



# Biotechnologische Verwertung nachwachsender Rohstoffe

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# Overview Bioenergy



- **Biofuels**
  - Liquid, transportable, safe; main use: transportation.
- **Biogas**
  - Advanced production processes; drawbacks in storage and transportation.
- **Bio-Hydrogen**
  - High energy content. Difficult to store and transport; safety issues.
- **Electricity**
  - Hydrogen based fuel cell
  - Enzymatic fuel cell

# Biofuels: state of the art

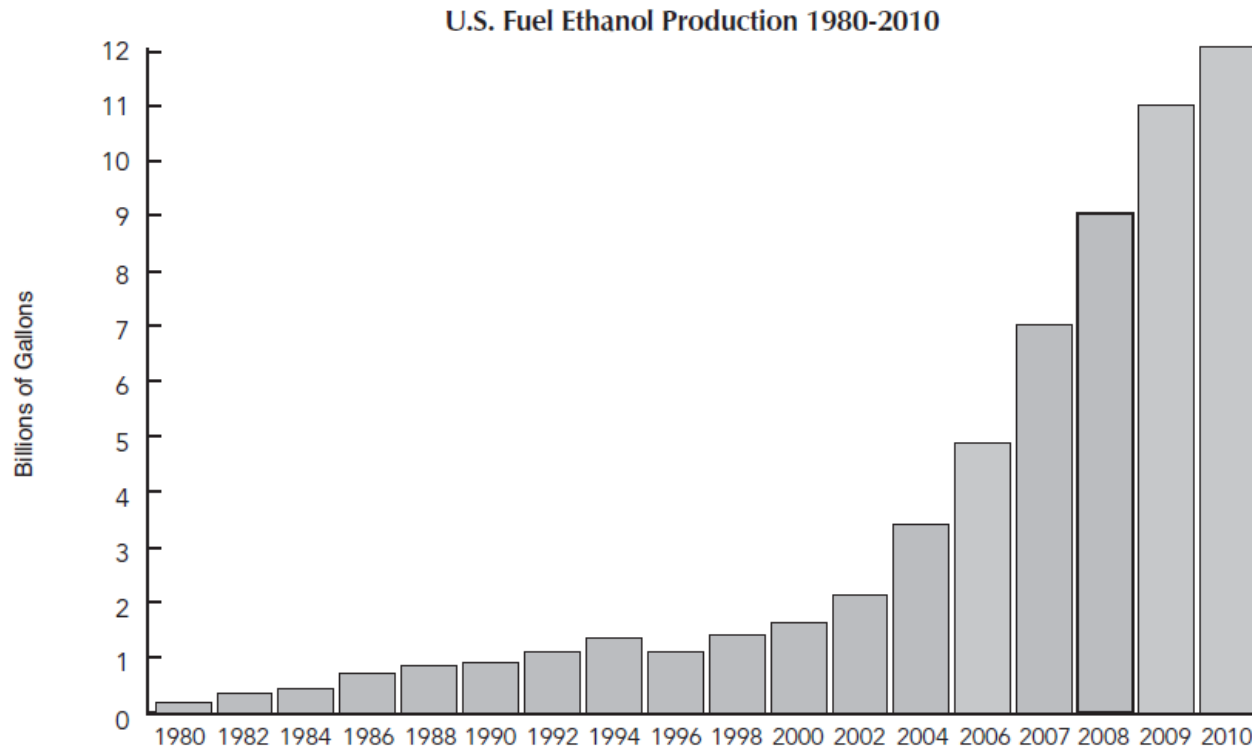
Most biofuels are produced by fermentation

- Ethanol CCO
  - Yeast or bacterial fermentation of sugar
- Butanol CCCCO
  - Bacteria; or engineered yeast; fermentation of sugar
- Lipids
  - Lipids produced by algae 
  - Biodiesel: made from oil crops 
- Other:
  - Methyl-butanol
  - Other alcohols CC(C)CCO

# Status of biofuel development

- Bioethanol
  - 1<sup>st</sup> generation: large scale production from sugar or starch, mainly US and Brazil
  - 2<sup>nd</sup> generation: cellulosic ethanol close to large scale; hemicellulosic ethanol in development
- Biobutanol
  - Status: production with engineered yeast and bacteria in development stage – g/L range
- Biodiesel
  - Fatty acid methyl (or ethyl) ester: large scale production
  - Algae oil: in development stage; technological challenges

