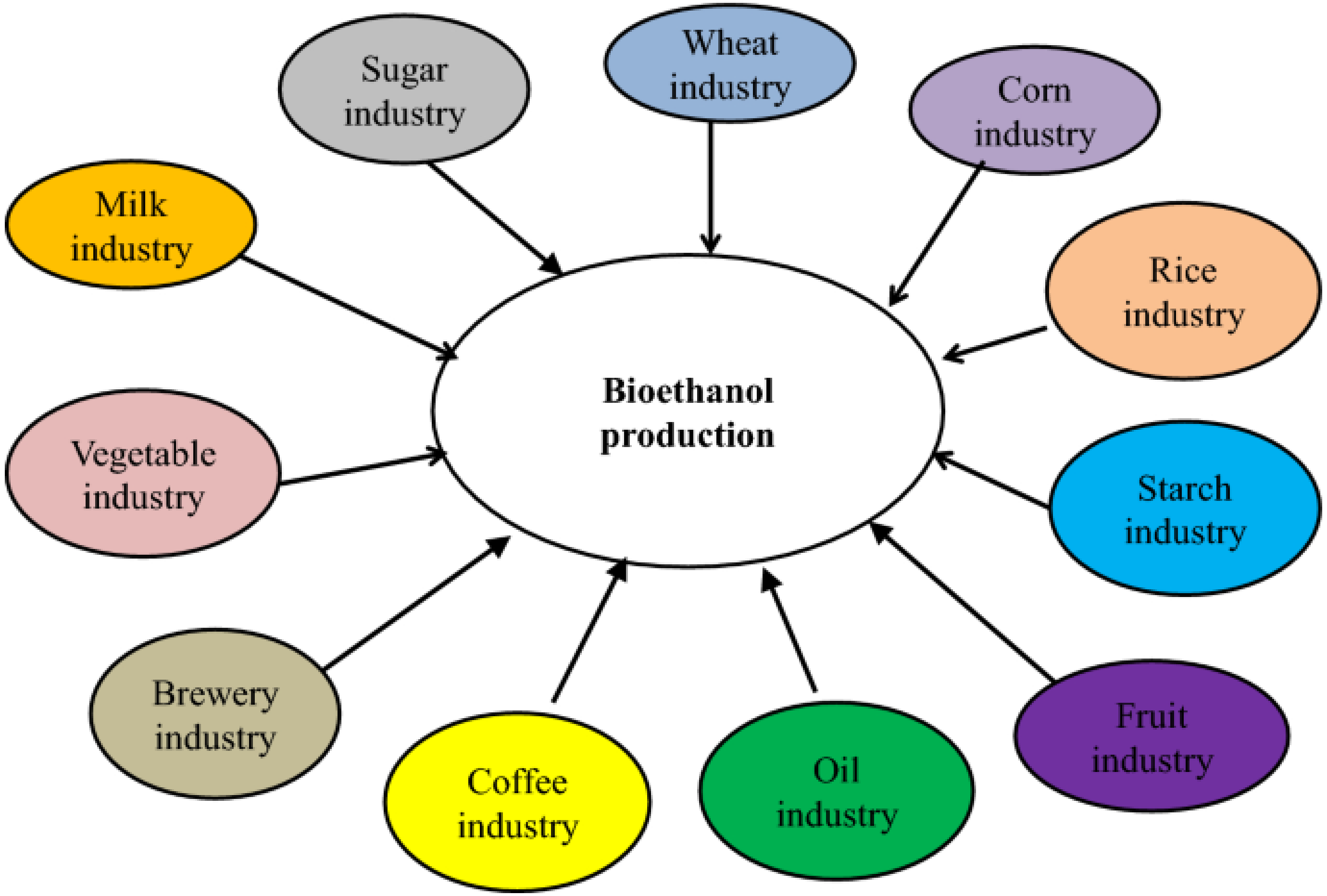
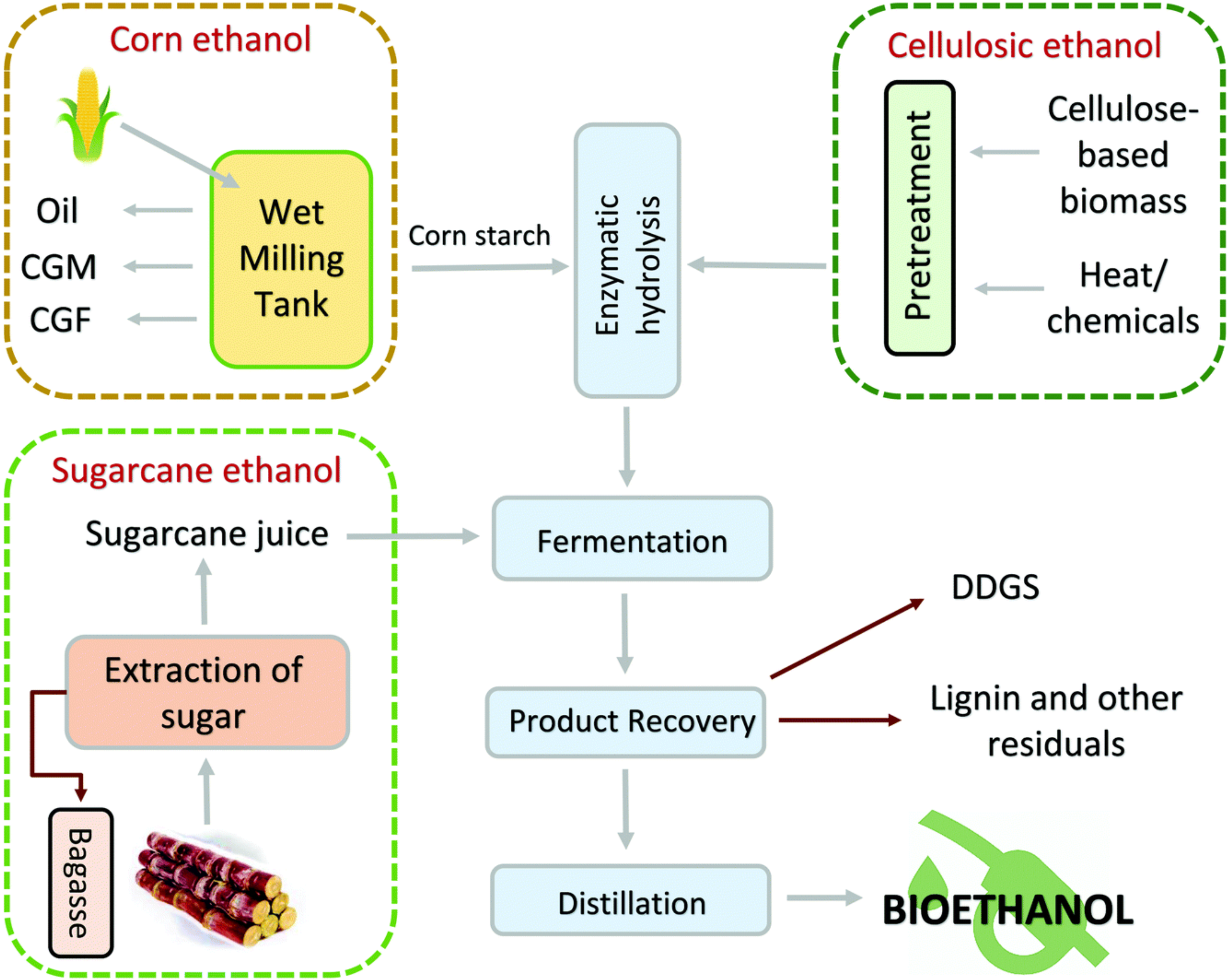
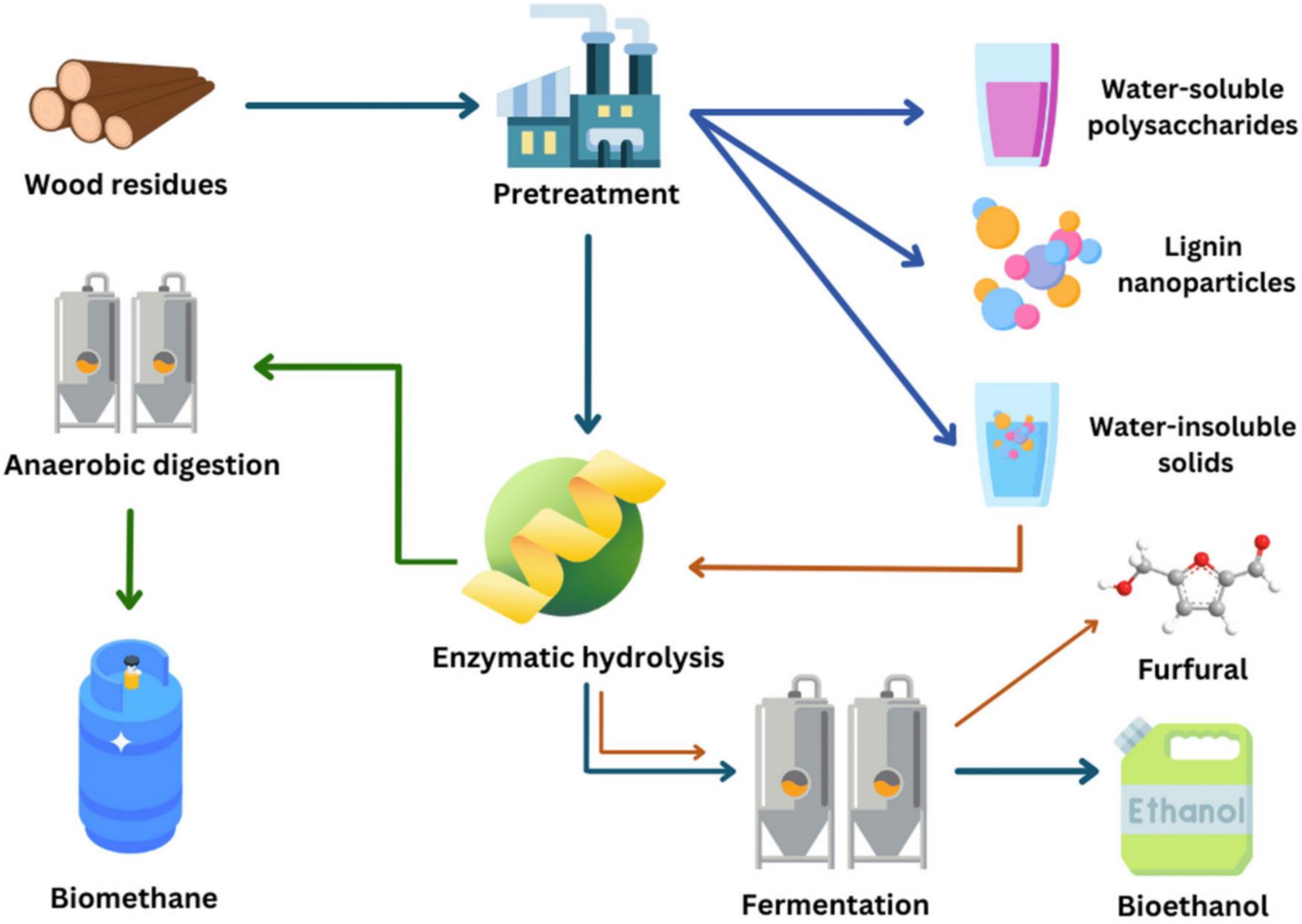


