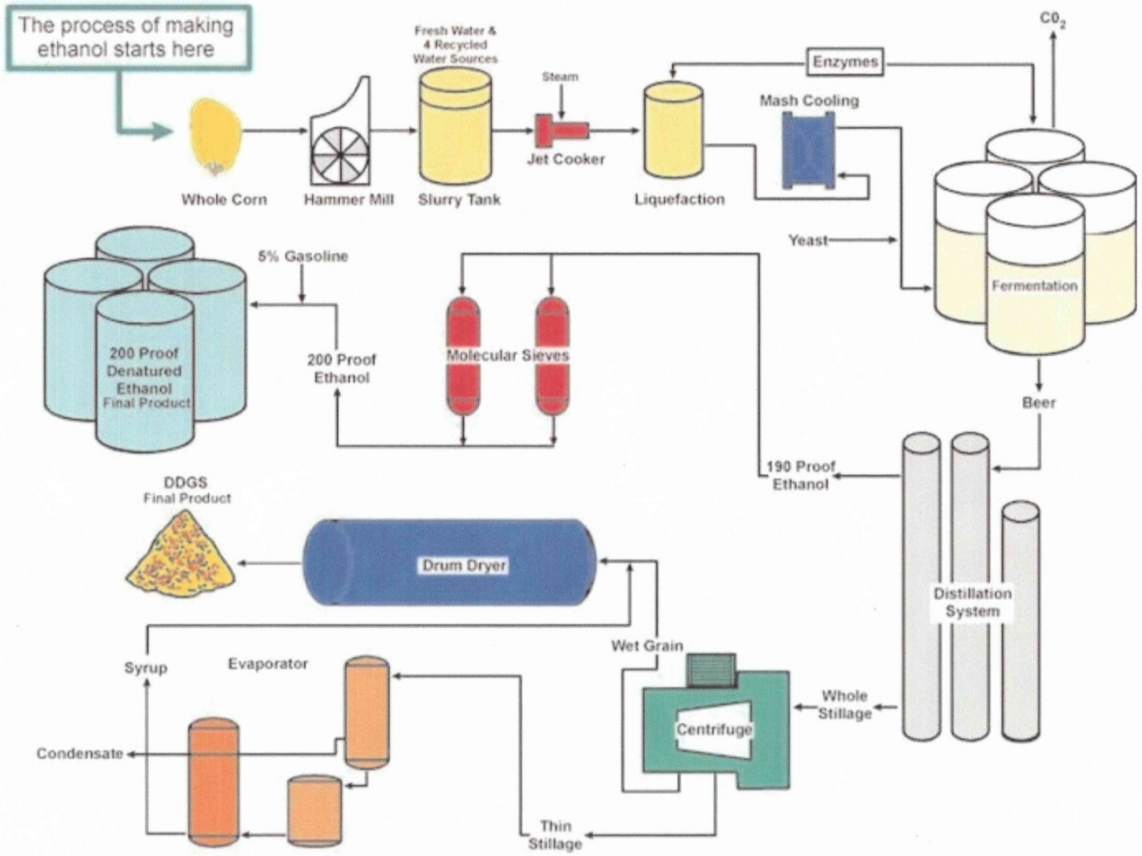
University of Puerto Rico – Mayagüez Campus

saliceti@uprm.edu

Agenda

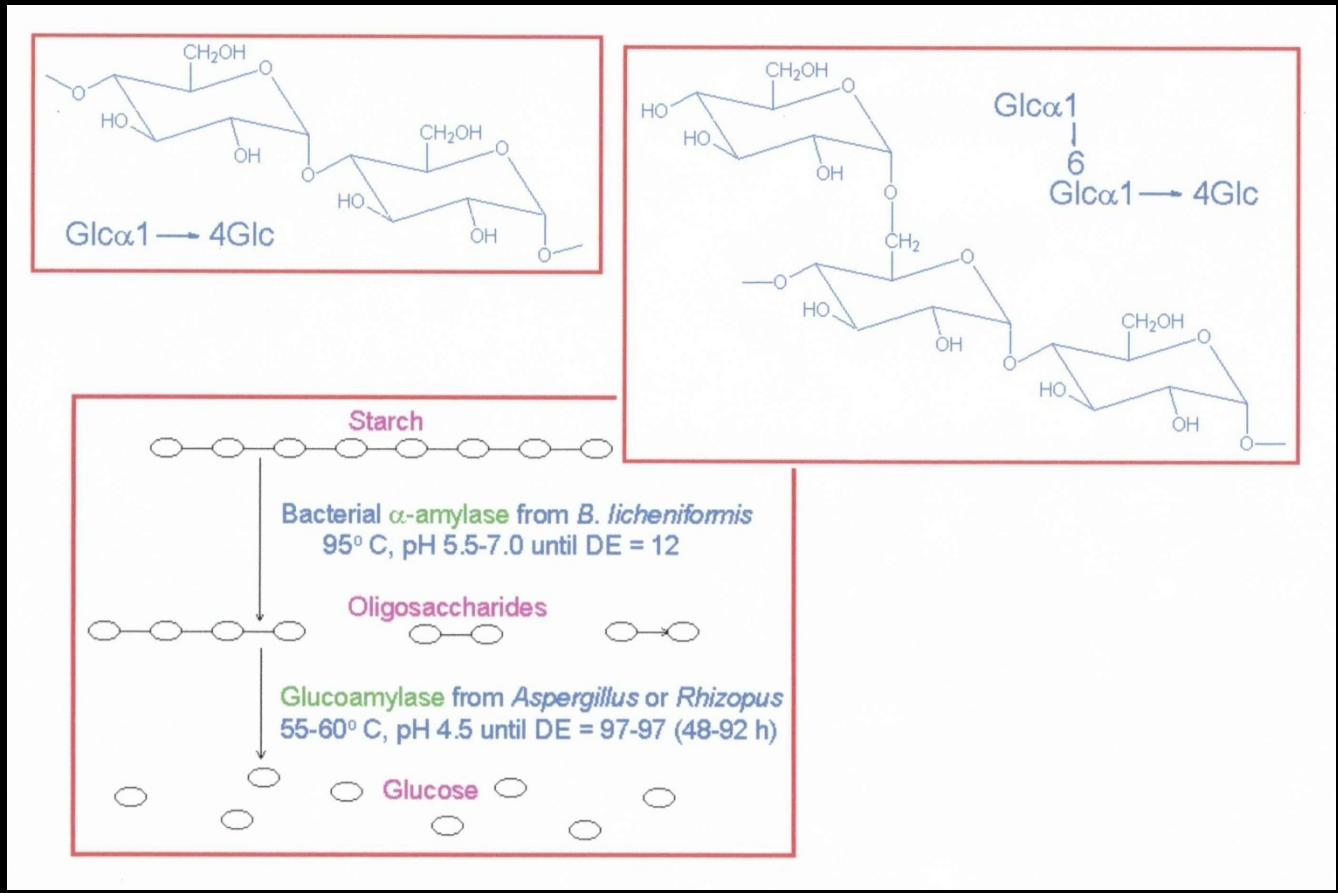
- Biorefinery - Corn
- Starch Hydrolysis
- Lignocellulosics - Biomass
- Cellulose Hydrolysis
- Cellulosic Ethanol Bioprocessing
- Metabolically-Engineered Microorganisms
- Cofermentation
- Closing Remarks

