



# ENVIRONMENTAL STUDIES & LIFE SCIENCES

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# ENVIRONMENTAL STUDIES & LIFE SCIENCES

## Bio-sustainability

**Bio-sustainability**  
**Biofuels**



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## Bio-sustainability – Biofuels

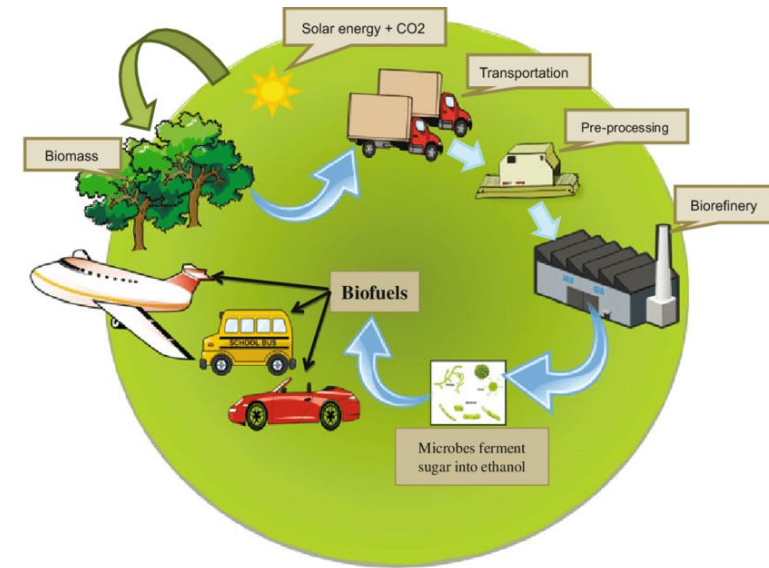
**Biofuels** are a renewable energy source, made from organic matter or wastes, that can play a valuable role in reducing carbon dioxide emissions.

Biofuels are one of the largest sources of renewable energy in use today. In the transport sector, they are blended with existing fuels such as gasoline and biodiesel.

Biofuels are being promoted as a **low-carbon alternative** to fossil fuels as they could help to **reduce greenhouse gas** (GHG) emissions and the related climate change impact from transport.

Rapid increases of energy consumption and human dependence on fossil fuels have led to the accumulation of greenhouse gases and consequently, climate change.

*Image source: [solarsurge.in](http://solarsurge.in)*



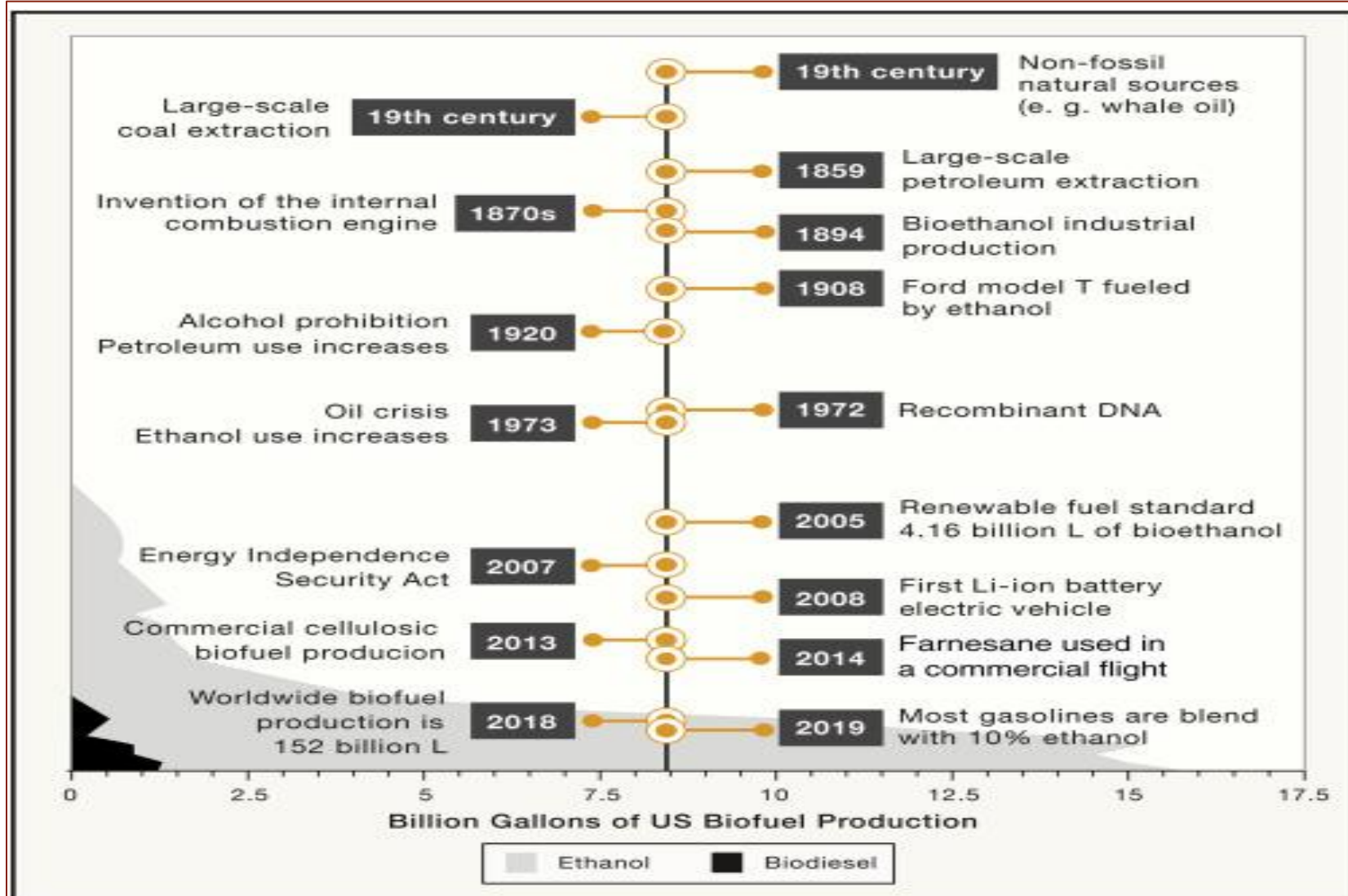
## Bio-sustainability – Biofuels

The major efforts have been taken to develop, test, and adopt clean renewable fuel alternatives. Production of **bioethanol** and **biodiesel** from crops (is well developed), other feedstock resources have shown high potential to provide efficient and cost-effective alternatives.