Sugar industry
Wheat industry
Corn industry
Milk industry
Rice industry
Bioethanol production
Vegetable industry
Starch industry
Brewery industry
Coffee industry
Oil industry
Fruit industry

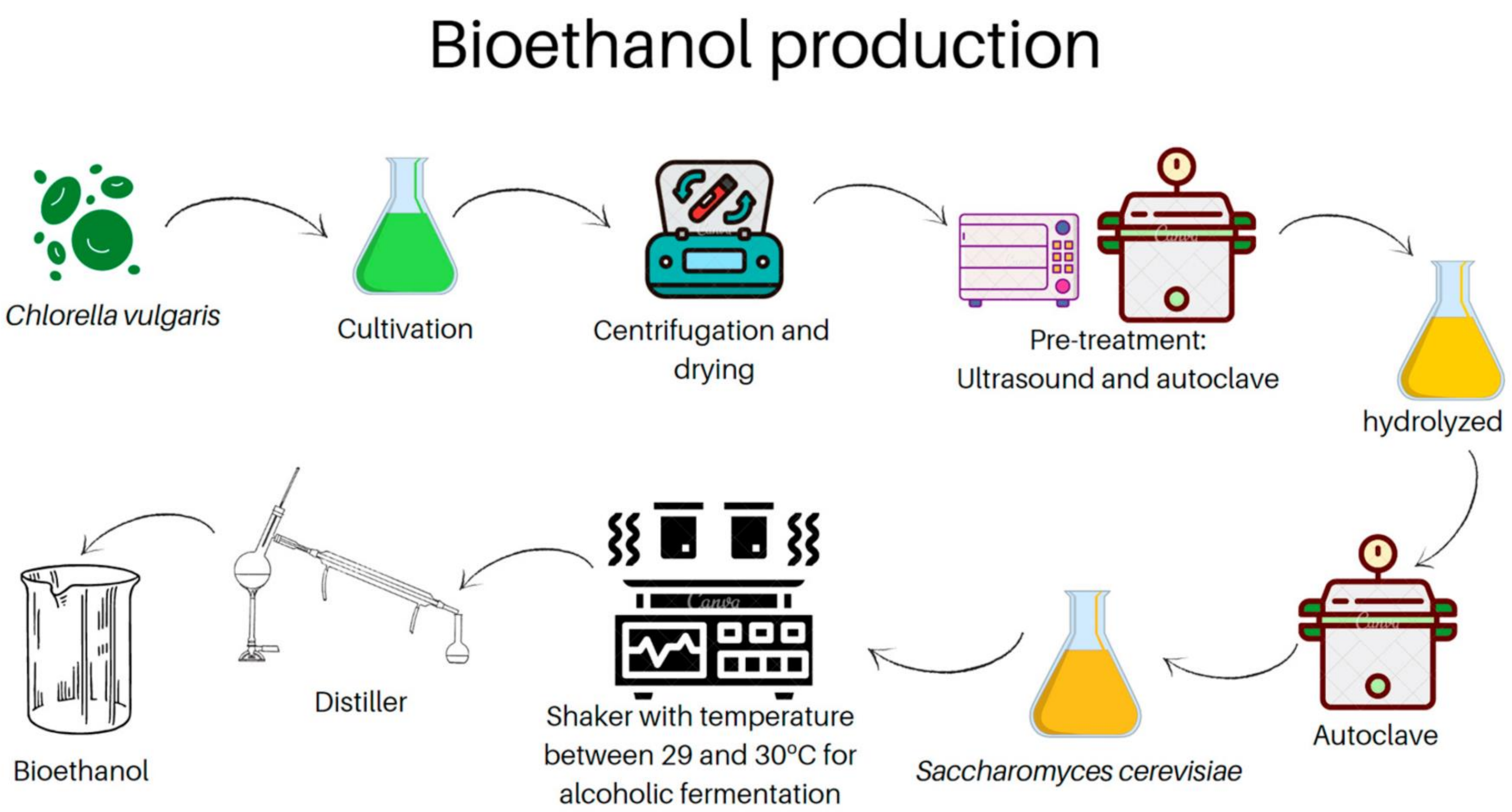
ETHANOL FERMENTATION

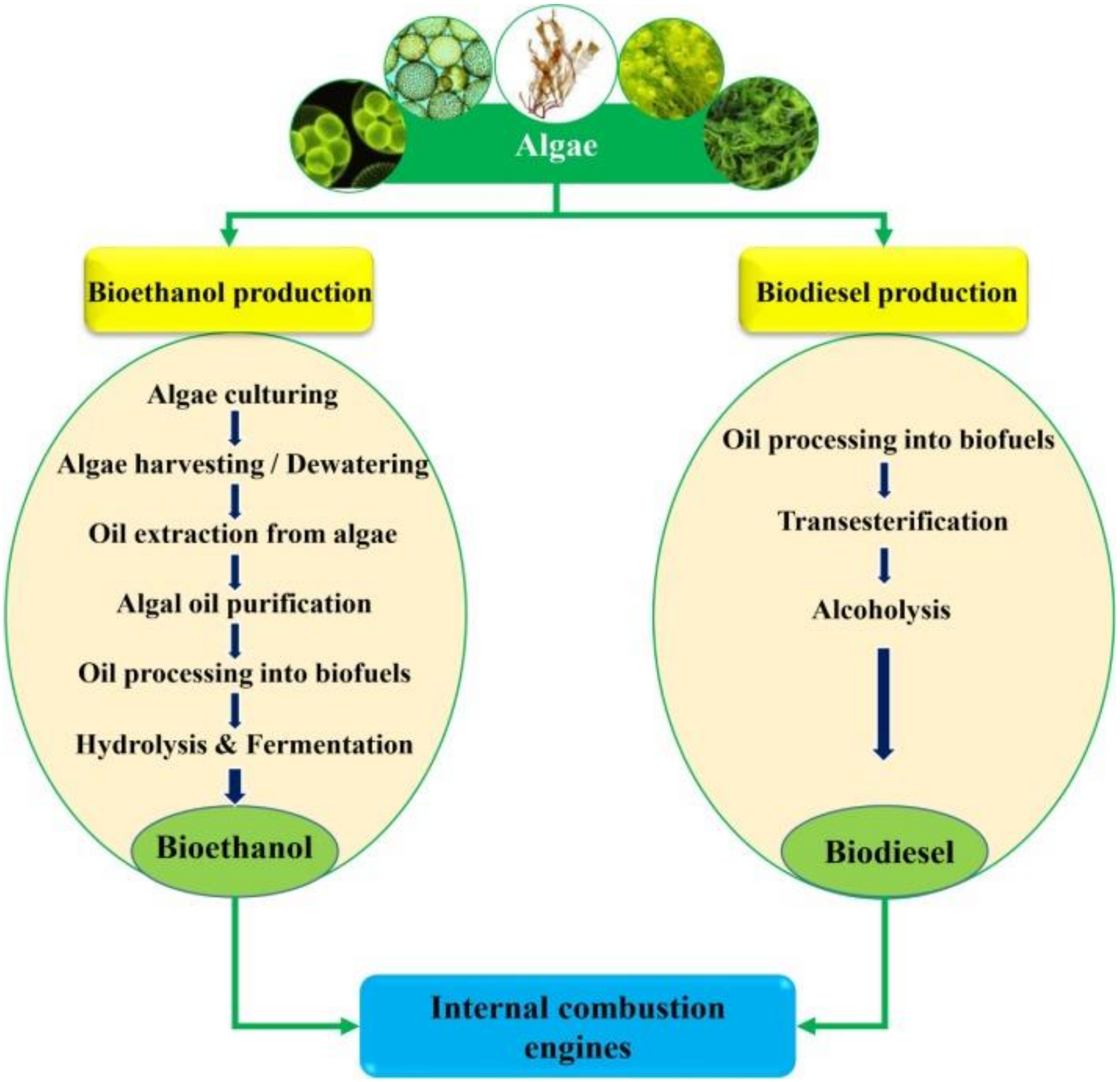
- A **biological process** in which **sugars** such as glucose, fructose, and sucrose are **converted into cellular energy** and thereby **produces ethanol and CO2** as metabolic waste products.
- It is an **anaerobic process**.
- Performed by microbes such as yeast and bacteria.
- The type of the organism chosen mostly depends on the nature of the substrate used.
- Among the yeast, ***Saccharomyces cerevisiae*** is the most commonly used, while among the bacteria, ***Zymomonas mobilis*** is the most frequently employed for ethanol production.


Corn ethanol
Oil
CGM
CGF
Wet Milling Tank
Corn starch
Enzymatic hydrolysis
Cellulosic ethanol
Pretreatment
Cellulose-based biomass
Heat/ chemicals
Sugarcane ethanol
Sugarcane juice
Extraction of sugar
Bagasse
Fermentation
Product Recovery
DDGS
Lignin and other residuals
Distillation
BIOETHANOL



Wood residues
Pretreatment
Water-soluble polysaccharides
Lignin nanoparticles
Water-insoluble solids
Anaerobic digestion
Enzymatic hydrolysis
Biomethane
Furfural
Ethanol
Fermentation
Bioethanol


Bioethanol production
Chlorella vulgaris
Cultivation
Centrifugation and drying
Pre-treatment: Ultrasound and autoclave
hydrolyzed
Autoclave
Saccharomyces cerevisiae
Shaker with temperature between 29 and 30°C for alcoholic fermentation
Distiller
Bioethanol

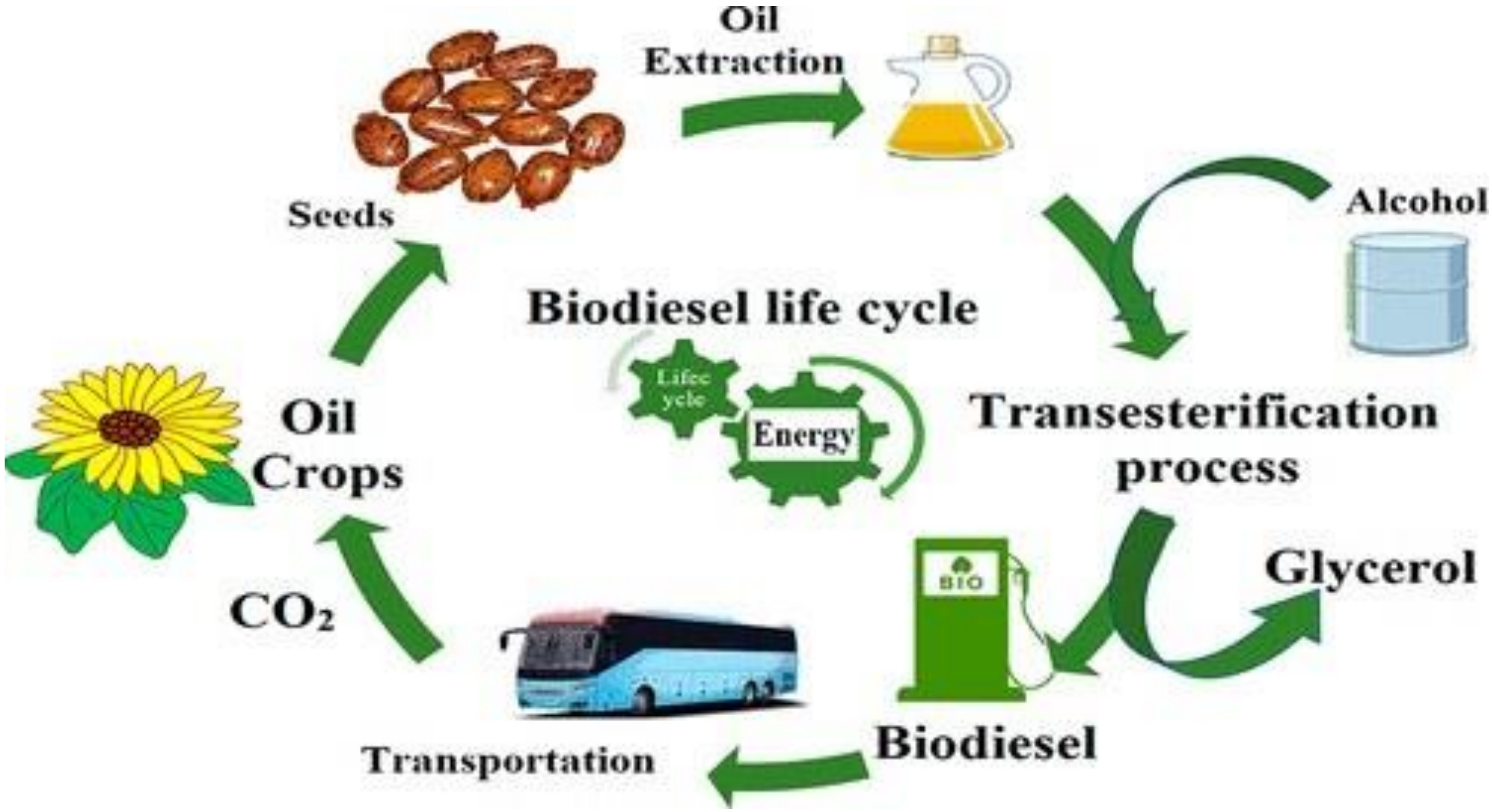

Algae
Bioethanol production
Biodiesel production
Algae culturing
Algae harvesting / Dewatering
Oil extraction from algae
Algal oil purification
Oil processing into biofuels
Hydrolysis & Fermentation
Bioethanol
Oil processing into biofuels
Transesterification
Alcoholysis
Biodiesel
Internal combustion engines