www.iowaethanol.com



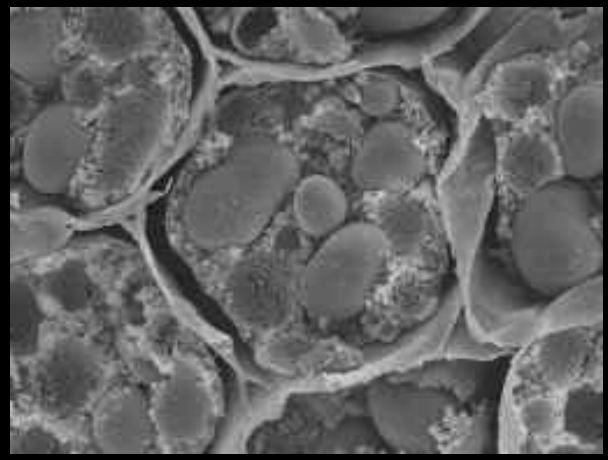
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Starch



Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Starch



Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

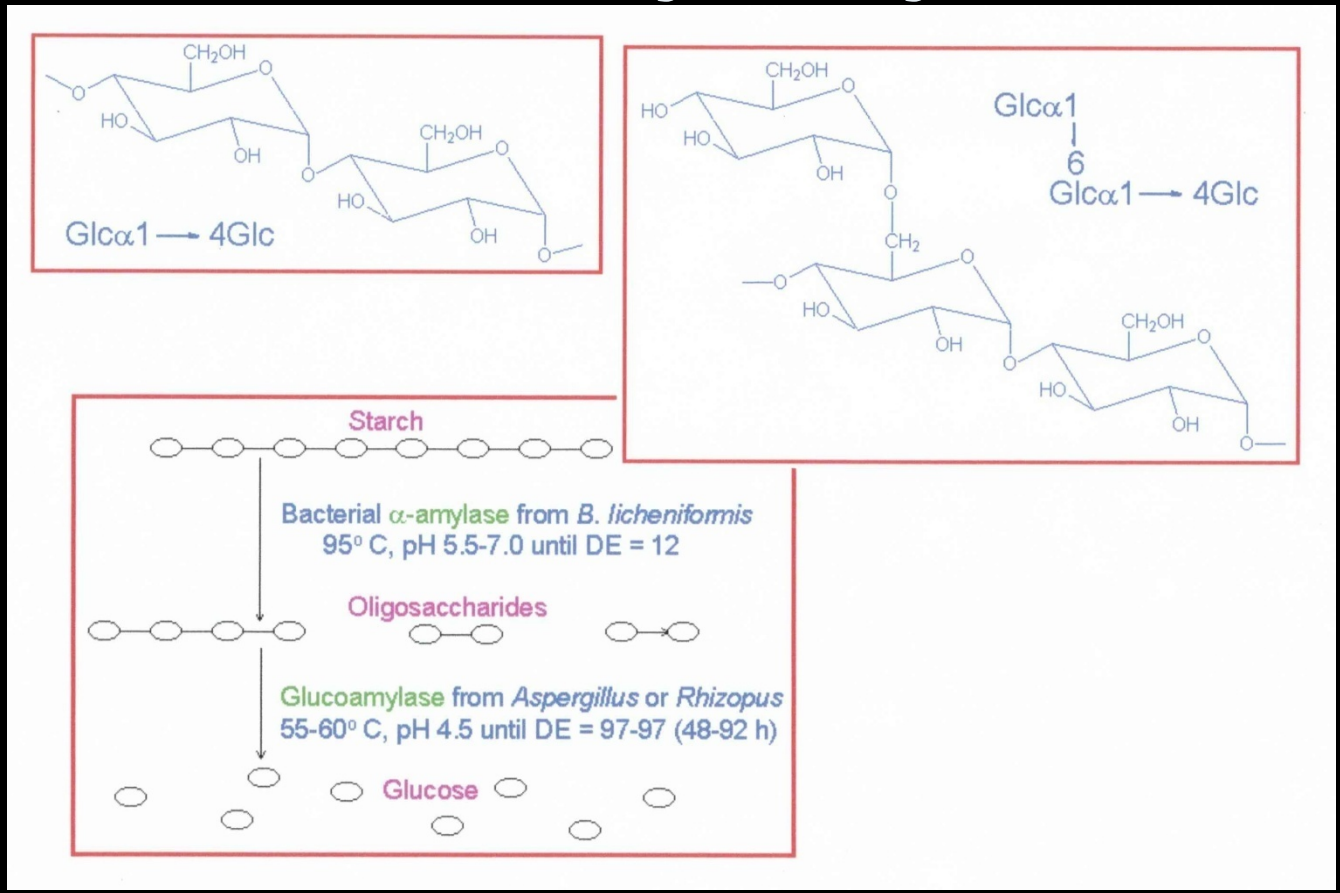
Cassaba - Yuca - Mandioca

Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Amylase

Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Starch Hydrolysis



Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Lignocellulosic Materials

Table 2.1. Approximate composition of selected lignocellulosic materials for ethanol production.

Materials	Cellulose (%)	Hemicellulose (%)	Lignin (%)
Herbaceous			
Alfalfa hay	38	9	14
[a] CBG	25	35.7	6.4
Switchgrass	45	31	12
Leaves	15–20	80–85	0
Crop residues			
Corn cobs	45	35	15
Corn stover	41	21–28	17–22
Sugarcane bagasse	40	22.5	25
Wheat straw	36	28	29
Nut shells	25–30	25–30	30–40
Hardwood			
Aspen	46	26	18
Hybrid poplar	43	21	26
Softwood			
Spruce	43	26	29
Pine	44	26	29
Cellulose wastes			
Newsprint	61	16	21
Newspaper	40–55	25–40	18–30
[b] RPS	50	10	0
Sorted refuse	60	20	20

[a] Coastal Bermuda grass.
[b] Recycled paper sludge.