The microbial fermentation can be engineered to increase the product yield and expand the chemical space of biofuels through the rational design and fine-tuning of biosynthetic pathways toward the realization of “***designer fuels***” and diverse future applications.

Biofuels can be produced from plants (i.e. energy crops), or from agricultural, commercial, domestic, and/or industrial wastes (if the waste has a biological origin)

The two most common types of biofuels in use today are ***bioethanol*** and ***biodiesel***, both of which represent the first generation of biofuel technology.



Ref: Biofuels for a sustainable future by Yuzhong *et. al.* 2021

### Generation of Biofuels

**First-generation** or **conventional biofuels** are those that are produced from edible energy crops such as sugar-based crops (sugarcane, sugar beet, and sorghum), starch-based crops (corn, wheat, and barley) or oil-based crops (rapeseed, sunflower, and canola).

Initially, these biofuels showed promise in minimizing reliance of conventional fossil fuels and lowering the emission of GHG associated with its combustion.

However, the production of first-generation biofuels has raised serious concerns on food supply, food security, and arable land requirements.

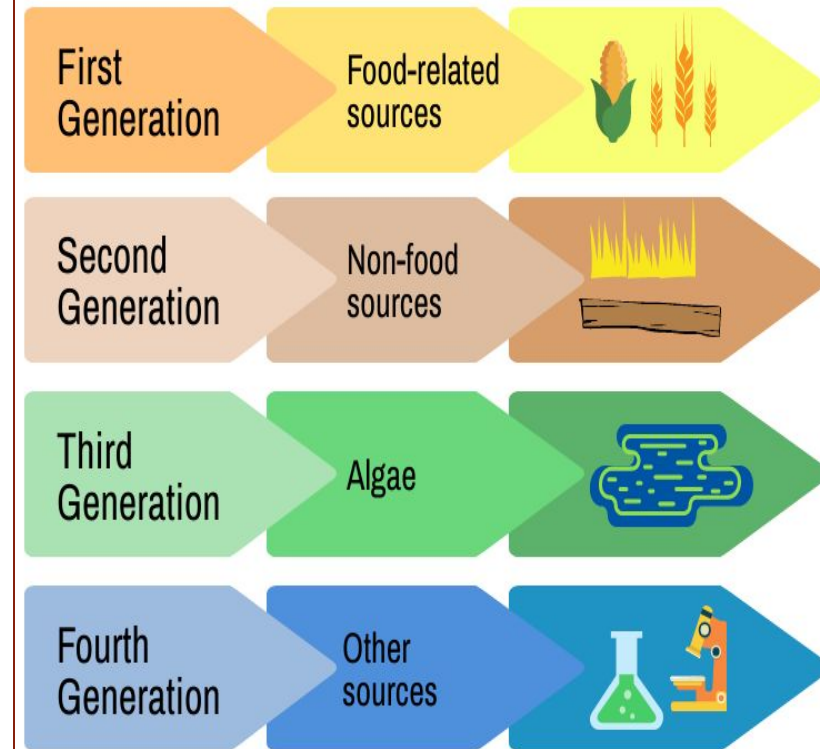


Image source: © 2019 letstalkscience



**First generation biofuels** (ethanol in particular) face three major criticisms:

- intensification of their use leads to competition with food resources (the food versus fuel debate),

- ethanol production from corn grain requires significant consumption of fossil resources, in such a way that there are minimum benefits from the carbon emissions perspective, and

- there is a requirement of land to grow corn.

Feedstock	Biofuel	Yield
Sunflower	Biodiesel	952–1070 L/ha/year
Canola	Biodiesel	974–1190 L/ha/year
Corn	Biodiesel	172 L/ha/year
Sorghum	Bioethanol	0.51 g/g
Sugarcane	Bioethanol	67 g/L
Oil palm	Bioethanol	11.50 g/L

**Source:** Preshanthan Moodley, in Sustainable Biofuels, 2021

**Second-generation biofuels** are fuels manufactured from various types of biomass / lignocellulosic crops. Biomass means any source of organic carbon that is renewed rapidly as part of the carbon cycle. Biomass is derived from plant materials, but can also include animal materials.

This generation technology allows lignin and cellulose of a plant to be separated so that cellulose can be fermented into alcohol.

These biofuels can be manufactured from different types of biomass as it defines any source of organic carbon. This can be renewed rapidly as part of the carbon cycle.

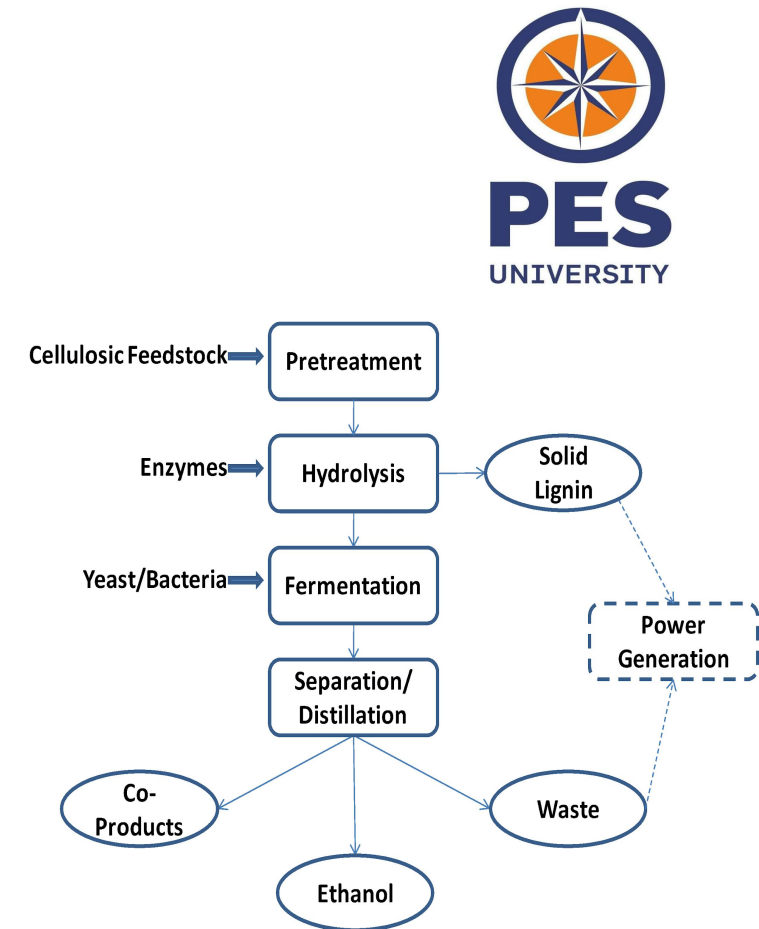


Image source:

