Bioethanol Overview

- What is bioconversion?
- Why bioconversion?
- Biomass composition
- Bioconversion to ethanol process
  - Pretreatment
  - Hydrolysis
  - Fermentation
- Pros and cons of bioethanol
- Comparison to other biofuels

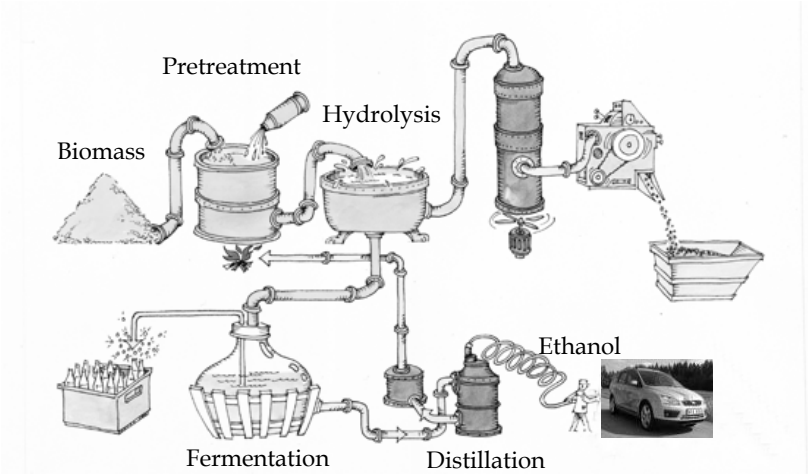
What is bioconversion?

- General: a process which uses biological agents (microorganisms or protein) to transform a feedstock into desirable products.

  Bioethanol

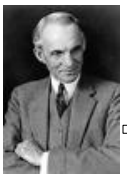
- A chemical/biochemical process by which lignocellulosic materials are converted to ethanol and other co-products.

Bioconversion



Ethanol (CH_3CH_2OH)

- Ethyl alcohol, grain alcohol
  - Clear, colorless liquid
- Ethanol made from cellulosic biomass instead of starch crops-bioethanol
- Advantages of bioethanol

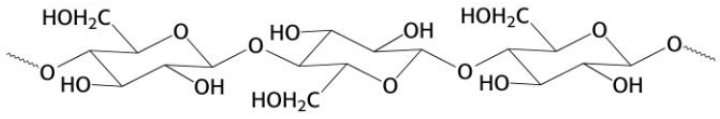


Henry Ford

"We can get fuel from apples, weeds, sawdust, almost anything…..
And it remains for someone to find how this fuel can be produced commercially-
better fuel at a better price than we now know."

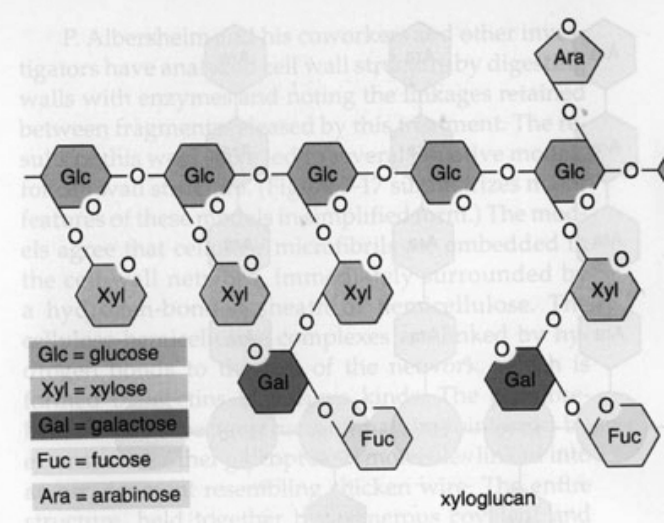
Henry Ford

Cellulose

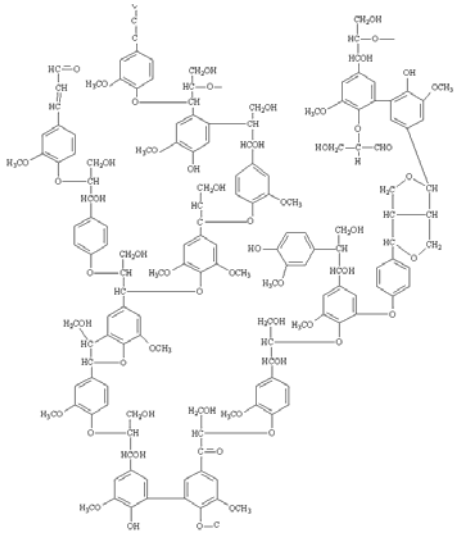


Cellulose
(β-1,4 linkages)

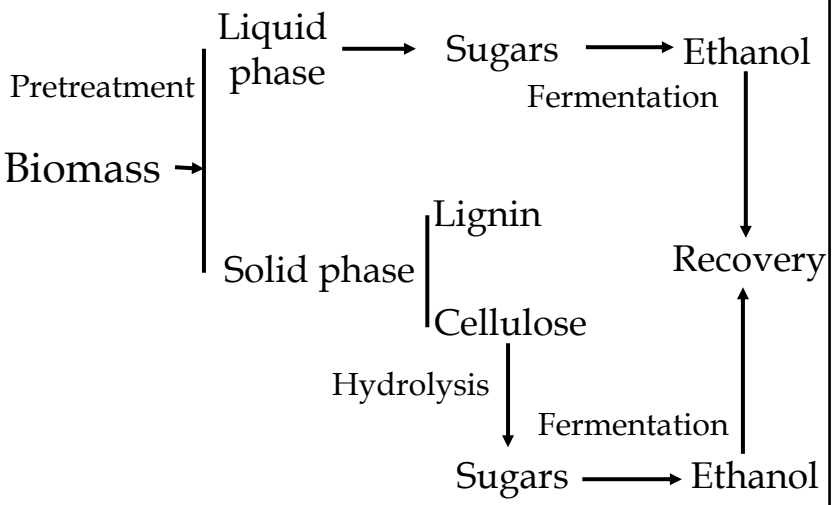
Hemicellulose



Lignin

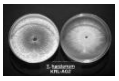
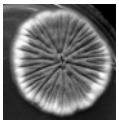