Benefits of Bioethanol

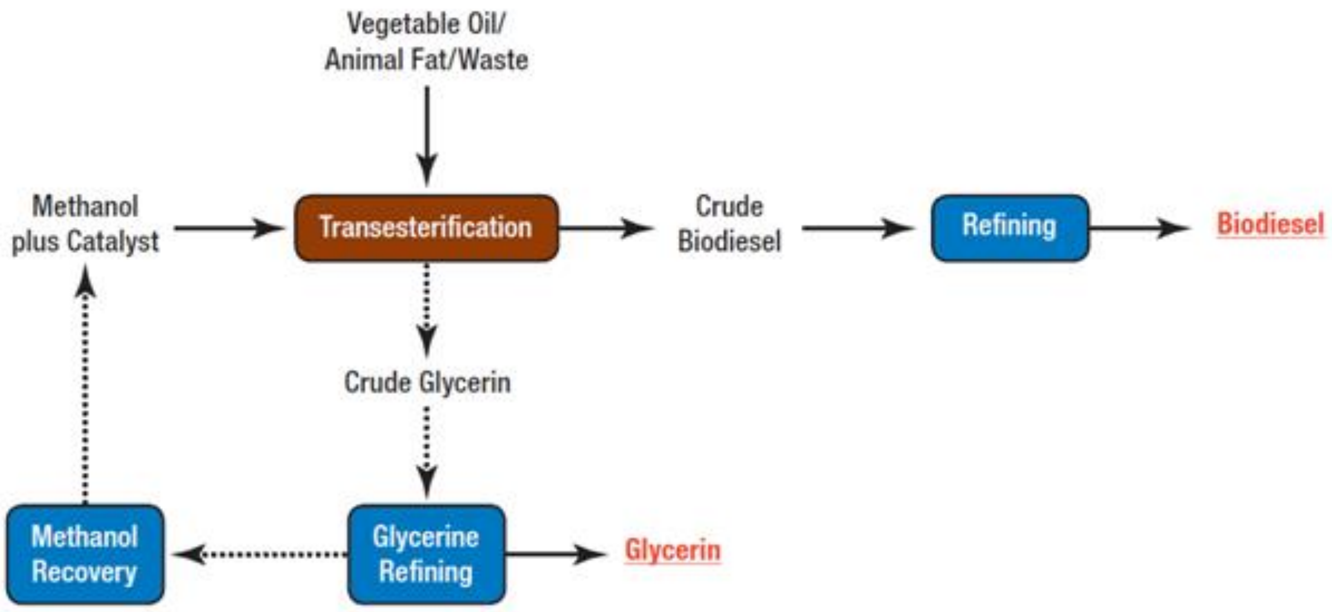
- It is a renewable, non-toxic resource
- It is biodegradable
- It mitigates global warming
- It helps reduce greenhouse gas emissions
- It reduces dependence on crude oil
- It reduces air pollution
- It creates new jobs in the agricultural and ethanol production industries