<https://www.mdpi.com/1996-1073/7/7/4430>

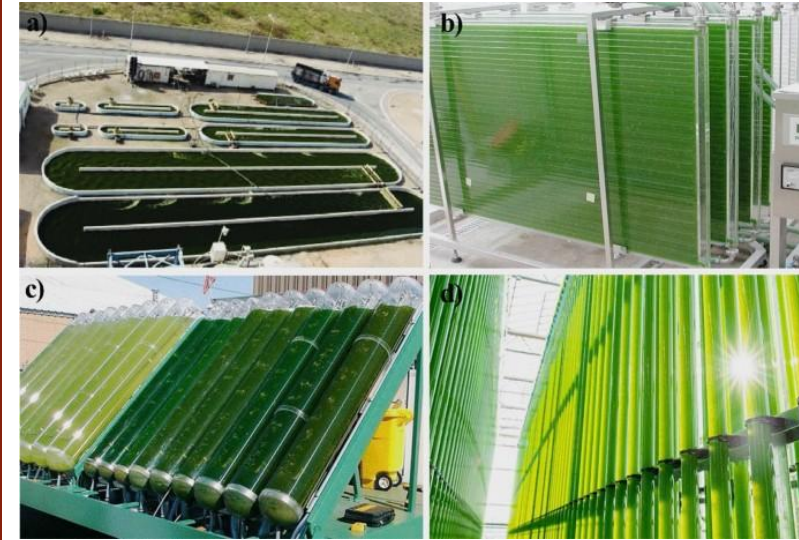


## Bio-sustainability – Biofuels

The worldwide increase in energy demand has led to the development and analysis of efficient sources capable of producing fuels and chemicals. The microalgae are seen as a promising alternative for the production of fuels due to their high photosynthetic conversion efficiency.

***Third generation biofuels*** are also known as “***algae fuel***” or “***oilage***” since they are produced from the algae.

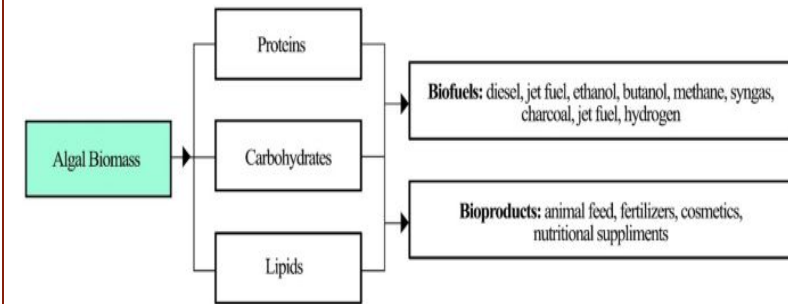
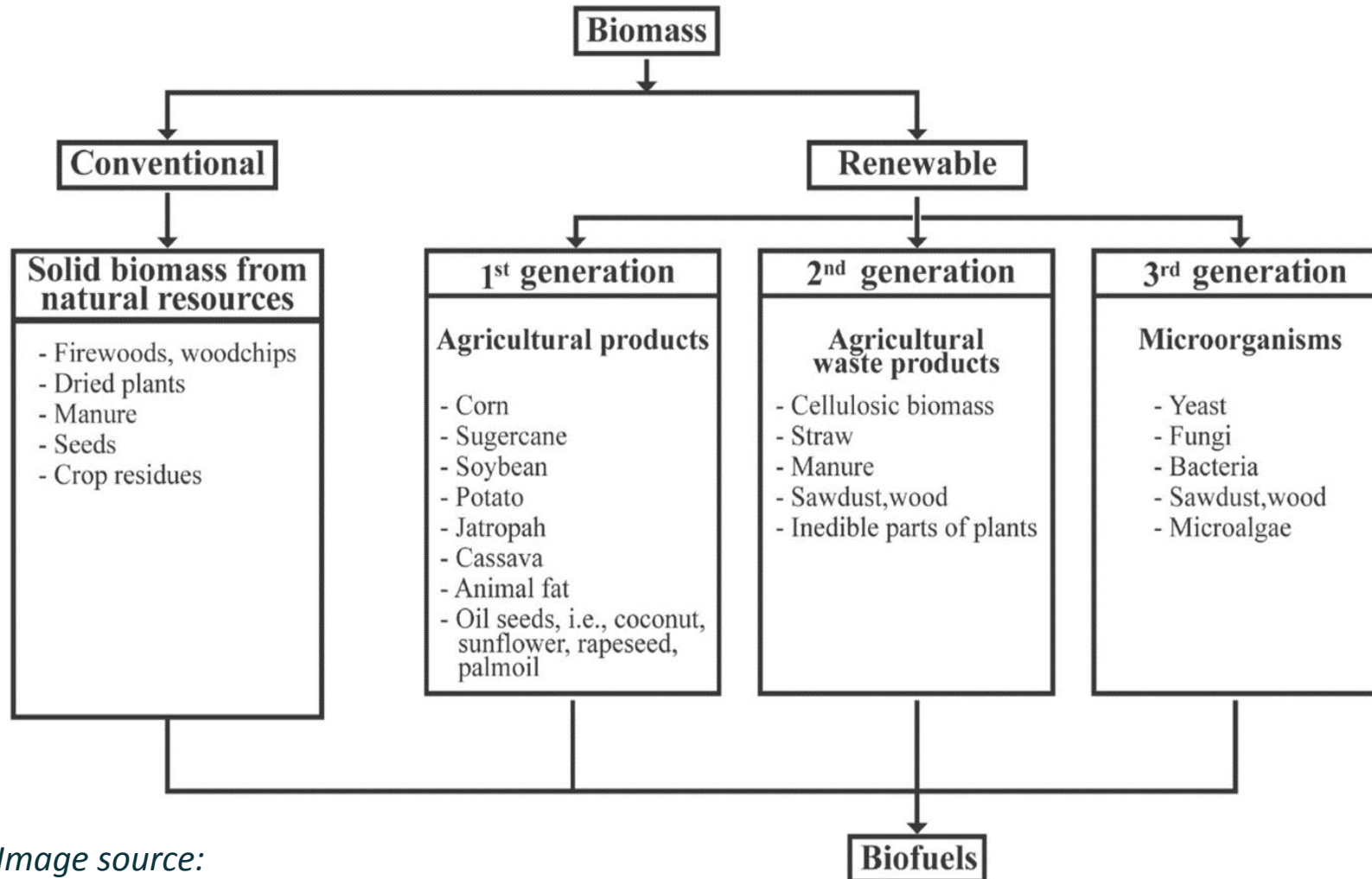
Algae leads to the production of all types of biofuels such as biodiesel, gasoline, butanol, propanol and ethanol with high yield, approximately 10 times higher than the second generation biofuel.