Sáez-Miranda, Saliceti-Piazza, McMillan, 2006

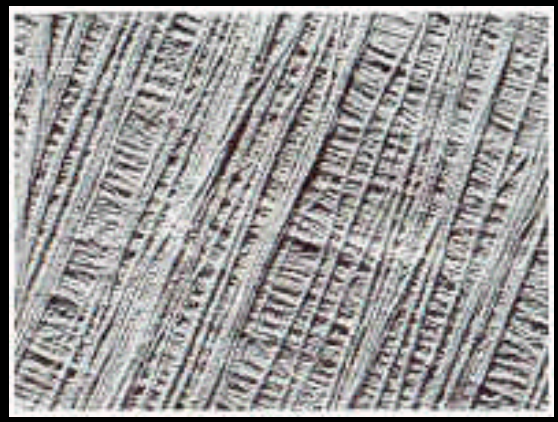
Sugar Cane

Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Bagasse

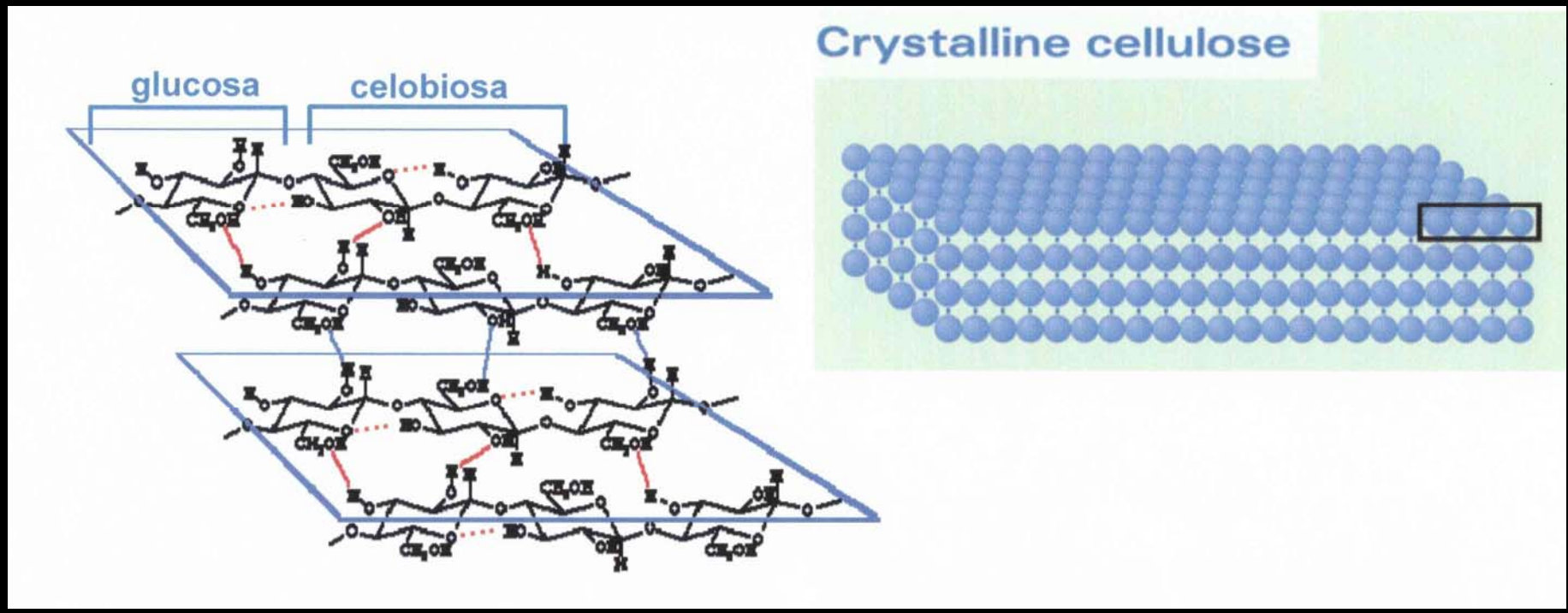
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Cellulose Microfibrils

