Biotechnology and Energy Conservation

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11th Lecture Bioethanol

The Aim:

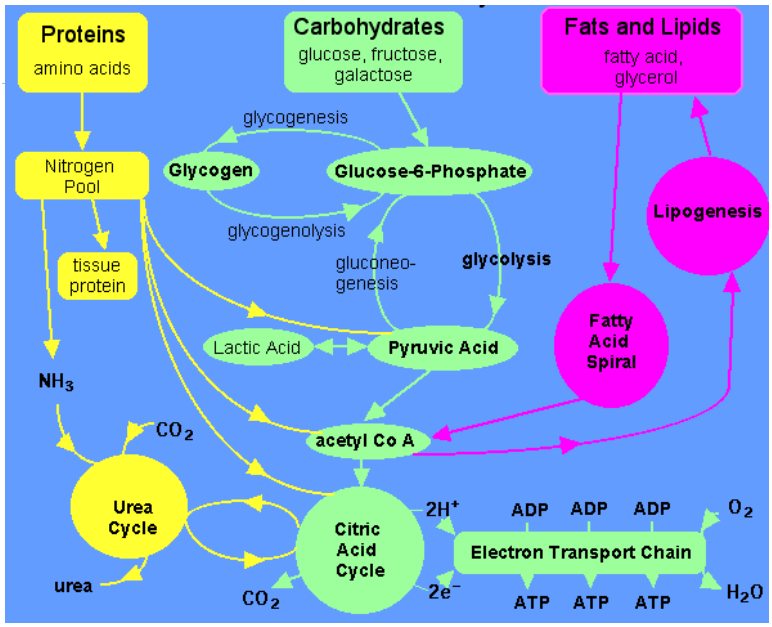
- The students can explain the source and principle method for bioethanol production
- The student can explain the advantage of using bioethanol regarding the environmental issue

Biomass as source of biofuel

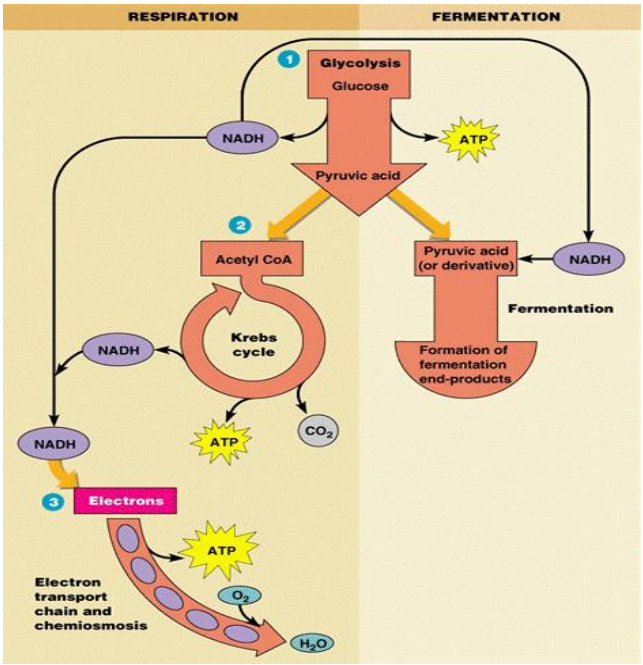
- Carbohydrate catabolism is the **breakdown** of carbohydrate into smaller units.
- The general reaction:

  $C_6H_{12}O_6 + O_2 \Longrightarrow CO_2 + H_2O + \text{energy}$
- Most energy (in the form of **ATP**) is produced from the oxidation of carbohydrate, and **glucose** is the most commonly used carbohydrate.
- Two major types of glucose catabolism
  - ***Respiration*** (for eucaryotic cells in mitochondria), when O_2 is presence
  - ***Fermentation***, when O_2 is absence