# Annual growth of US bioethanol production

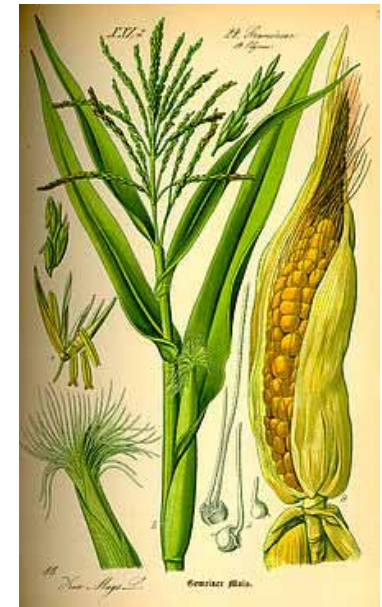


Source: CFDC (The Clean Fuels Development Coalition), Ethanol Fact Book

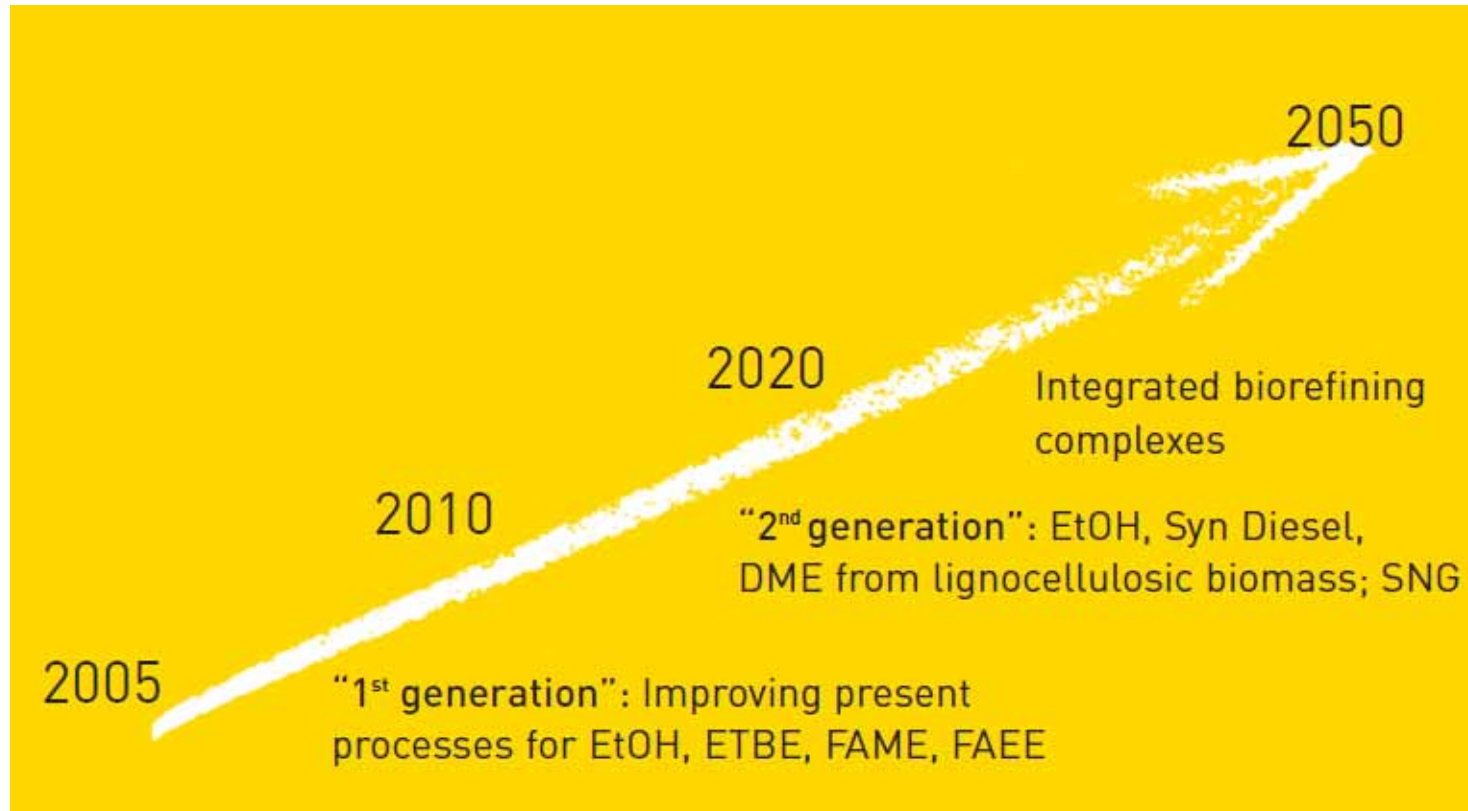
# Use of corn stover for cellulosic ethanol