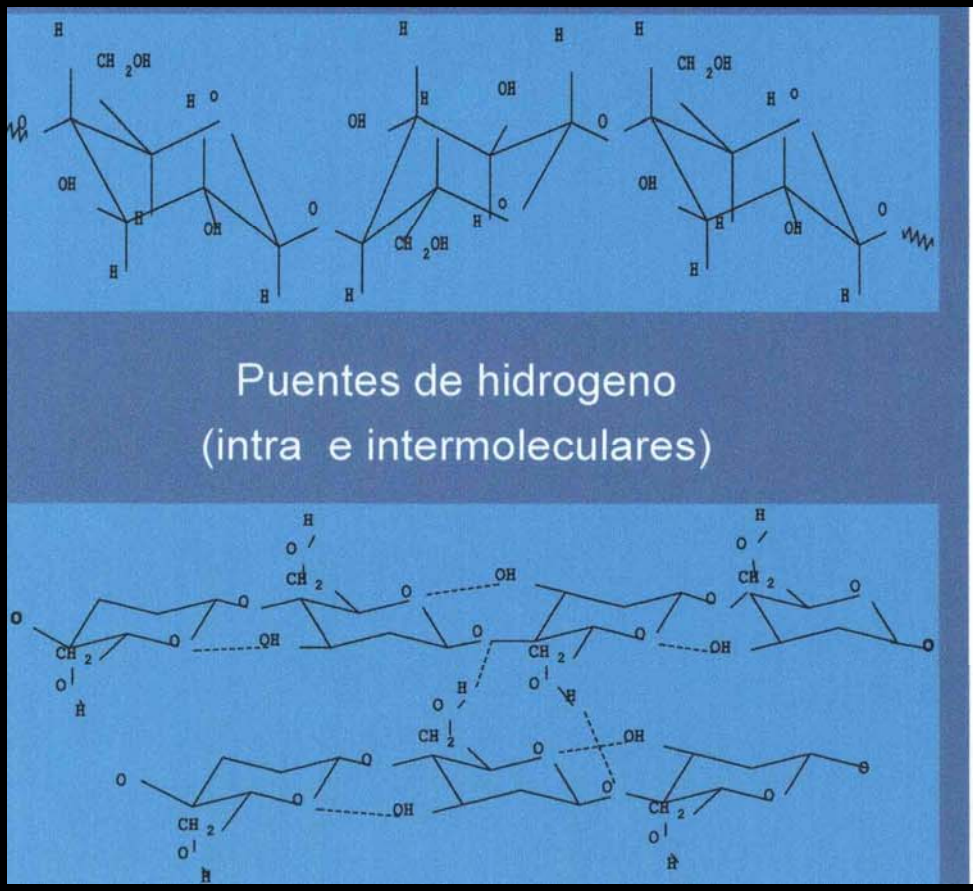


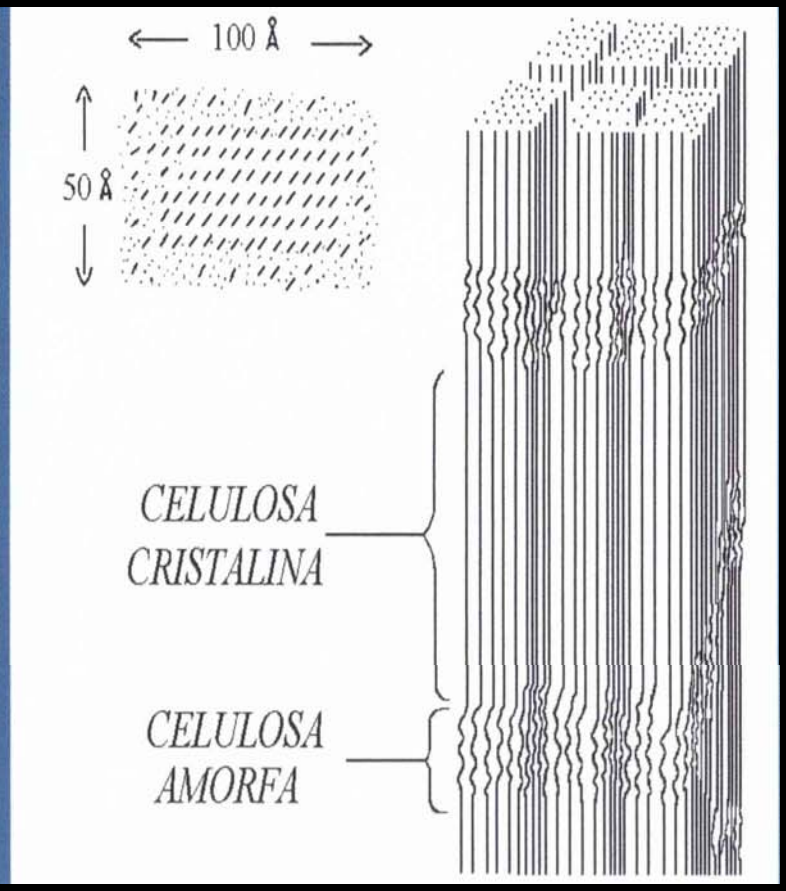
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Cellulose



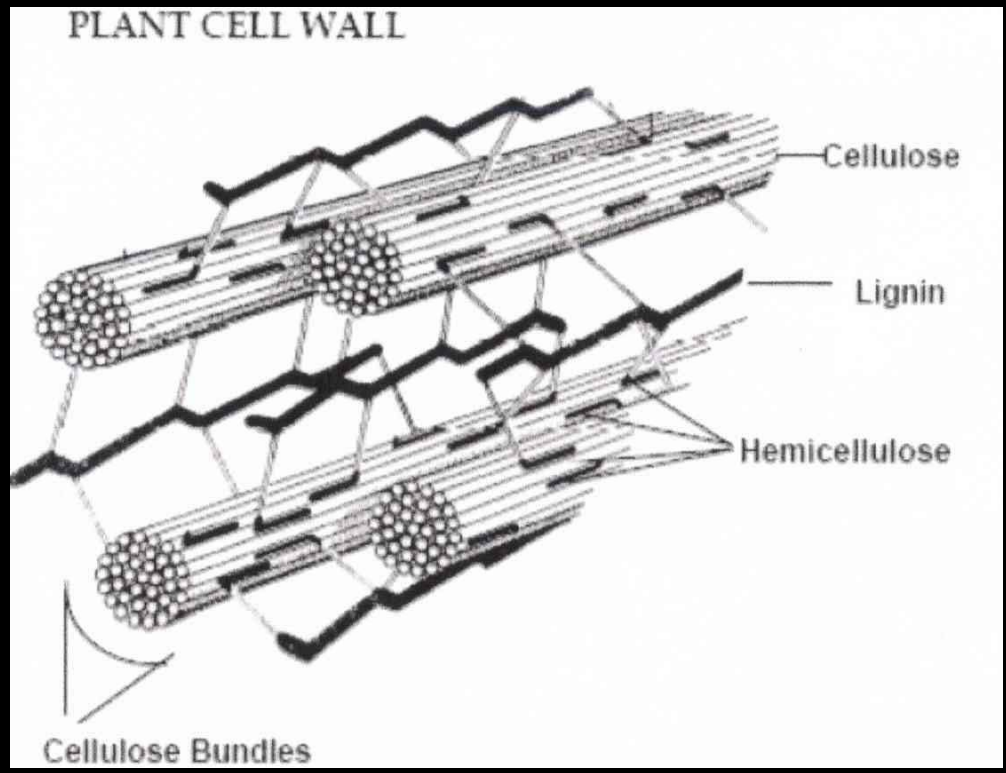
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez





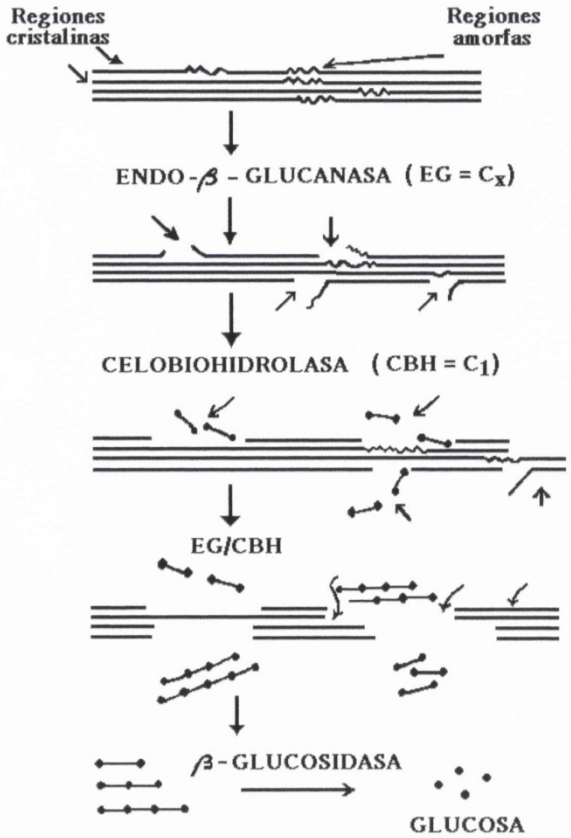
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Lignocellulose Structure



Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Cellulose Hydrolysis



CELULOSA

Atacada por endoglucanasas (*Trichoderma reseii* EGI y EGII) en los enlaces glicosídicos de las regiones amorfas

Atacada por las celobohidrolasas (*Trichoderma reseii* CBHI y CBHII) en los extremos no reductores

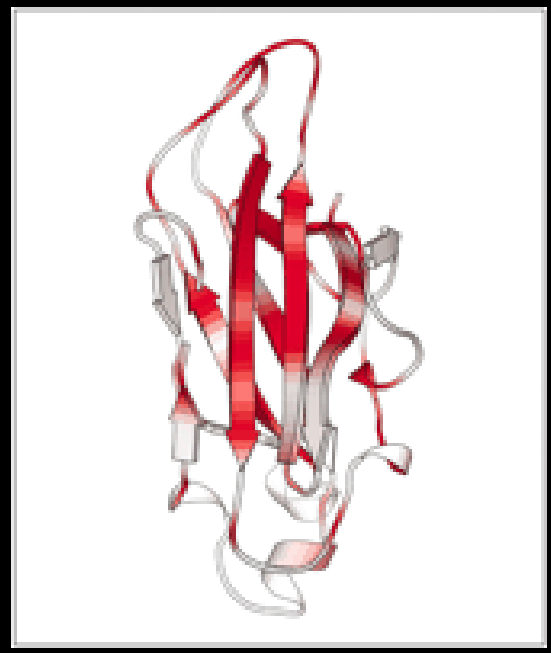
CELODEXTRINAS + CELOBIOSA

β-glucosidasa

GLUCOSA

Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Cellulases



Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Cellulosic Ethanol Bioprocessing