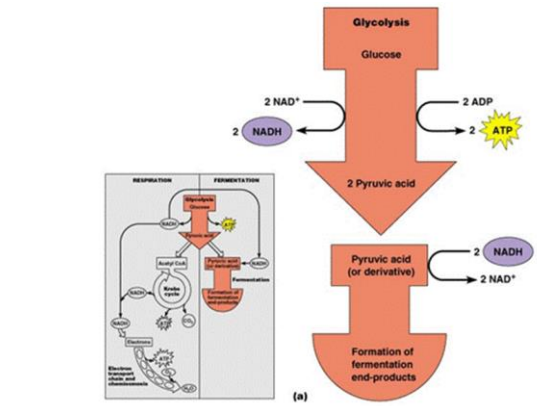
Metabolism summary

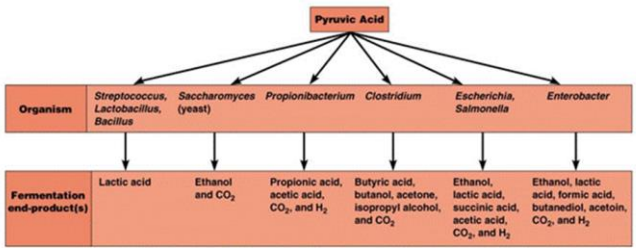


Path of respiration and fermentation

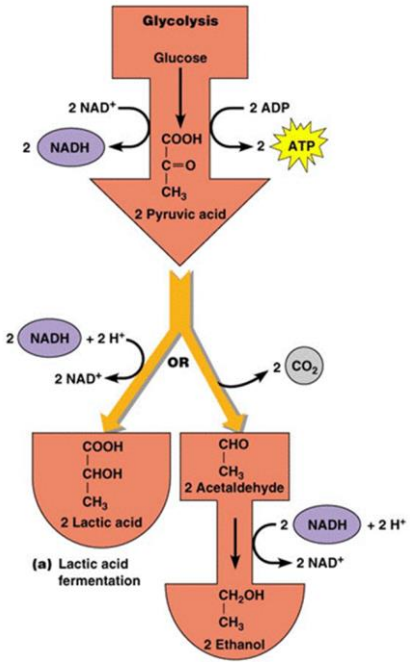


Fermentation





Alcohol fermentation



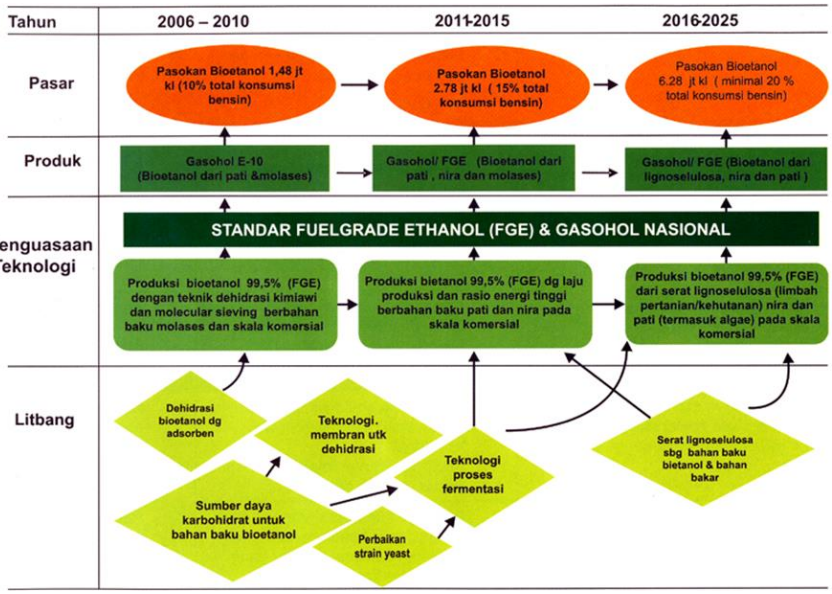
Some industrial uses for different types of fermentations