Source:

<https://link.springer.com/article/10.1007/s12667-022-00514-7>

## Bio-sustainability – Biofuels



Source:

<https://link.springer.com/article/10.1007/s12667-022-00514-7>

Image source:

<https://link.springer.com/article/10.1007/s12667-022-00514-7/figures/1>

**Fourth-generation biofuels** are the amalgamation of genomically prepared microorganisms and genetically engineered feedstock.

Cyanobacteria are engineered to increase the oil yield and are used for the efficient production of bioenergy.

The implementation of bioengineering principles to modify algal metabolism and properties to enhance the oil content in the cells.

The 4G ecofuels are the fuels that are got through fixed carbon from the air by new techniques.

## Bio-sustainability – Biofuels

- Currently the following types of biofuels are produced using different approaches

Biogas

Syngas

BioEthanol

Biodiesel

Green diesel

Bio-ethers

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## Bio-sustainability – Biofuels

Production of biofuels from renewable feedstocks has captured considerable scientific attention since they could be used to supply energy and alternative fuels.

***Bioethanol*** is one of the most interesting biofuels due to its positive impact on the environment. Currently, it is mostly produced from sugar & starch-containing raw materials.

However, various available types of lignocellulosic biomass such as agricultural and forestry residues, and herbaceous energy crops could serve as feedstocks for the production of bioethanol.

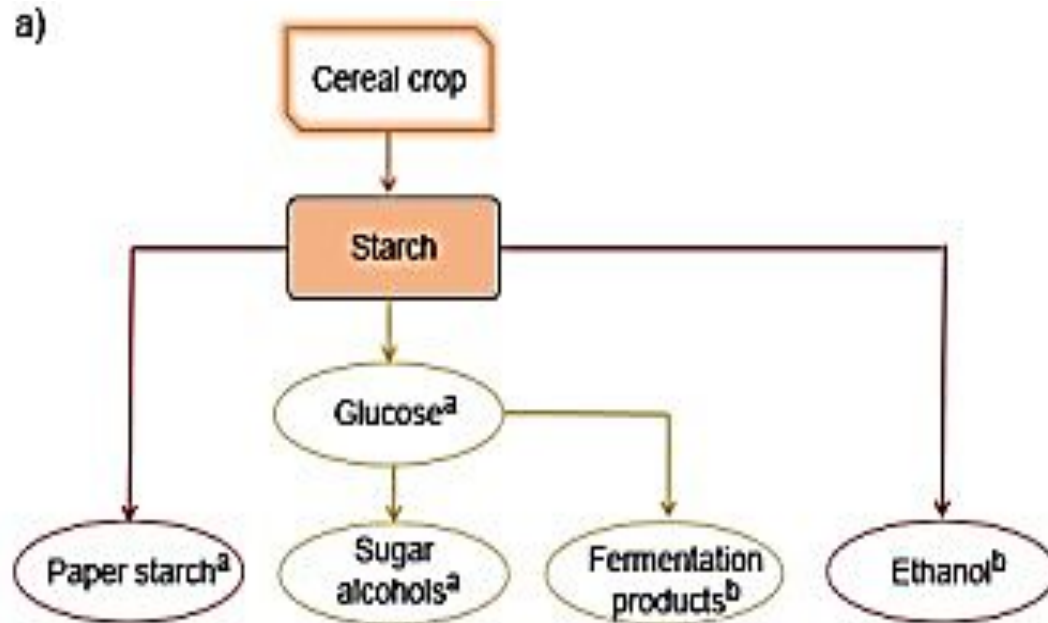


biodiesel plant - Bing images



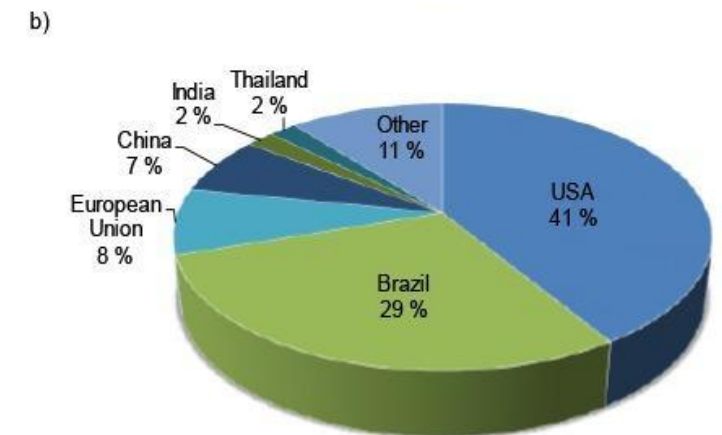
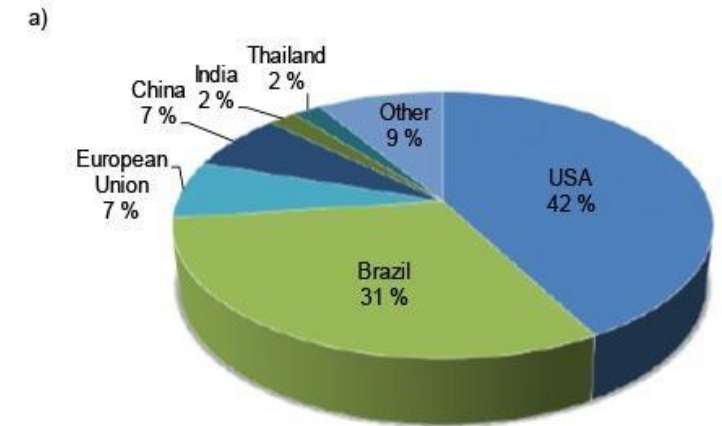
## Bio-sustainability – Biofuels

The common method for converting biomass into ethanol is called ***fermentation*** when microorganisms (e.g., bacteria and yeast) metabolize plant sugars and produce ethanol.