<b>Annual transportation fuel production</b>	<b>Production Mrd. Liter</b>
Ethanol production US	40
Ethanol production worldwide	74
Theoretical ethanol production from 50% of US corn stover	17
Total from mineral oil worldwide	1500



# Status of biofuel development



BIOFUELS IN THE EUROPEAN UNION • A VISION FOR 2030 AND BEYOND

# Integrated Biorefinery Concept

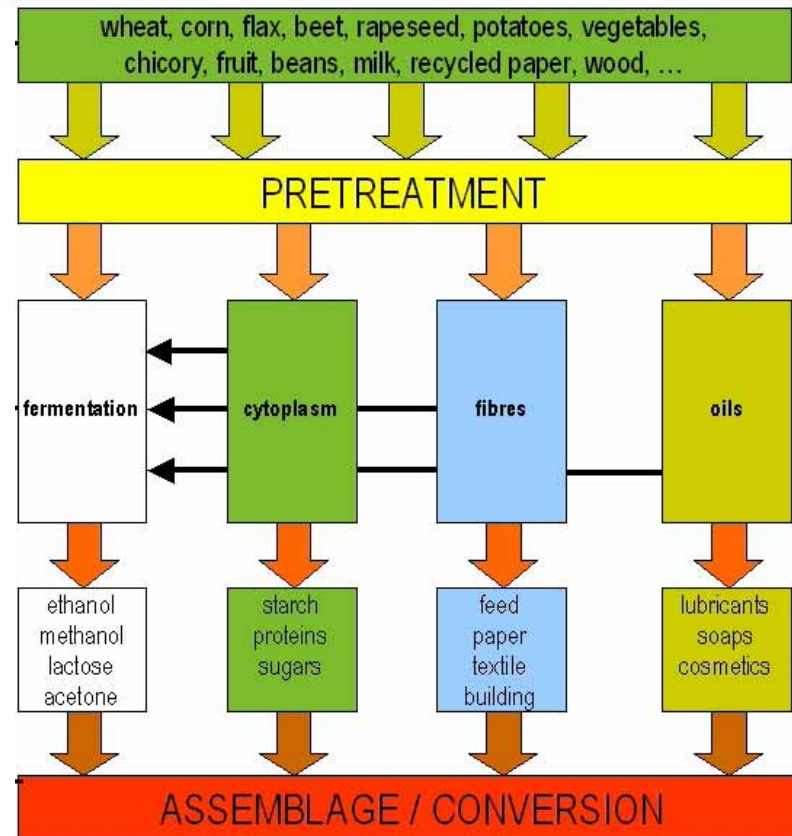
- Use of all biomass
  - Sugar / Starch
  - Lignocellulose
  - Protein, oils, fibres
- Different substrate flows
  - Glucose from starch or cellulose
  - Xylose and arabinose from hemicellulose
  - Glycerol from oils
- Mixed product flows
  - Bioenergy
  - Biomaterials