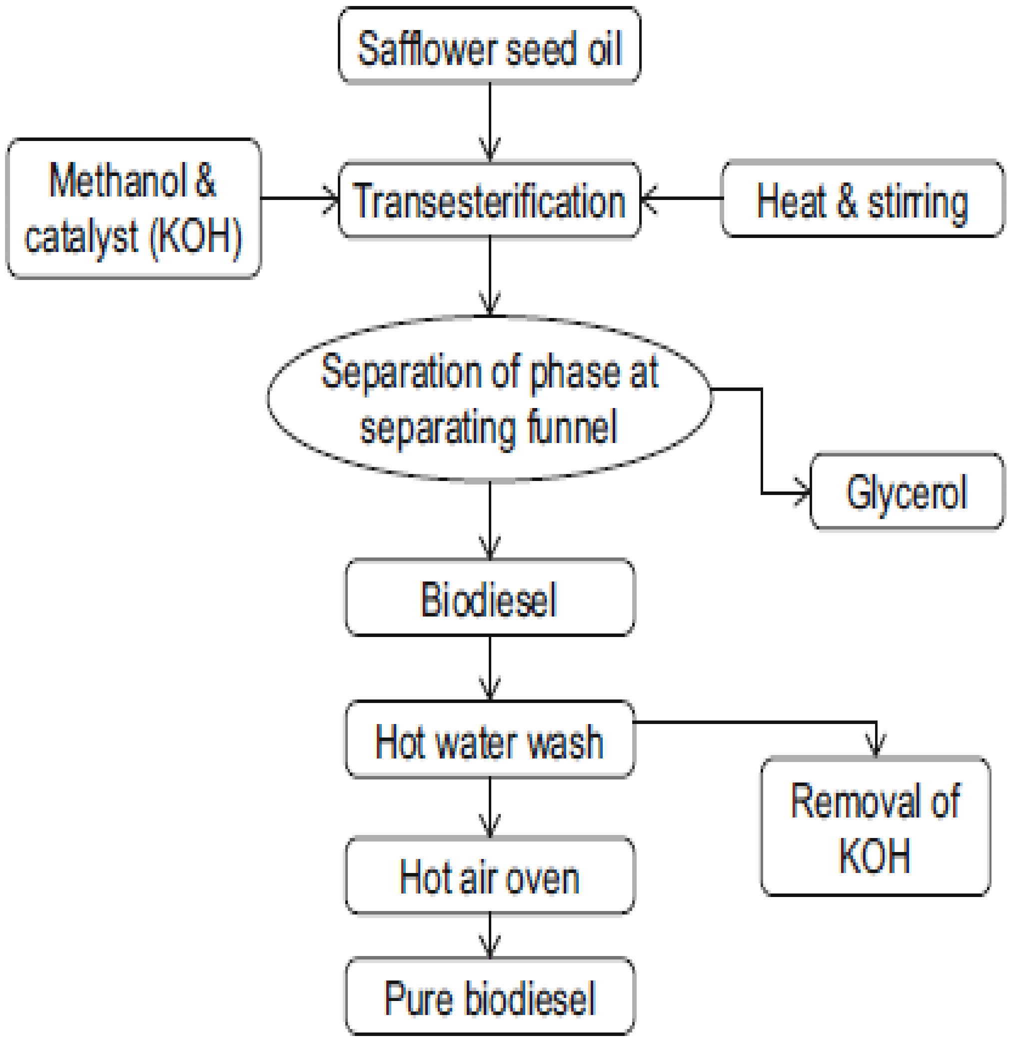
carbon collective

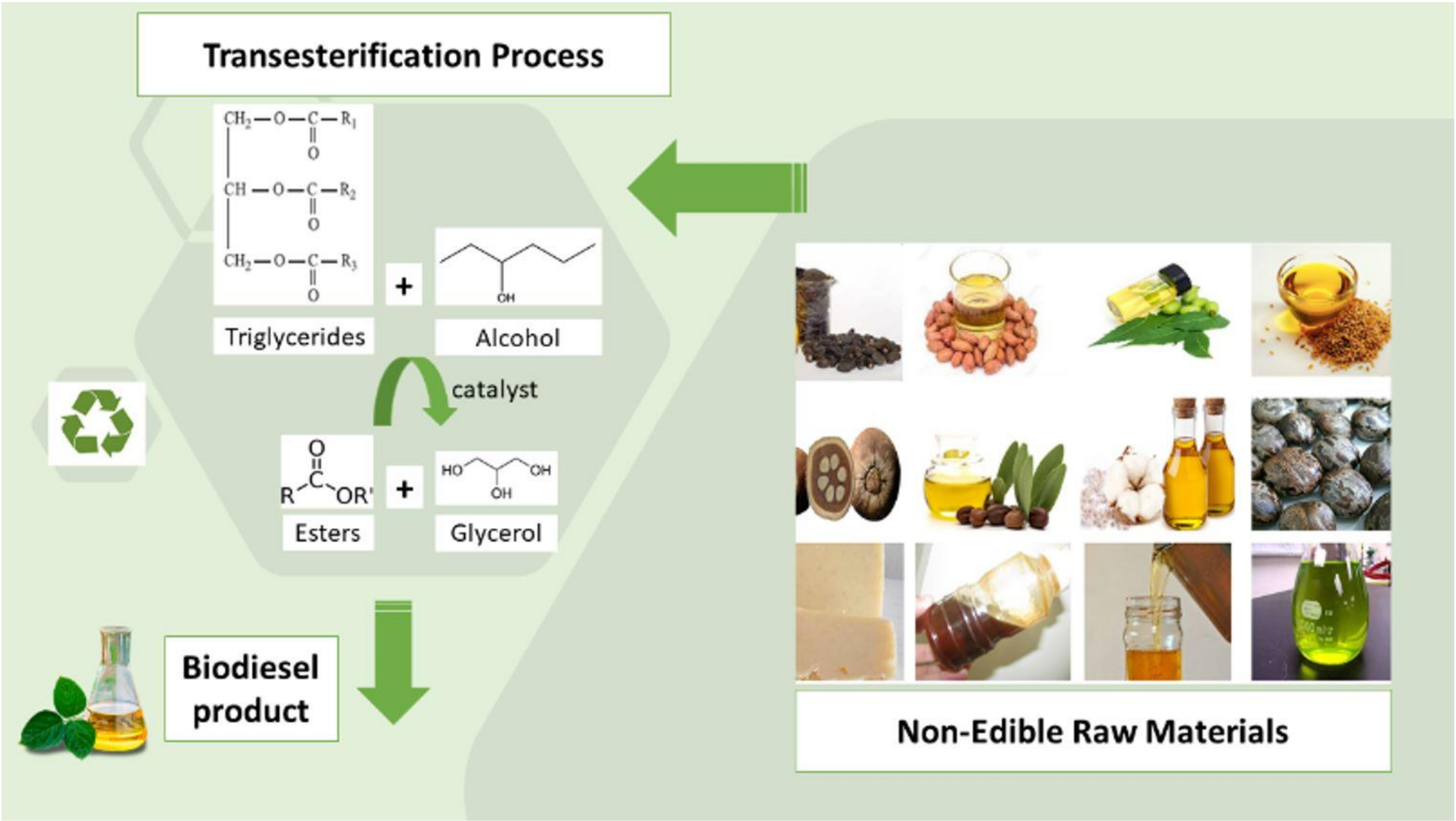

E85
85%
ETHANOL
15%
GASOLINE
V E85
VERASUN E85
85% Ethanol for Flex-Fuel Vehicles
AP

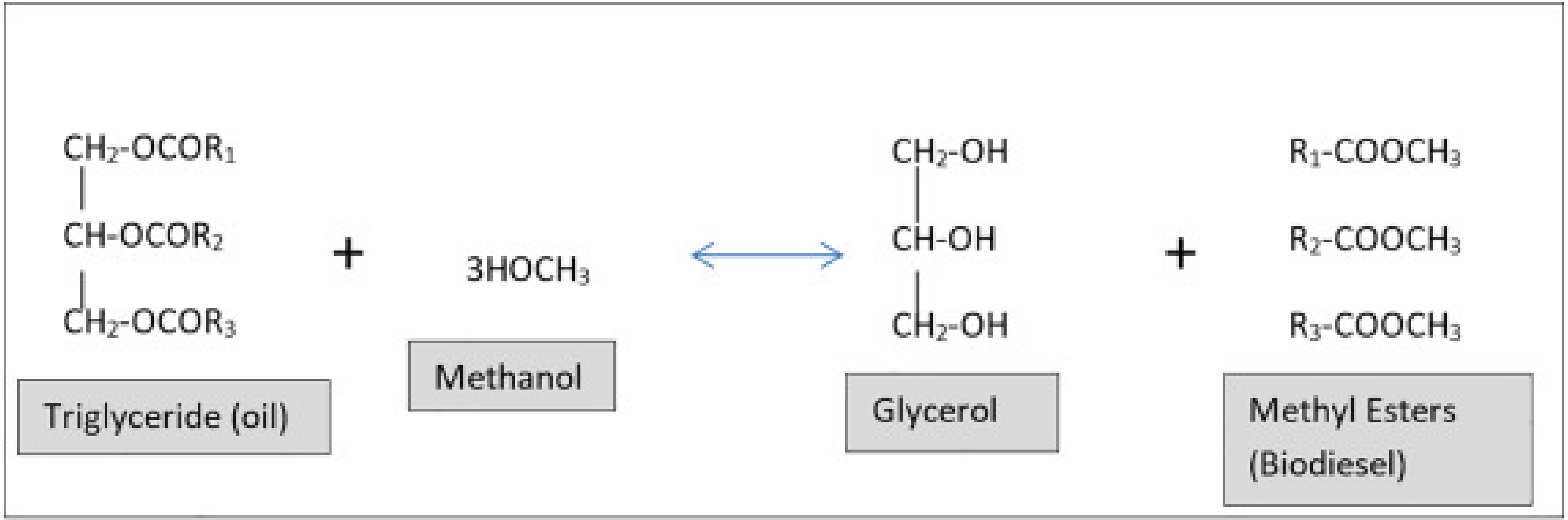

Oil
Extraction
Seeds
Alcohol
Biodiesel life cycle
Lifec
ycle
Energy
Oil
Crops
Transesterification
process
BIO
Glycerol
CO_2
Transportation
Biodiesel

Schematic of Biodiesel Production Path






Transesterification Process
Triglycerides
Alcohol
catalyst
Esters
Glycerol
Biodiesel product
Non-Edible Raw Materials


CH2-OCOR1
CH-OCOR2
CH2-OCOR3
Triglyceride (oil)
+
3HOCH3
Methanol
CH2-OH
CH-OH
CH2-OH
Glycerol
+
R1-COOCH3
R2-COOCH3
R3-COOCH3
Methyl Esters (Biodiesel)