The Predictions of the world bioethanol production (a) and consumption (b) by 2024

Source: Bioethanol Production from Renewable Raw Materials and Its Separation and Purification: A Review - PMC (nih.gov)



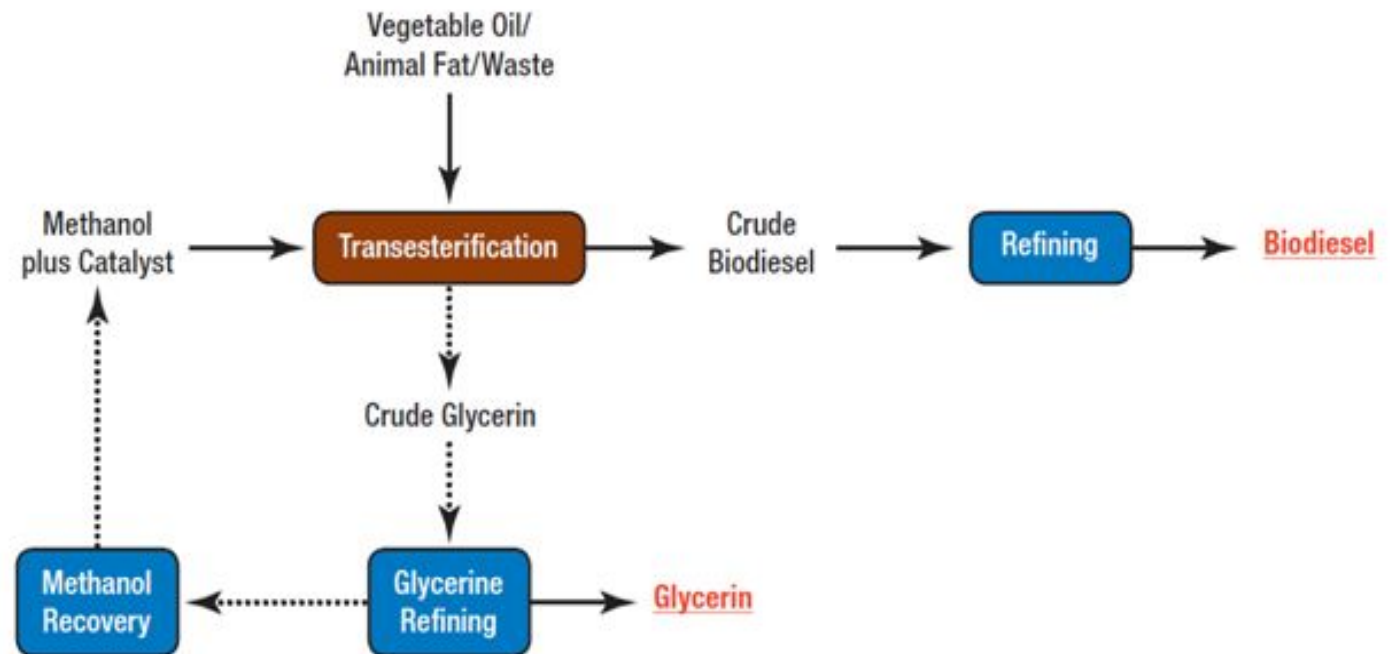


## Bio-sustainability – Biofuels

**Biodiesel:** It is a liquid fuel produced from renewable sources, such as new and used vegetable oils and animal fats and is a cleaner-burning replacement for petroleum-based diesel fuel.

Biodiesel is nontoxic and biodegradable and is produced by combining alcohol with vegetable oil, animal fat, or recycled cooking grease.

### Schematic of Biodiesel Production Path



The consumption volume of biodiesel in India in 2022 was approximately 180 million liters. This was an increase from the consumption volume of 165 million liters of biodiesel in the previous year (*Published by Lucía Fernández, Feb 8, 2023*).

The Biodiesel procurement by OMCs increased from 1.1 crore litres during 2015-16 to 10.56 crore litres during 2019-20.

Presently, bio-diesel is being produced in the country primarily from imported palm stearin oil.

The Renewable Energy Group (REG) is the largest FAME biodiesel producer in the U.S., with 5 plants and capacity of 432 million gallons. REG was acquired in June 2022 by Chevron (Ramon, 2022).

## Bio-sustainability – Biofuels

### ***Advantages of biofuels***

- Efficient fuel
- Non-dependency on fossil fuels
- Durability of vehicles' engine
- Easy to source
- Renewable
- Reduces greenhouse gases
- Lower levels of pollution

### ***Disadvantages of biofuels***

- High Cost of Production
- Huge amount of crops required to produce biofuels
- Water use
- Land use
- Dependent of weather
- Use of Fertilizers for the crop production



## Bio-sustainability – Biofuels

India's biofuel production accounts for only 1% of the global production

It is worth noticing that India is the second largest producer of sugarcane in the world but accounts for only about 1% of global ethanol production