# Integrated Biorefinery

## Multi-purpose biorefinery

innovation by nature



# Integration of bioenergy and biomaterial production



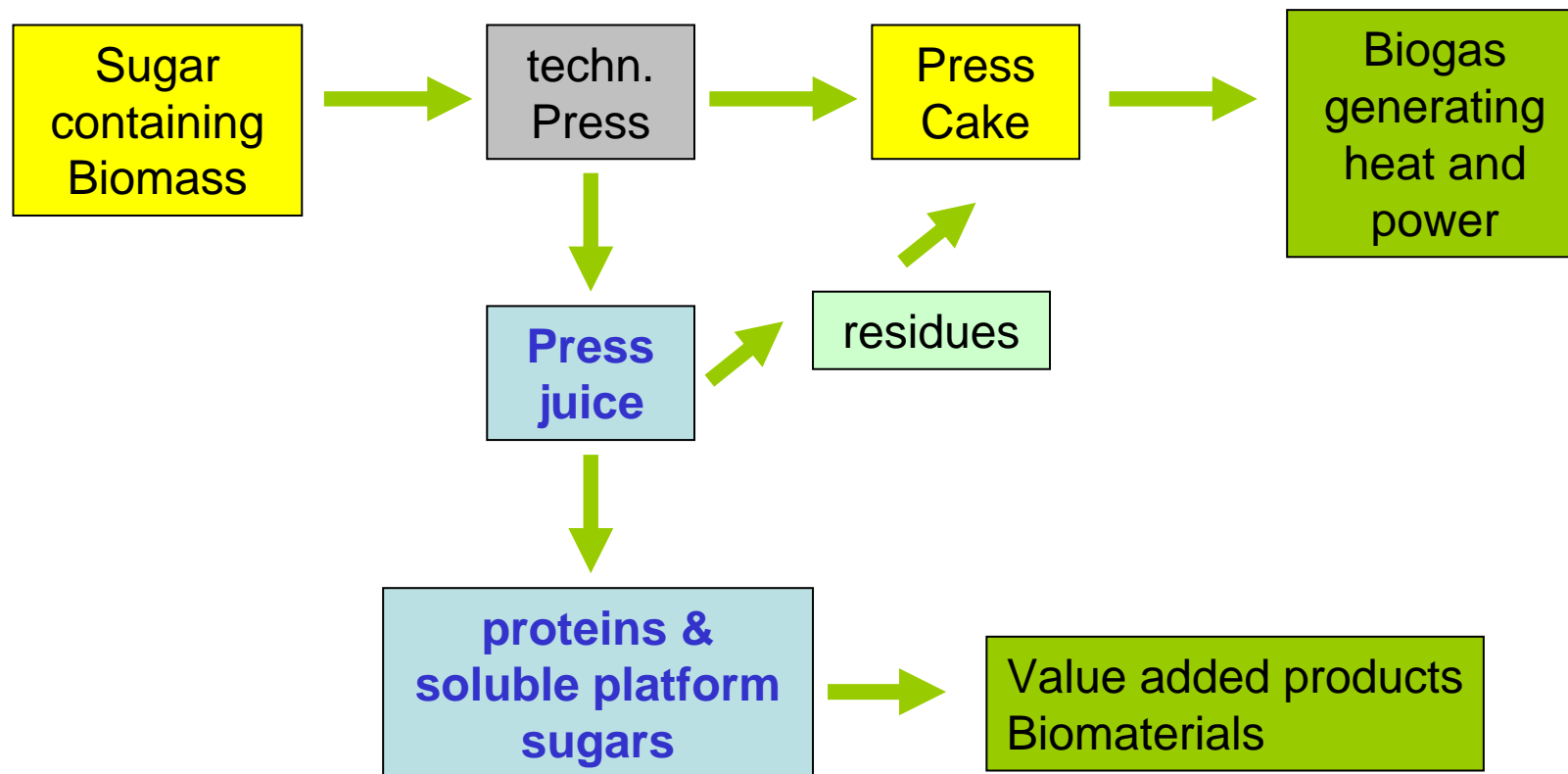
- Example: Sweet Sorghum
- Press juice is rich of sugar
  - can be easily converted to biomaterials
  - value added products
- Press cake: conversion to bioenergy
  - saccharification → bioethanol
  - biogas