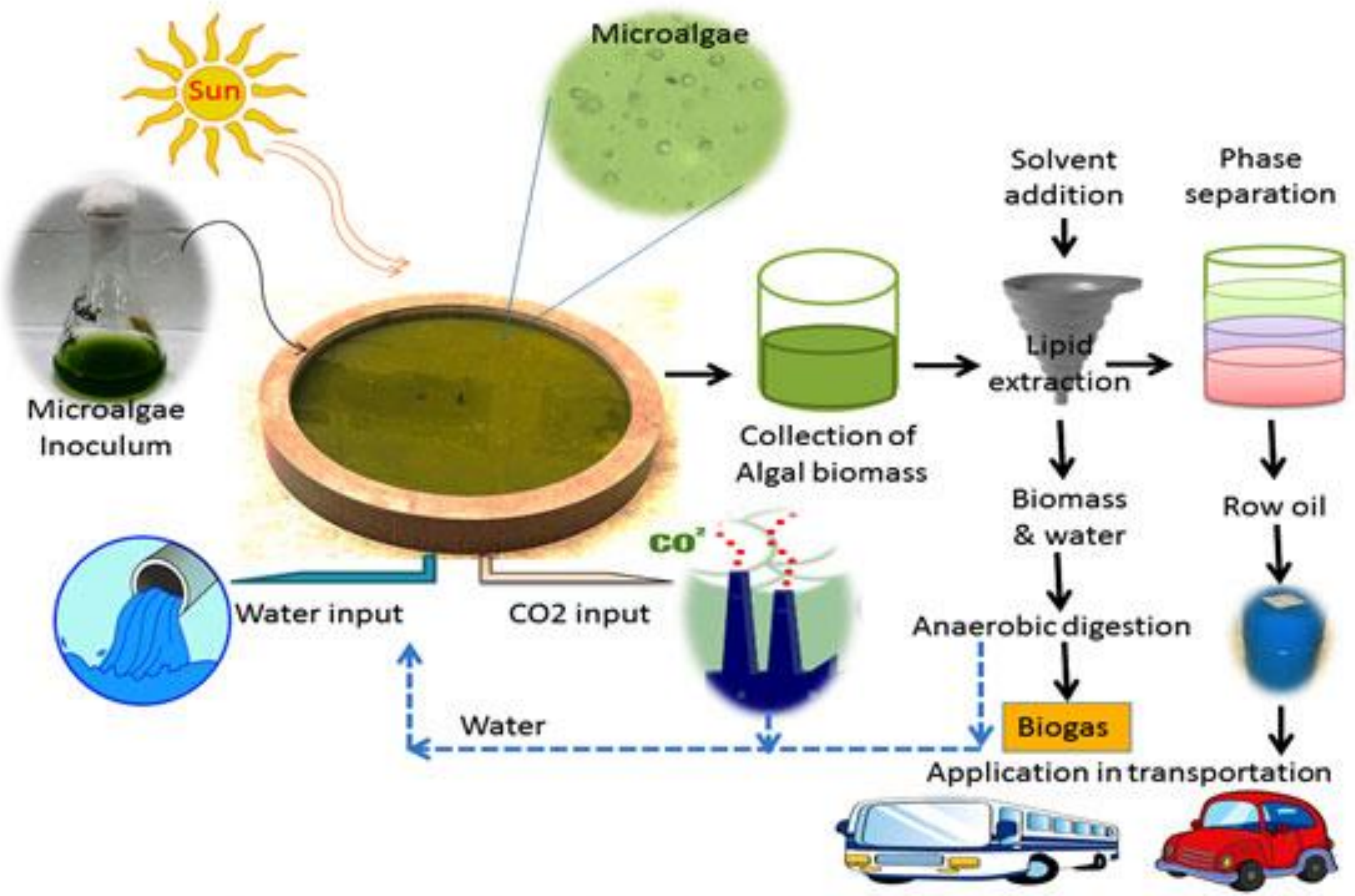
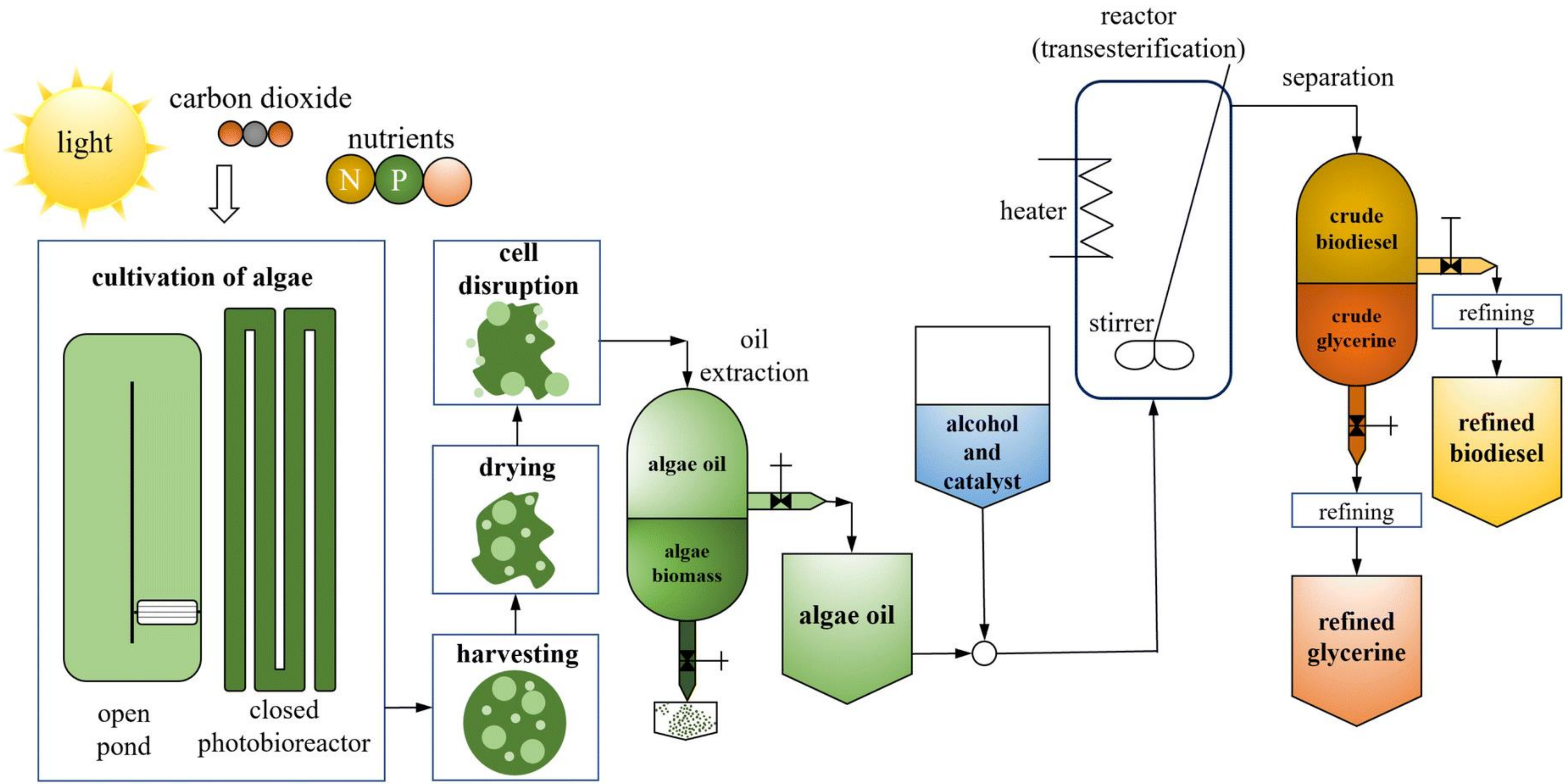