- Separate Hydrolysis and Fermentation - SHF
- Simultaneous Saccharification and Fermentation - SSF
  - Lower enzyme loading
- Simultaneous Saccharification and Cofermentation - SSCF
  - Use of metabollically-engineered microorganisms
- Hybrid Systems
  - Hybrid Hydrolysis and Fermentation - HHF
  - Combination between SHF and SSCF
  - Starts with high temperature saccharification step
  - Followed by simultaneous mesophilic hydrolysis and cofermentation

Sáez-Miranda, Saliceti-Piazza, McMillan, 2006

SSCF or HHF

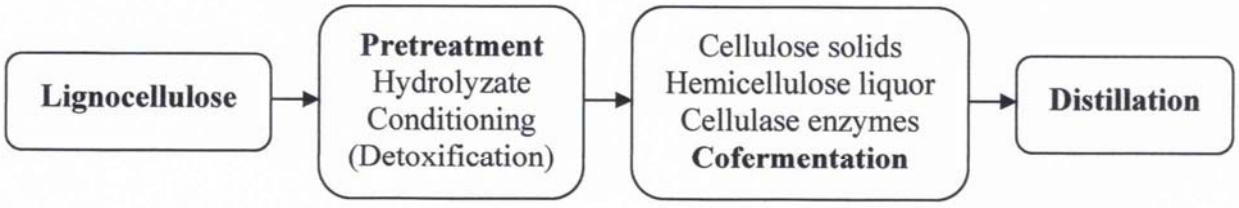
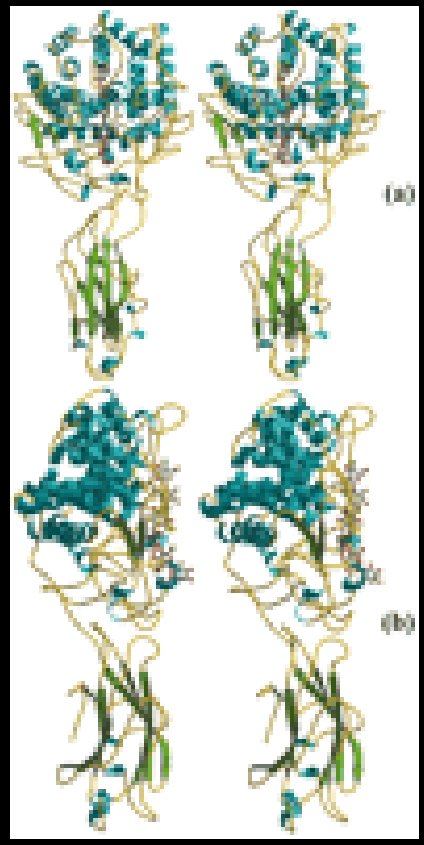
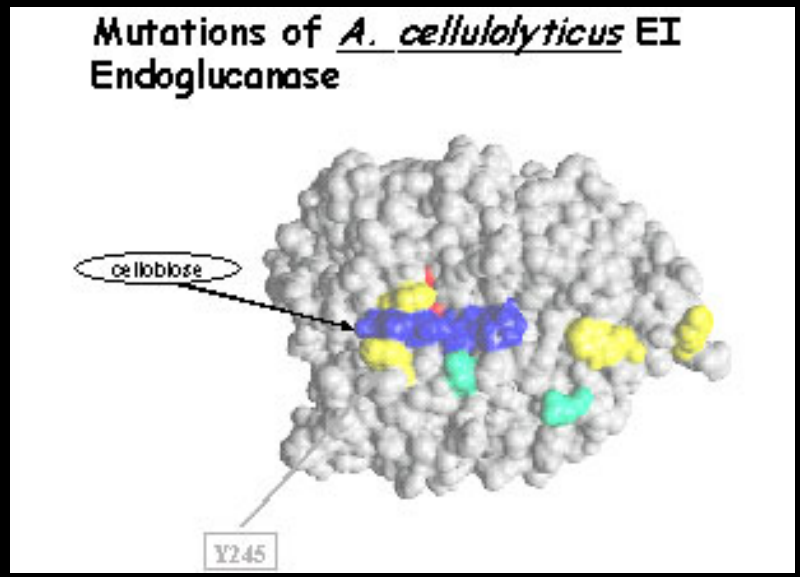


Figure 2.2. Potential simplified technology (SSCF or HHF process) for the conversion of lignocellulose biomass to ethanol.