# Mixed Biorefinery: Materials – Energy



Example: Utilization of glucose for biomaterials



# Products from White Biotechnology

- **Organic acids**

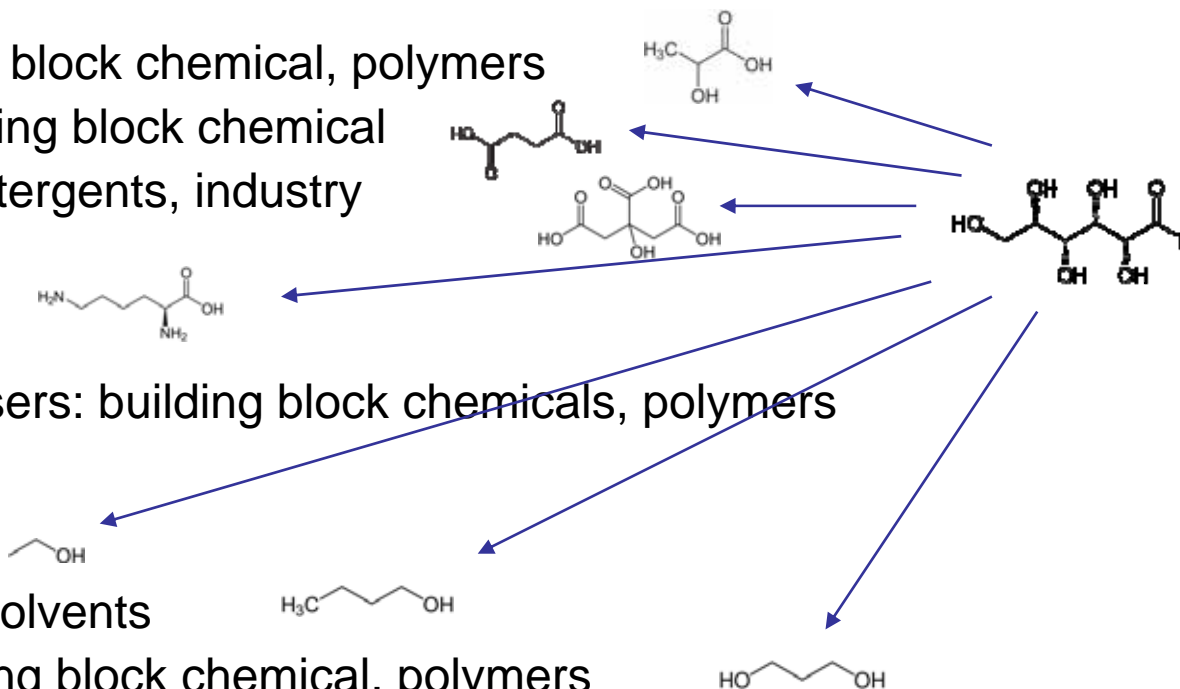
- lactic acid: building block chemical, polymers
- succinic acid: building block chemical
- citric acid: food, detergents, industry

- **Amino acids**

- Lysin: food, feed
- Amino acid precursors: building block chemicals, polymers

- **Alcohols**

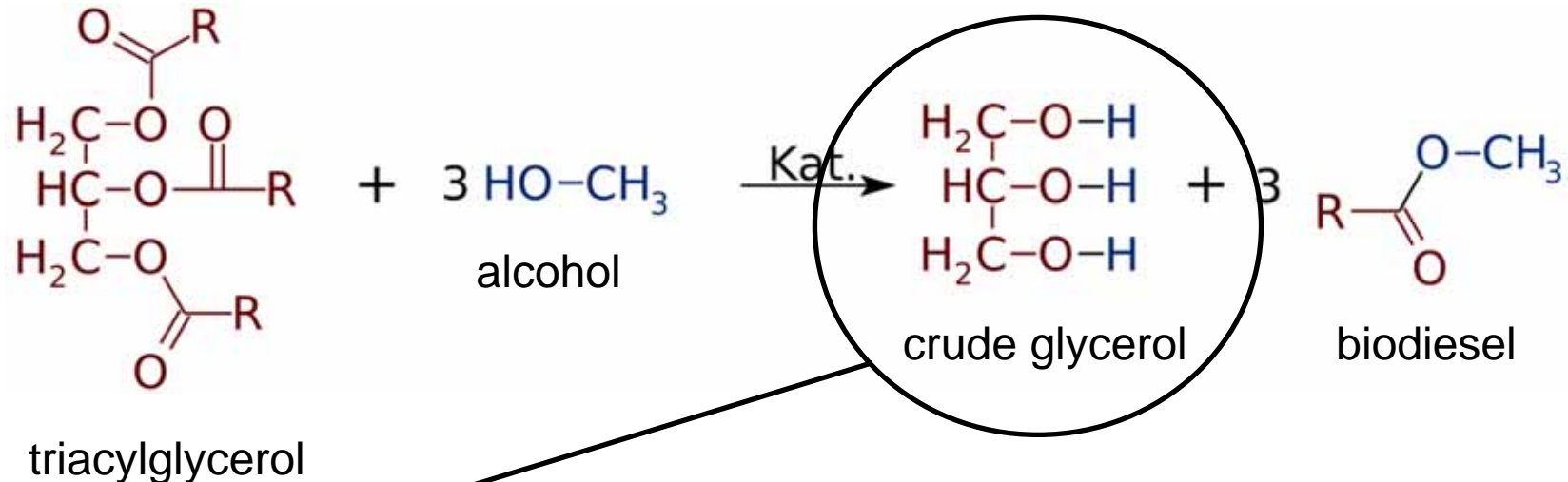
- Ethanol: biofuels
- Butanol: biofuels, solvents
- Propanediol: building block chemical, polymers