Bioconversion of biomass to ethanol



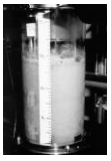
Steam explosion

- Treatment of biomass with high-pressure steam for a short period of time followed by sudden decompression
- Acid (H_2SO_4, SO_2) impregnation of biomass increases SE efficiency
- Typical conditions:
  - Temperature: 170-250ºC, 338-482 F
  - Time: 10sec-10min

What are cellulases?

- Enzymes made by many strains of bacteria and fungi
- Catalyzes the depolymerization of cellulose chains
  - (details in Renata Bura's class)

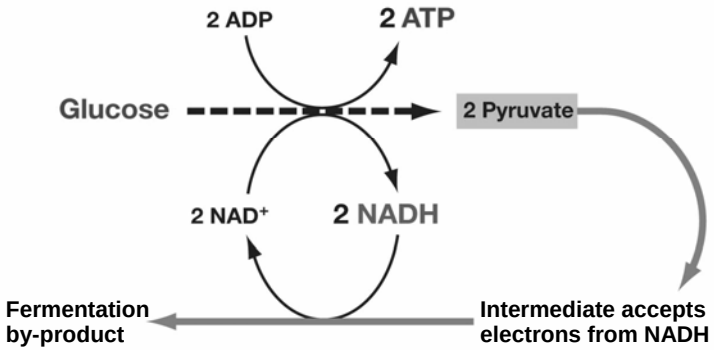
Fermentation

- Defined as:

  Cellular metabolism under anaerobic conditions (absence of oxygen) for the production of energy and metabolic intermediates
- Many organisms can "ferment"
- Not all produce ethanol as an end-product

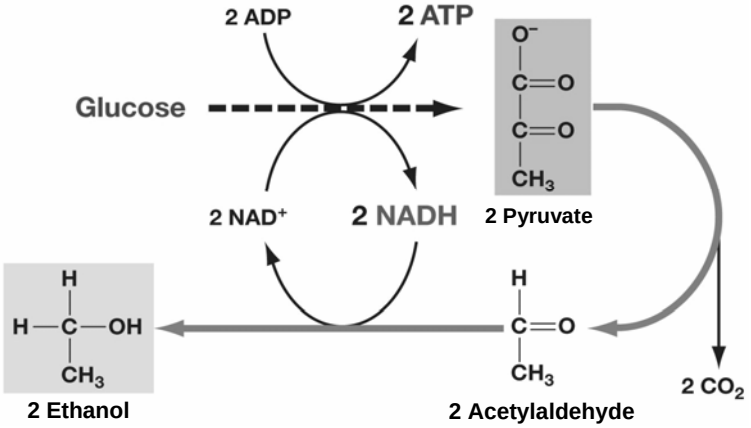
Fermentation Regenerates NAD^+

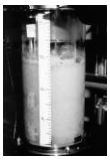
(a) Fermentation pathways allow cells to regenerate NAD^+ for glycolysis.



GENERAL PATHWAY

(c) Alcohol fermentation occurs in yeast.

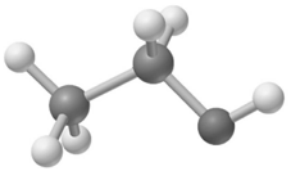




Fermentation

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2\,CO_2 + 2\,CH_3CH_2OH$$

Glucose — Ethanol



Conversion factor 0.51

1g/L of glucose: 0.51g/L ethanol (maximum)

Biofuels-comparison

	Production (billion gallons)	Production cost ($)	Energy balance	GHE reduction (%)
Corn (grain)				
Cane				
Lignocellulose				
Biodiesel				

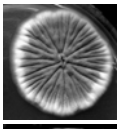
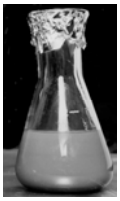
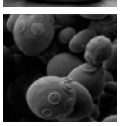





Flexible-Fuel Vehicles (FFV)

- Use E85 (85% ethanol and 15% gasoline)
- Cost of FFV is similar to traditional gasoline vehicle
- 1gallon of E85 provides the same energy as 0.72 gallons of gasoline (lower E content)
- Special materials required for fuel lines, hoses, valves, gaskets, fuel tank (corrosive ethanol)
- Washington state more than 35, 000 of FFVs (U.S. over 4 million FFVs)
  - Ford Focus, Chrysler Sebring, Dodge Stratus, Dodge Caravan, Chevrolet Avalanche

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Exam 2 Study Guide

- Compare bioenergy with petroleum in terms of sources and how they are made
- Advantages and problems with biofuels compared to petroleum
- The structure of plants and how it relates to bioenergy
- Bioethanol vs Biodiesel vs Biomethanol
  - Plant material used
  - How they are made
  - Differences in relative energy and why