Sáez-Miranda, Saliceti-Piazza, McMillan, 2006

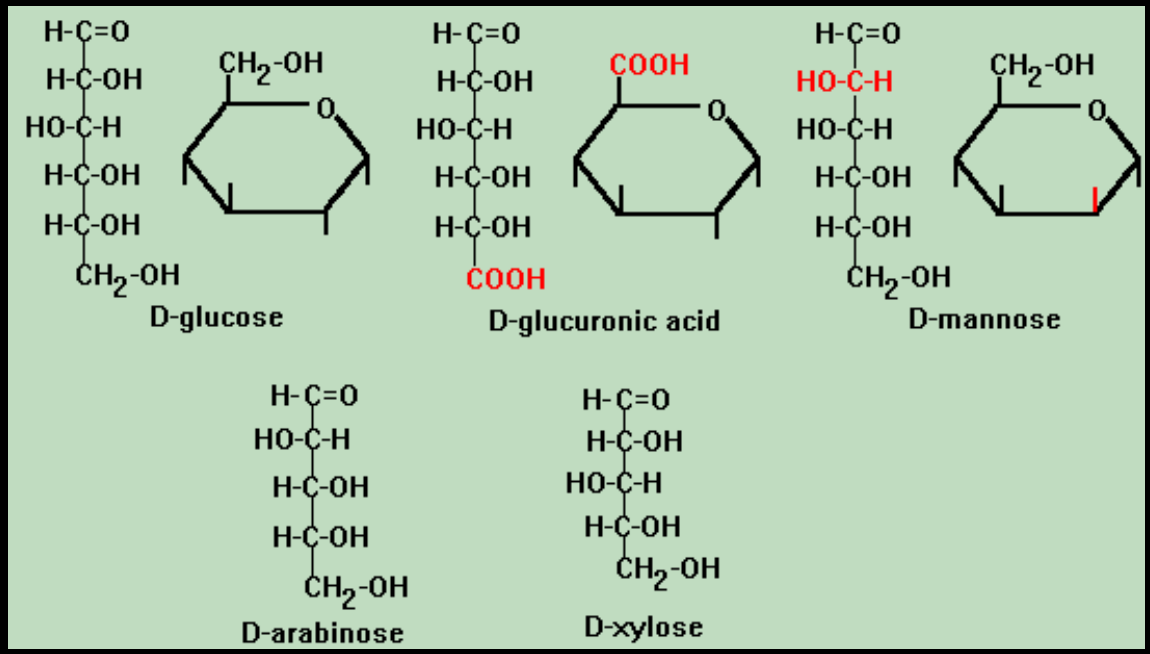
Site Selected Mutagenesis





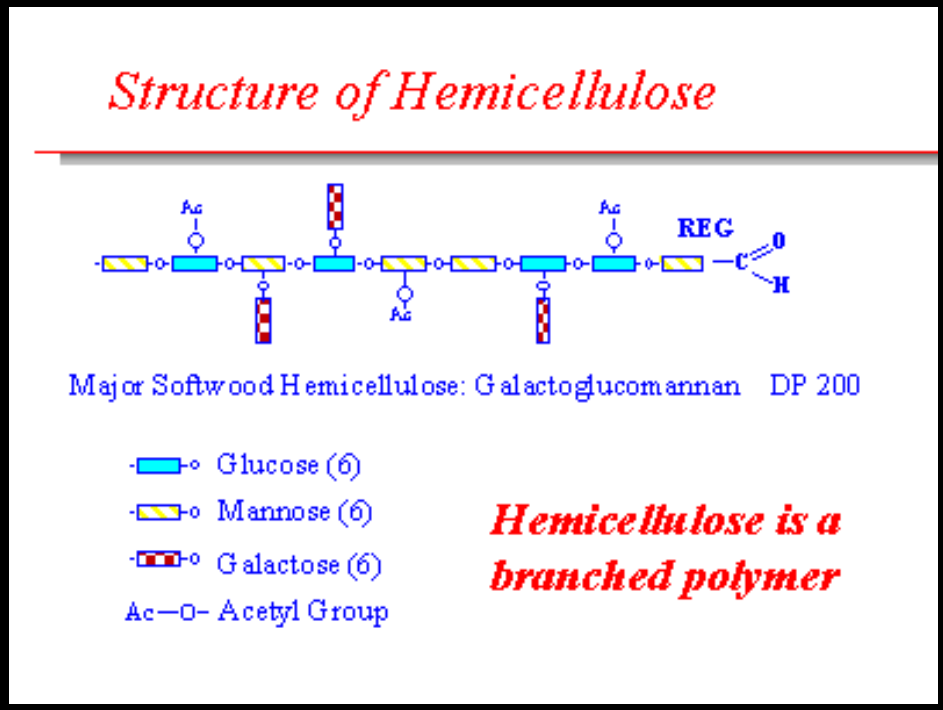
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

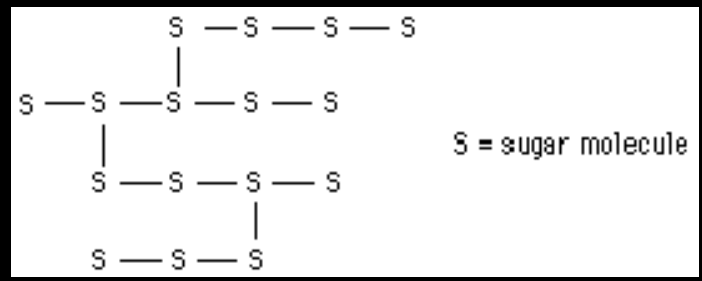
Hemicellulose Sugars



Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

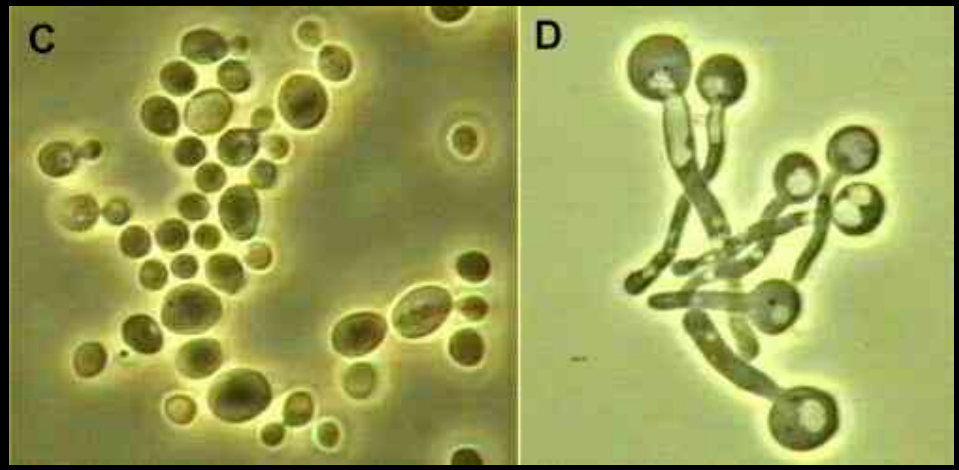
Hemicellulose





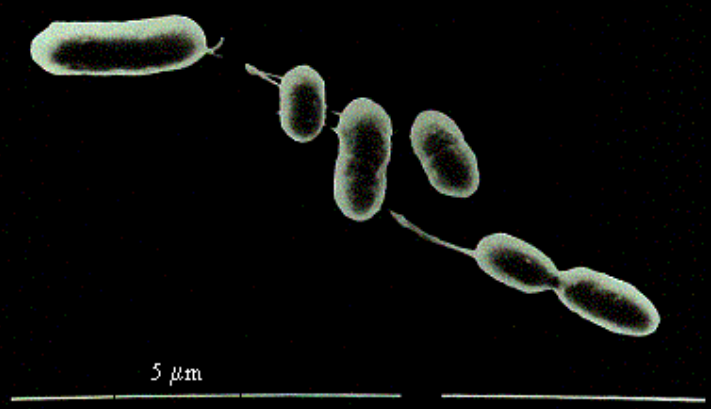
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Metabolically-Engineered *Saccharomyces cerevisiae*