## Produced from sugar

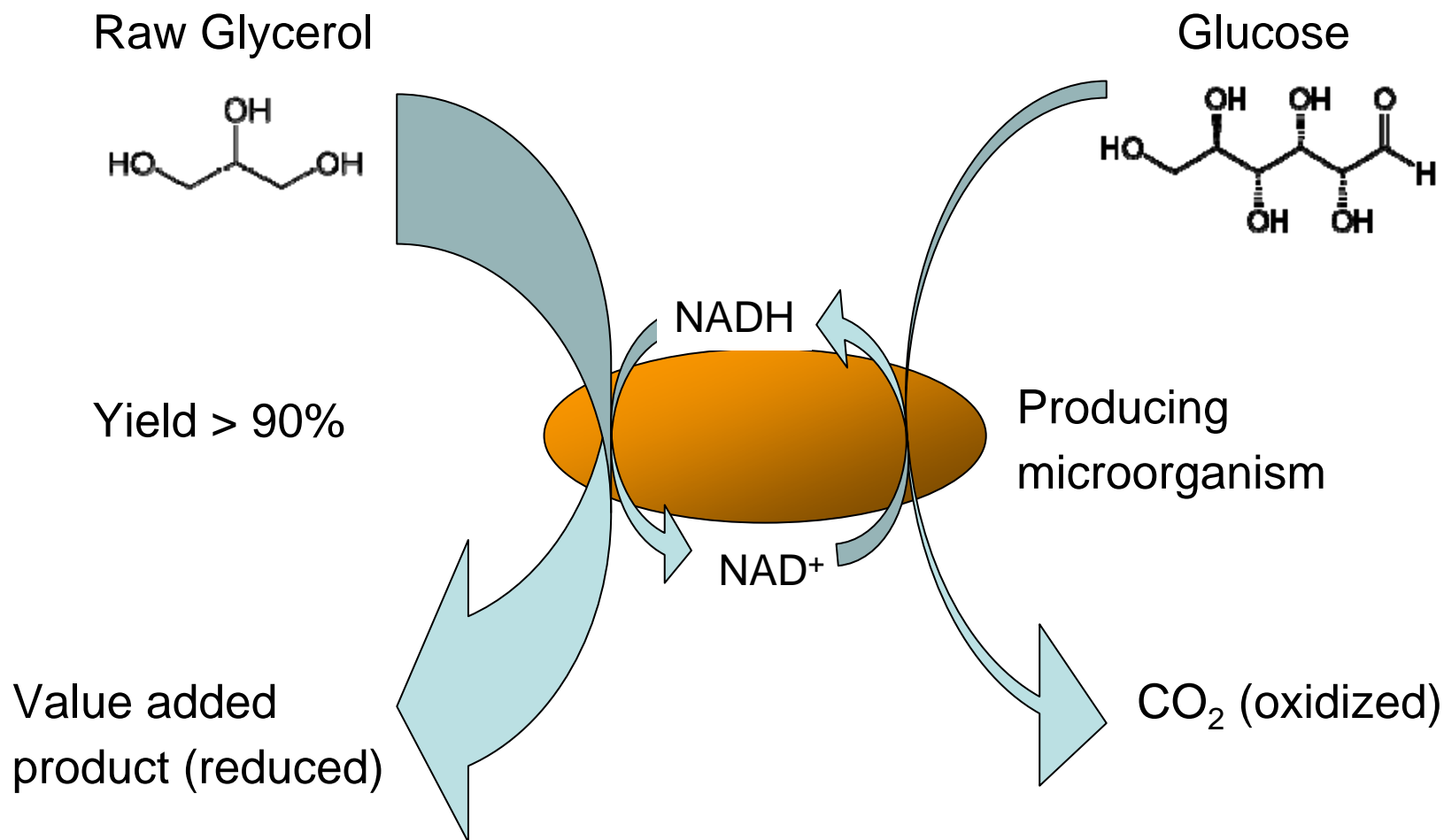
**Metabolic engineering** = essential technology to direct the process from substrate to product