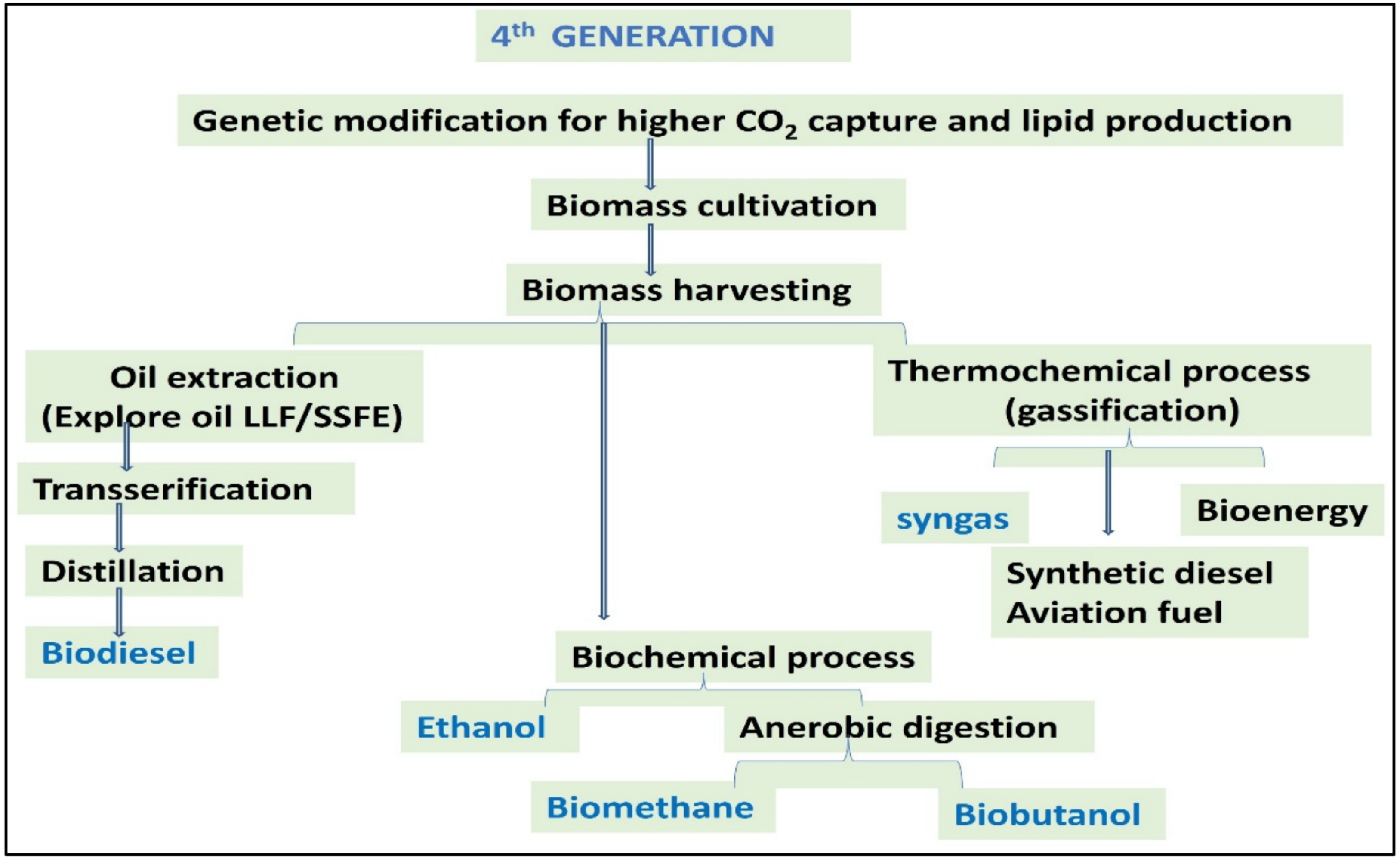
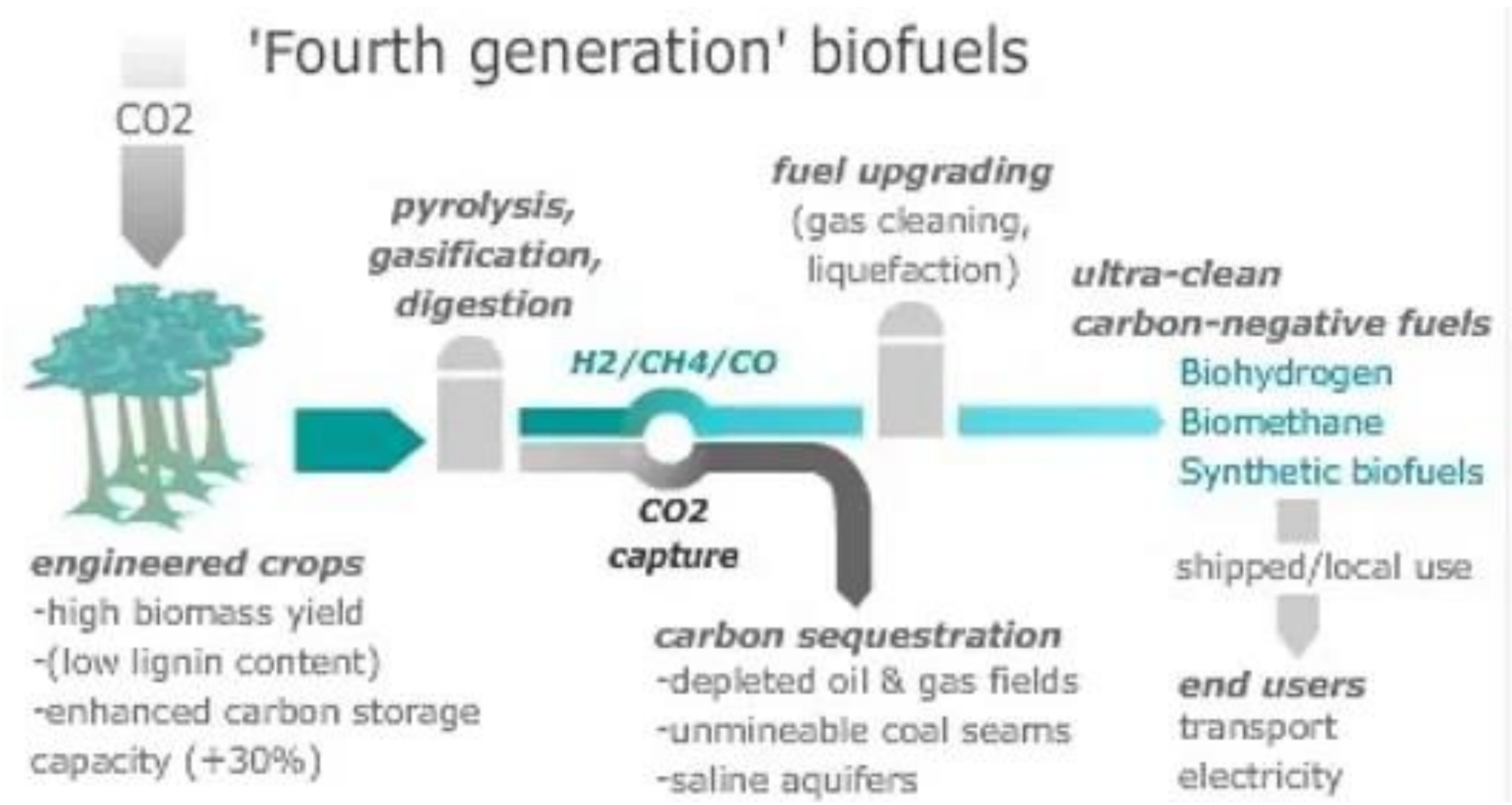