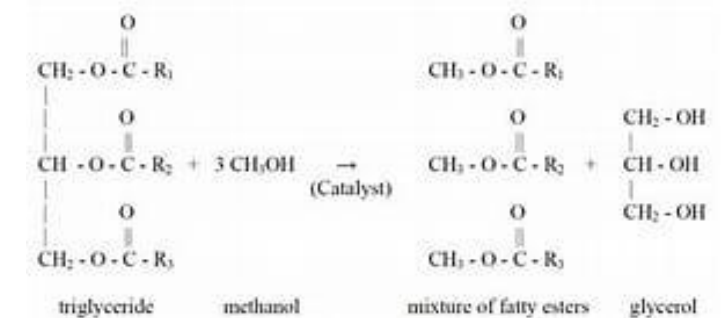
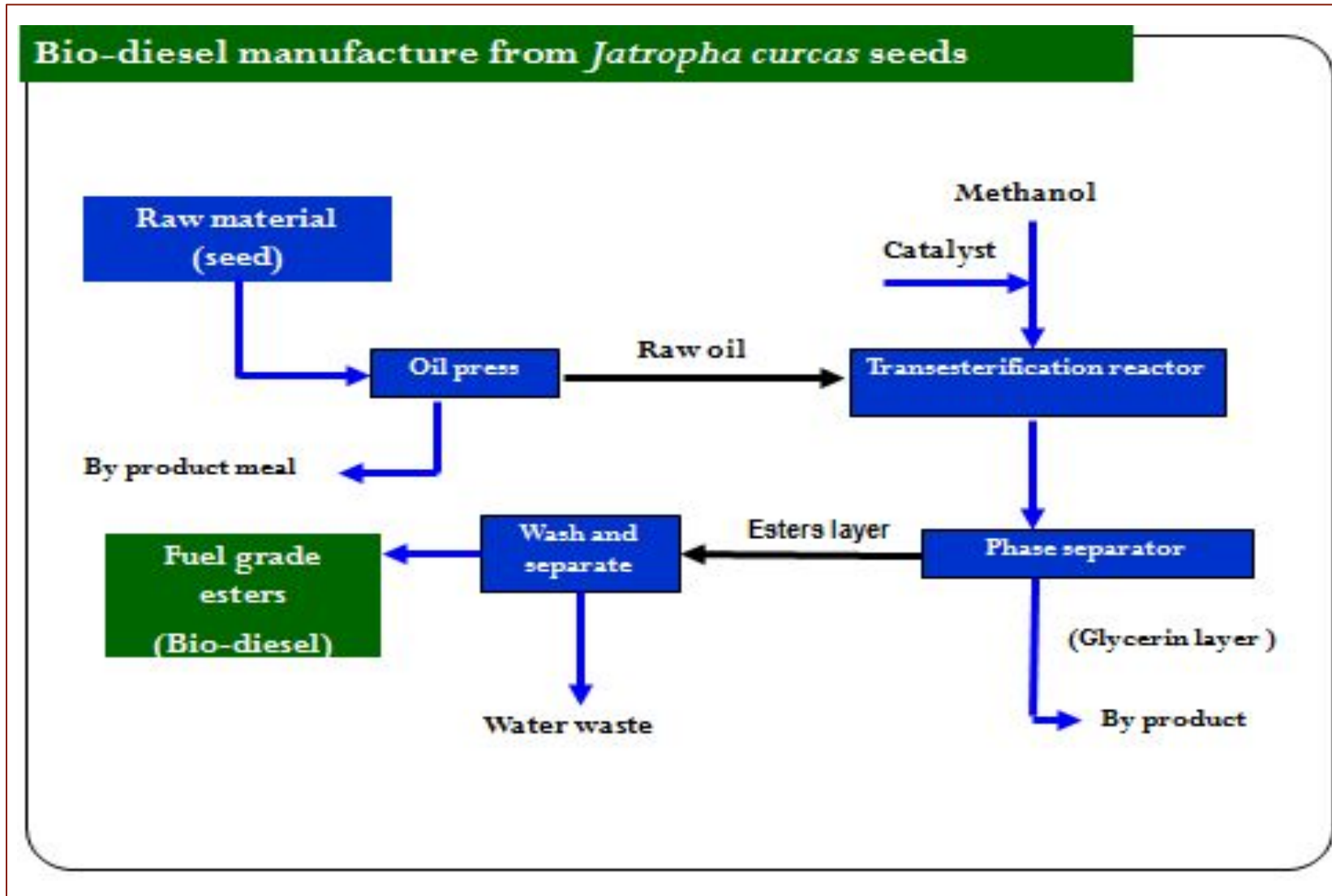
In India, Jatropha seeds were used to produce biodiesel, but the production has not been consistent

Farmers were encouraged to plant Jatropha, but the yield was far below what was expected

This led to the raw material cost becoming fairly expensive, making biodiesel even more expensive than petroleum based diesel

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## Bio-sustainability – Biofuels



Bioenergy consists of biomass (biological mass) used in the production of energy;