# Integrated Biorefinery: Biodiesel - Biomaterials

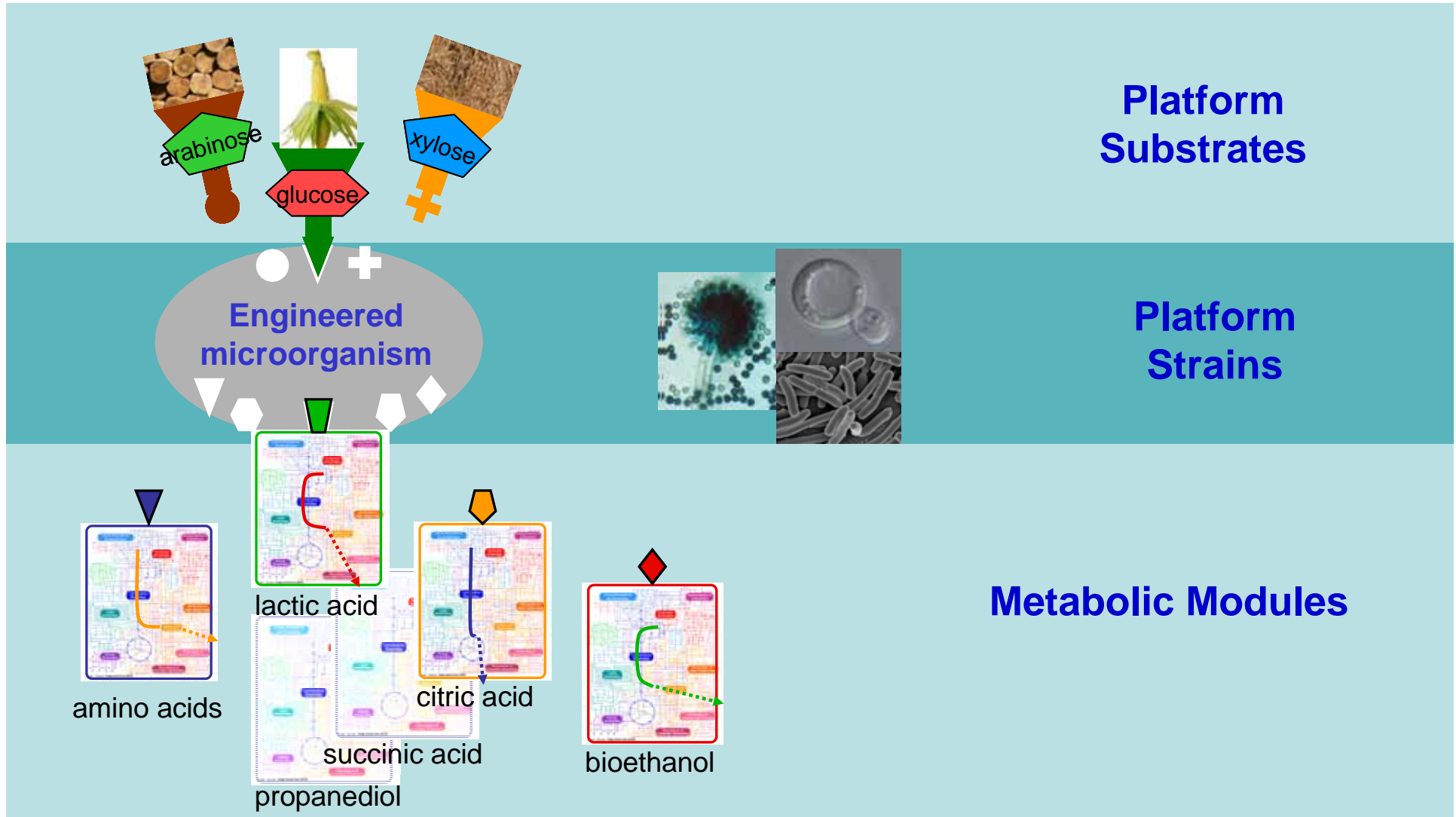


- 1,3-propanediol
- 1,2-propanediol
- Dihydroxyacetone
- Succinic acid
- Citric acid
- Hydrogen
- Mixed products: ethanol, succinate, acetate, lactate, and hydrogen
- omega-3 polyunsaturated fatty acids
- Polyesters
- Polyglycerols