Figure 1: Overview of the Biofuel Production from the Microalgae.



light
carbon dioxide
nutrients
N
P
cultivation of algae
open pond
closed photobioreactor
harvesting
drying
cell disruption
oil extraction
algae oil
algae biomass
algae oil
alcohol and catalyst
reactor (transesterification)
heater
stirrer
separation
crude biodiesel
crude glycerine
refining
refining
refined biodiesel
refined glycerine

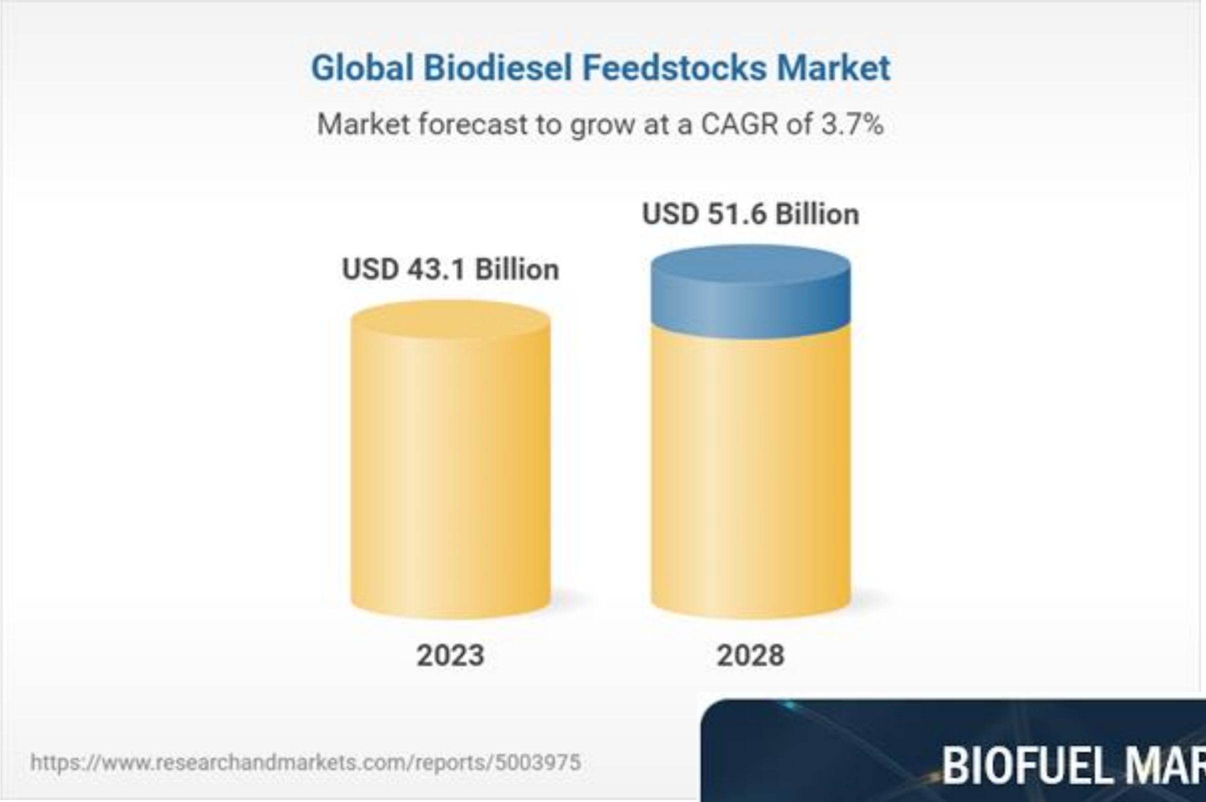

4th GENERATION
Genetic modification for higher CO2 capture and lipid production
Biomass cultivation
Biomass harvesting
Oil extraction
(Explore oil LLF/SSFE)
Transserification
Distillation
Biodiesel
Thermochemical process
(gassification)
syngas
Bioenergy
Synthetic diesel
Aviation fuel
Biochemical process
Ethanol
Anerobic digestion
Biomethane
Biobutanol