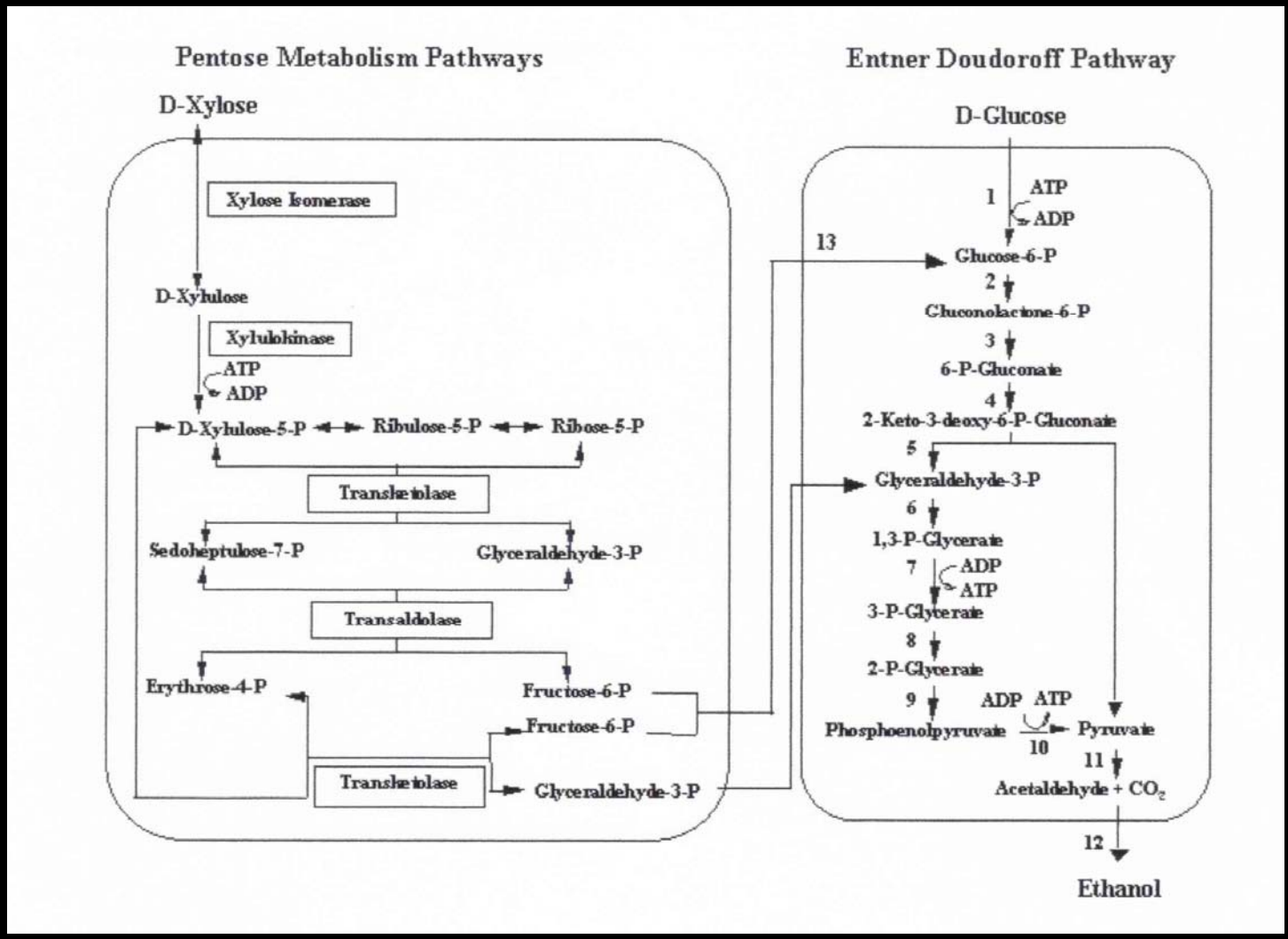


Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Metabolically-Engineered *Zymomonas mobilis*



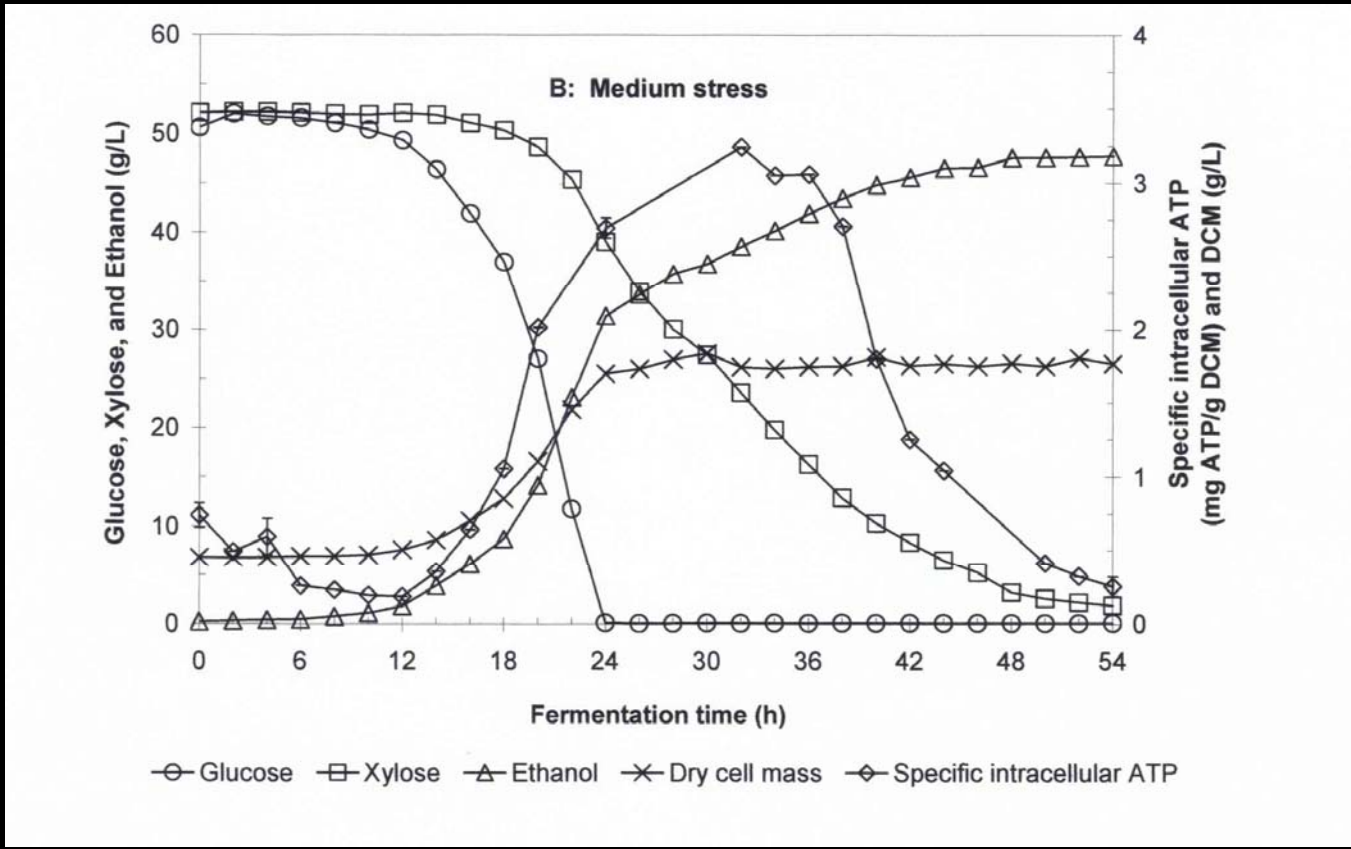
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez