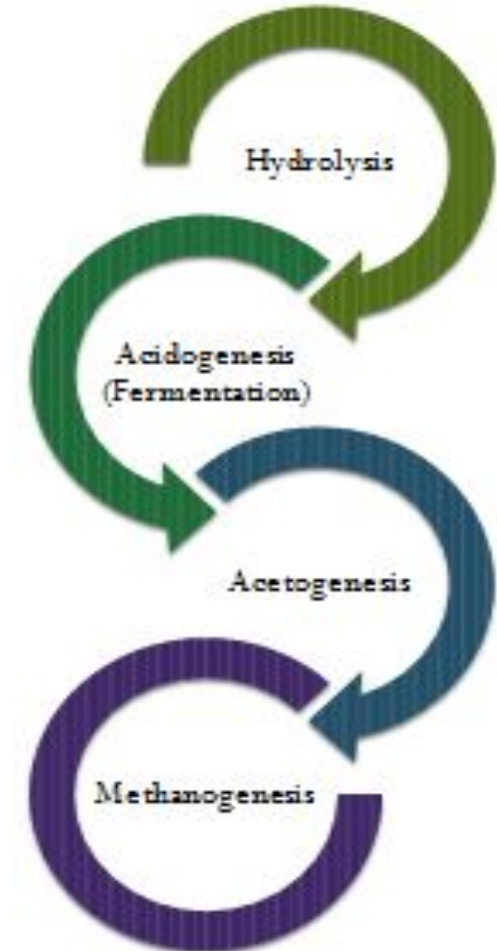
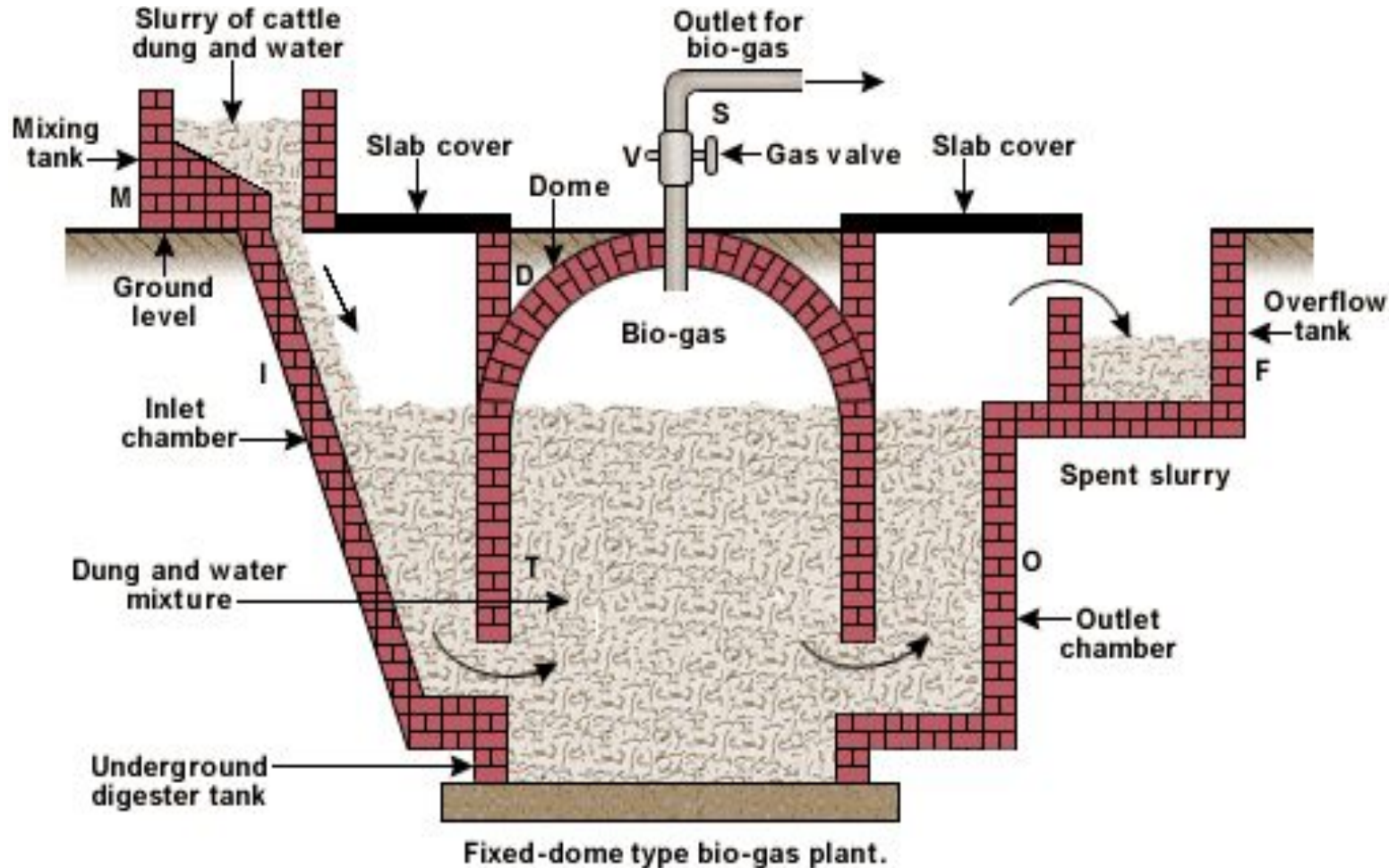
Phototrophs use light to survive and propagate (Plants)

$\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{Solar energy}} \text{CH}_2\text{O} + \text{O}_2$ ,  
or carbohydrate & oxygen

**Chemotrophs** eat phototrophs (green plants). While biomass combustion releases  $\text{CO}_2$  into the atmosphere, new plants require  $\text{CO}_2$  to grow, balancing the process.



### *Biogas plant*

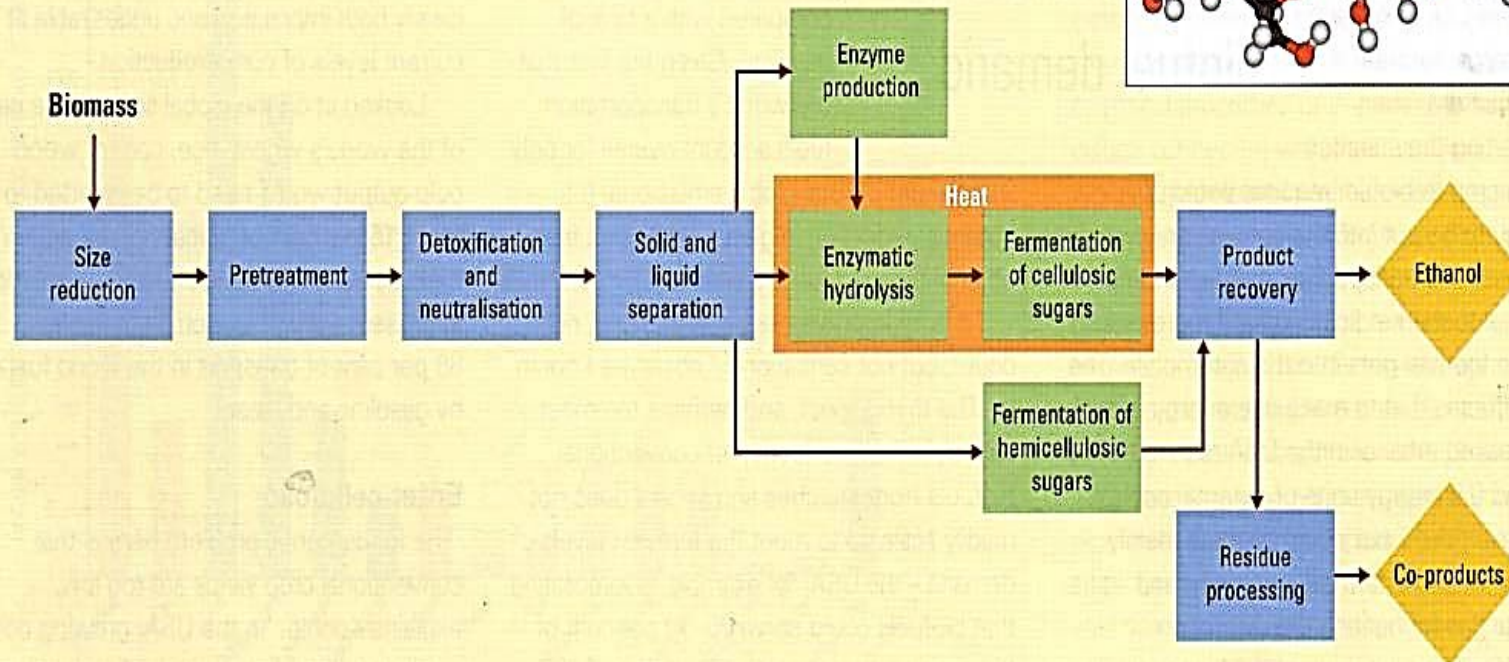
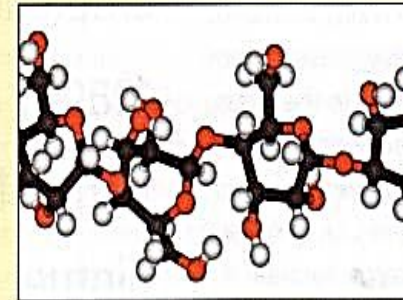