Fermentation End-Product(s)	Industrial or Commercial Use	Starting Material	Microorganism
Ethanol	Beer	Malt extract	*Saccharomyces cerevisiae* (yeast, a fungus)
	Wine	Grape or other fruit juices	*Saccharomyces cerevisiae* var. *ellipsoideus*
	Fuel	Agricultural wastes	*Saccharomyces cerevisiae*
Acetic Acid	Vinegar	Ethanol	*Acetobacter* (bacterium)
Lactic Acid	Cheese, yogurt	Milk	*Lactobacillus, Streptococcus* (bacteria)
	Rye bread	Grain, sugar	*Lactobacillus delbruckii* (bacterium)
	Sauerkraut	Cabbage	*Lactobacillus plantarum* (bacterium)
	Summer sausage	Meat	*Pediococcus* (bacterium)
Propionic Acid and Carbon Dioxide	Swiss cheese	Lactic acid	*Propionibacterium freudenreichii* (bacterium)
Acetone and Butanol	Pharmaceutical, industrial uses	Molasses	*Clostridium acetobutylicum* (bacterium)
Glycerol	Pharmaceutical, industrial uses	Molasses	*Saccharomyces cerevisiae*
Citric Acid	Flavoring	Molasses	*Aspergillus* (fungus)
Methane	Fuel	Acetic acid	*Methanosarcina* (bacterium)
Sorbose	Vitamin C (ascorbic acid)	Sorbitol	*Gluconobacter*

Acceleration Program of Biofuels Application:

- Peraturan Presiden No 5 Tahun 2006 (Kebijakan Energi Nasional)
- BBN menjadi lebih dari 5% terhadap konsumsi energi nasional pada tahun 2025
- Inpres No 1 Tahun 2006 (Penyediaan dan Pemanfaatan BBN)
- Keppres No 10 Tahun 2006 (Tim Nasional Pengembangan BBN untuk Percepatan Pengurangan Kemiskinan dan Pengangguran)

Blue Print of Biofuel Development 2006-2025 (Tim Nasional BBN): Bioethanol Road Map



Bioethanol

- Bioethanol used as fuel for vehicle (transportation). Bioethanol is ethanol which is produced by fermentation process from organic material
- Raw material used for ethanol production is simple sugar (molasses, sap from coconut/palm trees), starch (cassava, sago, corn), and cellulose (woody material, paddy / corn straw)
- Ethanol or ethyl alcohol (C_2H_5OH) characteristics are colorless, biodegradable, less toxic, high octane number (118) (can be introduced for replacing Pb in gasoline). Additive MTBE (methyl tertiary butyl ether) bilangan oktan 109. Bilangan oktan unleaded bensin 87.
- Ethanol produce carbon dioxide and water when burned. Its mixture with gasoline add the availability of oxygen in fuel so that increase the burning process and reduce the emission
- Gasohol (gasoline-ethanol mixture) has been marketed as E10 – E20 (addition of bioethanol of 10-20% into gasoline). Some machine use Gasoline-Bioethanol of 85% (E85)