- Polyesters
- polyhydroxyalkanoates

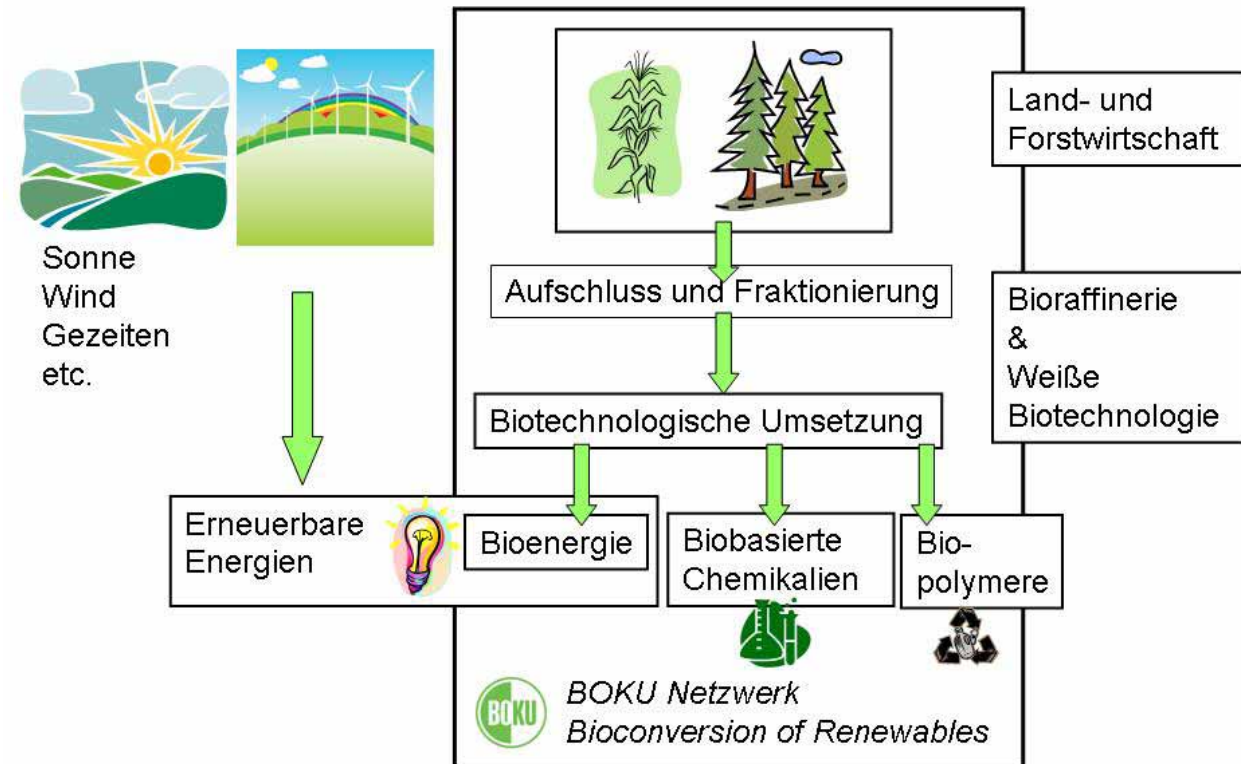
# Glycerol Conversion by Biotechnology



# Biotech Platform Strains and Processes



# Joint Biorefinery – Biotechnology Concept



- Joint efforts are needed
- BOKU Network for Bioconversion of Renewables



# BOKU Network for Bioconversion of Renewables