### Bioethanol

#### Producing ethanol from cellulose

Below: Typical process for converting cellulose in biomass to ethanol.

Inset right: Cellulose molecular structure





### Applications

Methanol fuelled  
absorption cooling



Methanol fuelled  
cook stove

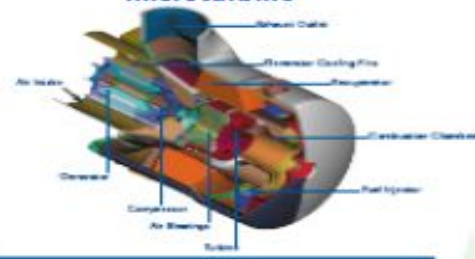


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Methanol fuelled  
lantern



Methanol fuelled  
microturbine



### Other Applications of Methanol



### Applications



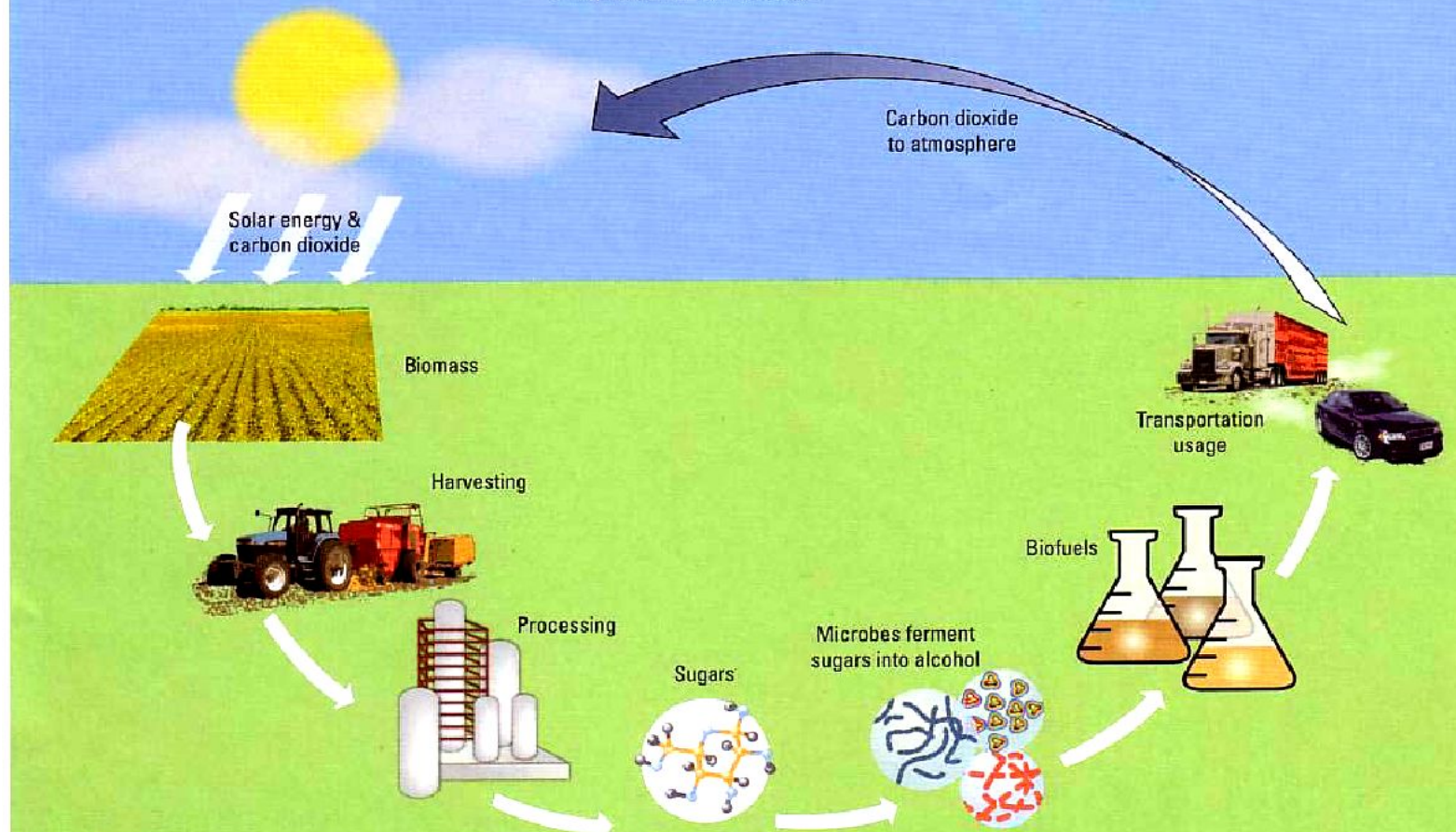
- Daimler-Benz, with Ballard, has produced their methanol-driven car, Necar.

#### Its features are:

- Top-speed: 120km/h
- Only weighs 1.7 tons
- Upto 400km for 38l of methanol

### The biofuels cycle

Carbon, in the form of carbon dioxide ( $\text{CO}_2$ ), is absorbed from the atmosphere by growing plants, in the process of photosynthesis. The plants – biomass – can be converted to biofuel and used for transportation. This emits  $\text{CO}_2$ , returning it to the atmosphere for absorption in the growth of new biomass.







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