TECHNICAL PRODUCTION OF BIOETANOL

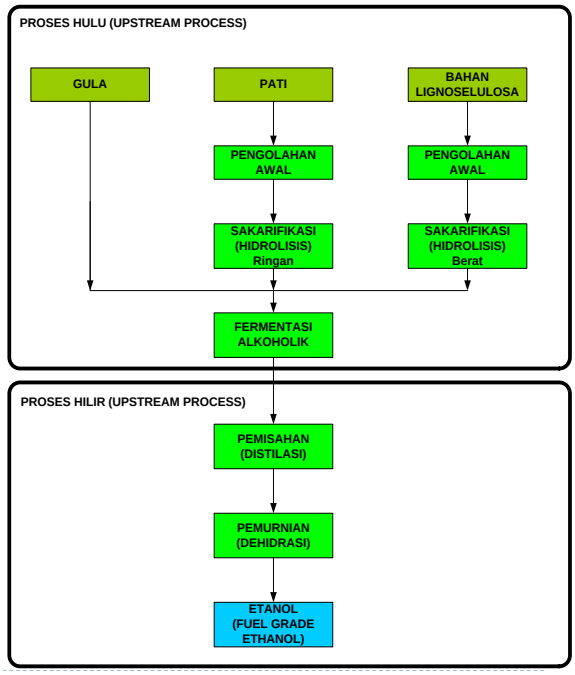
Starch based material

1. Production of starch flour from the plant, or crushing of the starch based material;
2. Addition of water and heated until gelatinized followed by addition of enzyme (amylase) which make conversion of starch to sugar; or mild chemical hydrolysis.
3. Fermentation of hydrolysate following neutralization process (conversion of sugar into ethanol by yeast, *Saccharomyces cerevisiae* or *Candida utilis*);
4. Wet distillation following separation of fermentate (purify ethanol from fermentate);

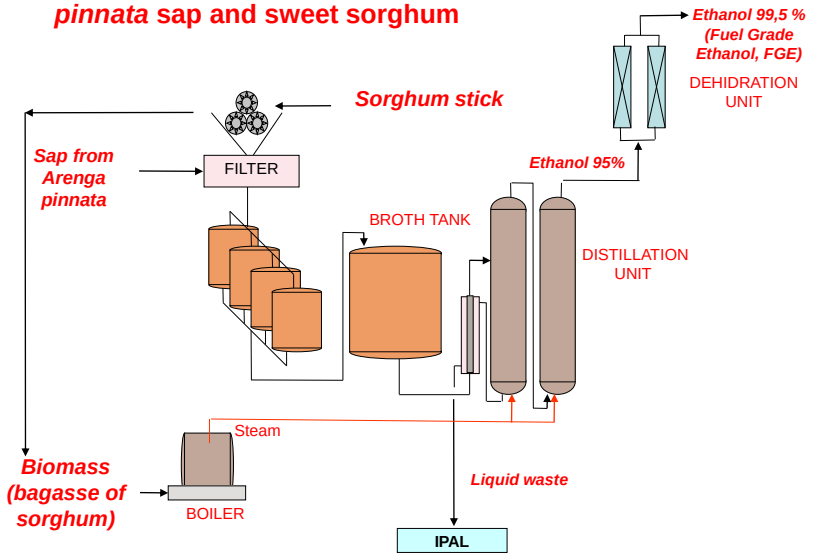
Cellulose based material

1. Production of woody dust;
2. Strong chemical hydrolysis.
3. Fermentation of hydrolysate following neutralization process (conversion of sugar into ethanol by yeast, *Saccharomyces cerevisiae* or *Candida utilis*);
4. Wet distillation following separation of fermentate (purify ethanol from fermentate);

Flow Chart Process of Bioethanol Production



Bioethanol production from *Arenga pinnata* sap and sweet sorghum



Potency of ethanol from some sources

No	Source	Yield (ton/ha/year)	Alcohol	
			Liter/ton	Liter/ton/year
1	Cassava	25 (23,6)	180 (155)	4.500 (3.656)
2	Molasses	3,6	270	973
3	Sorghum	6,0	334,4	2.000
4	Sweet potato	62,5[a])	125	7.812
5	Sago	6,88[b])	608	4.133
6	Sugar cane	75	67	5.025
7	Nipah	27	93	2.500
8	Sweet Sorghum	80[c])	75	6.000
9	***Arenga pinnata*[d])**	**2.880**	**70**	**20.160**

Keterangan: a) Panen 2.5 kali/tahun; b) pati sagu kering; c) panen 2 kali/tahun; d) Masa sadap 200 hari/tahun, jumlah pohon disadap 80 pohon/ha, produktivitas 15 liter/ph/hari, rendemen 7 %.

Arenga pinnata plantation and alcohol processing unit