Sáez-Miranda, Saliceti-Piazza, McMillan, 2006

Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

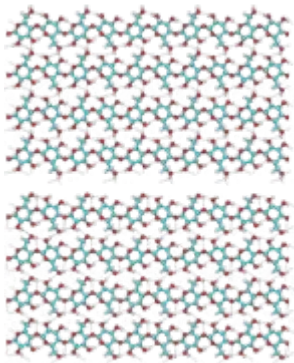
Typical Cofermentation



Sáez-Miranda, Saliceti-Piazza, McMillan, 2006

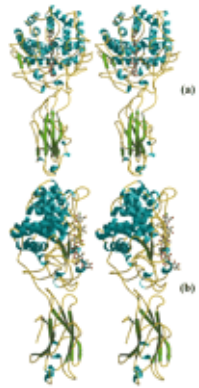
Bagasse Fractionation and Saccharification of Cellulose

Bagasse

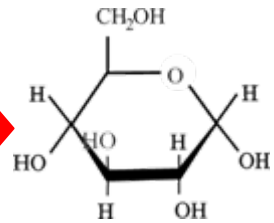


Cellulose

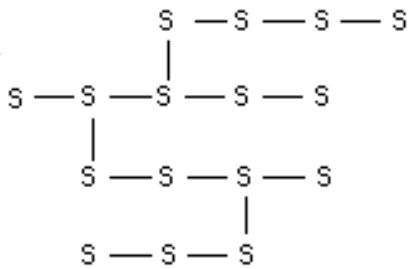
+



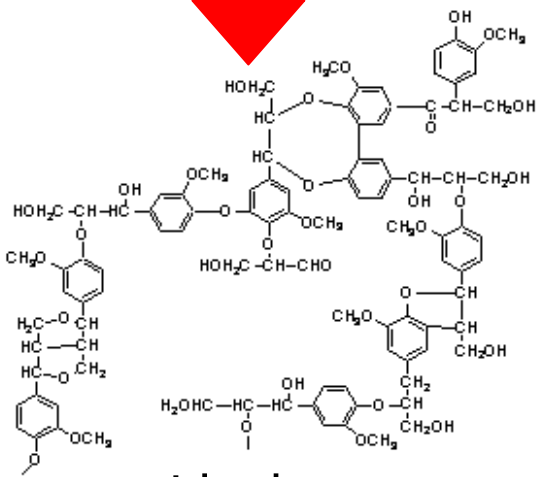
Cellulases



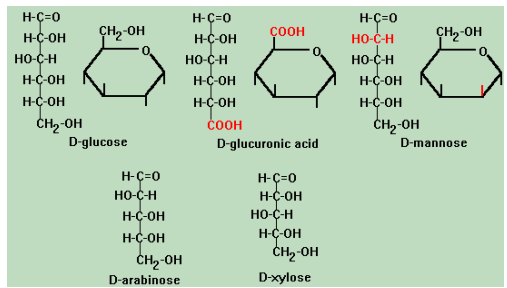
Glucose, 6 Carbon Sugar



Hemicellulose



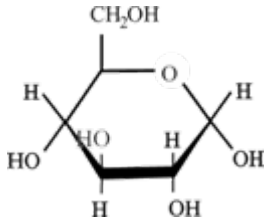
Lignin



5 & 6 Carbon Sugars

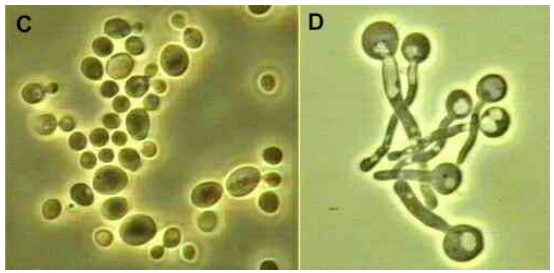
Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

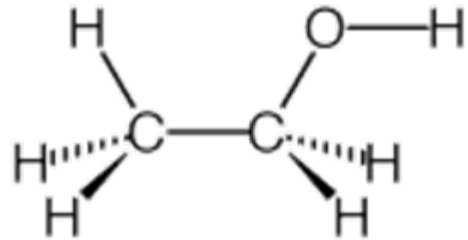
Fermentation of Biomass Sugars and Lignin Conversion



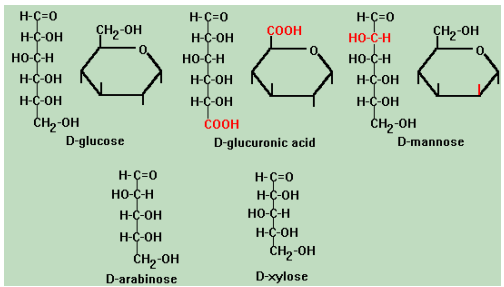
Glucose

+



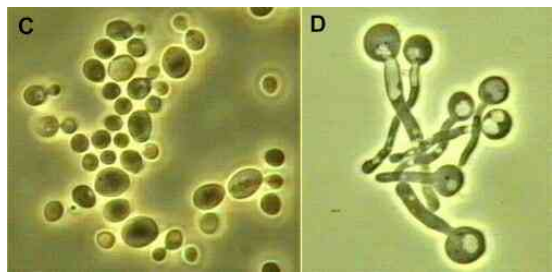


Ethanol

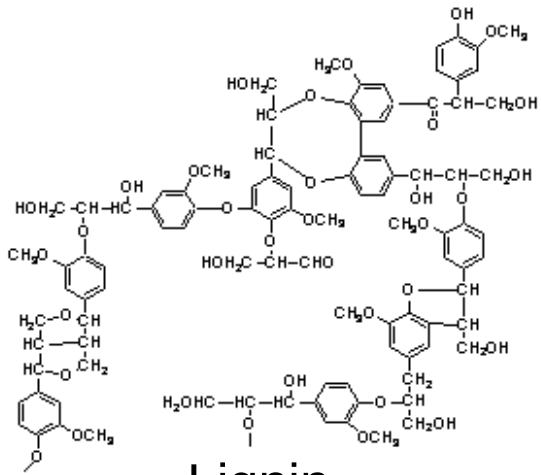


5 & 6 Carbon Sugars

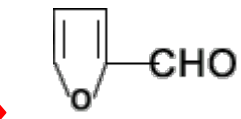
+

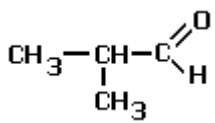


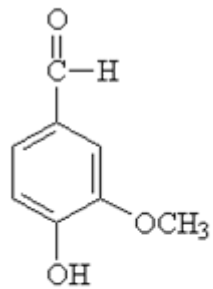
Metabolically-Engineered Microorganisms



Lignin







Vanillin

artificial vanilla flavoring

Value-Added Chemicals: Furfural, Aldehydes, Vanillin, etc.

Lorenzo Saliceti-Piazza, Ph.D., P.E., UPR-Mayagüez

Industrial Biotechnology

The Third Wave of Biotechnology

BIO

Closing Remarks

- Puerto Rico needs to develop renewable energy sources
- Bioenergy is one attractive alternative
  - Bioethanol
  - Biodiesel
- A strong agricultural infrastructure is needed
- Use of high technology is essential
- A renewable energy agenda must exist
- We have the human resources and knowledge to develop a bio-economy structure