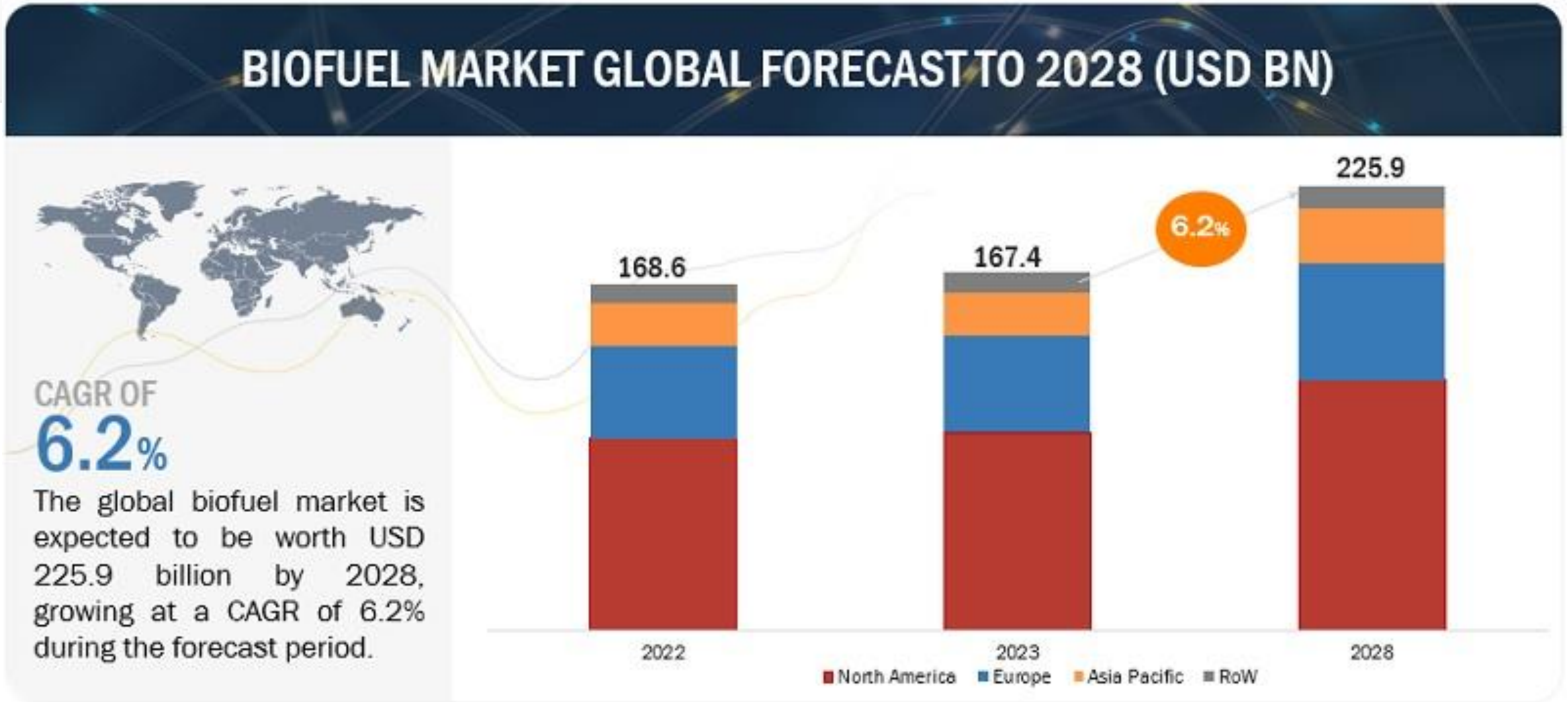


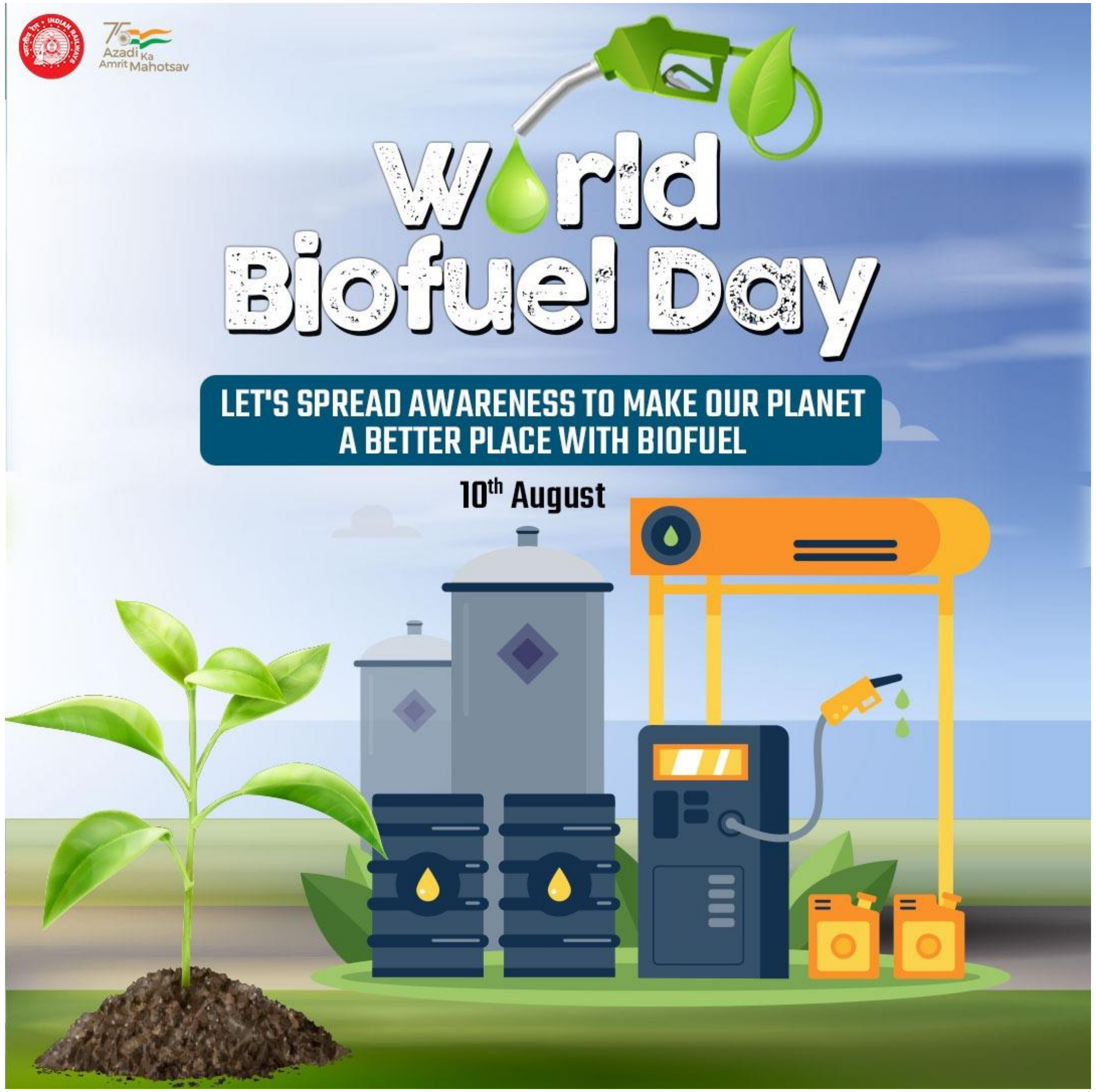
'Fourth generation' biofuels
CO2
pyrolysis,
gasification,
digestion
fuel upgrading
(gas cleaning,
liquefaction)
ultra-clean
carbon-negative fuels
H2/CH4/CO
Biohydrogen
Biomethane
Synthetic biofuels
CO2
capture
shipped/local use
engineered crops
-high biomass yield
-(low lignin content)
-enhanced carbon storage
capacity (+30%)
carbon sequestration
-depleted oil & gas fields
-unmineable coal seams
-saline aquifers
end users
transport
electricity

Advantages of Biodiesel Production

- Biodiesel is excellent for the environment, even it helps farmers to provide clean soil, water, and air for their crops.
- Biodiesel production boosts the nation's economy by creating jobs, generating tax revenue, and increasing our nation's GDP.
- Most of the fossil fuels will get bone-tired and end up in smoke one day. But sources like corn, wheat, vegetables, and from wastage of cooked oil and plants are renewable and will never be exhausted.
- One of the primary benefits of using Biodiesel is energy efficiency.
- It is best proven for reducing foreign oil dependency. Also, it is beneficial for health.
- It leads positive impact on the economy of the country. Moreover, it is good at reducing greenhouse gases, sustainability, and high-quality engine performance.
- Using biodiesel as a vehicle fuel increases energy security, improves air quality and the environment, and provides safety benefits.
- Biodiesel offers exceptional performance over petrodiesel as it includes lubricity. Over time, a high level of lubricity reduces wear and tear on your engine.

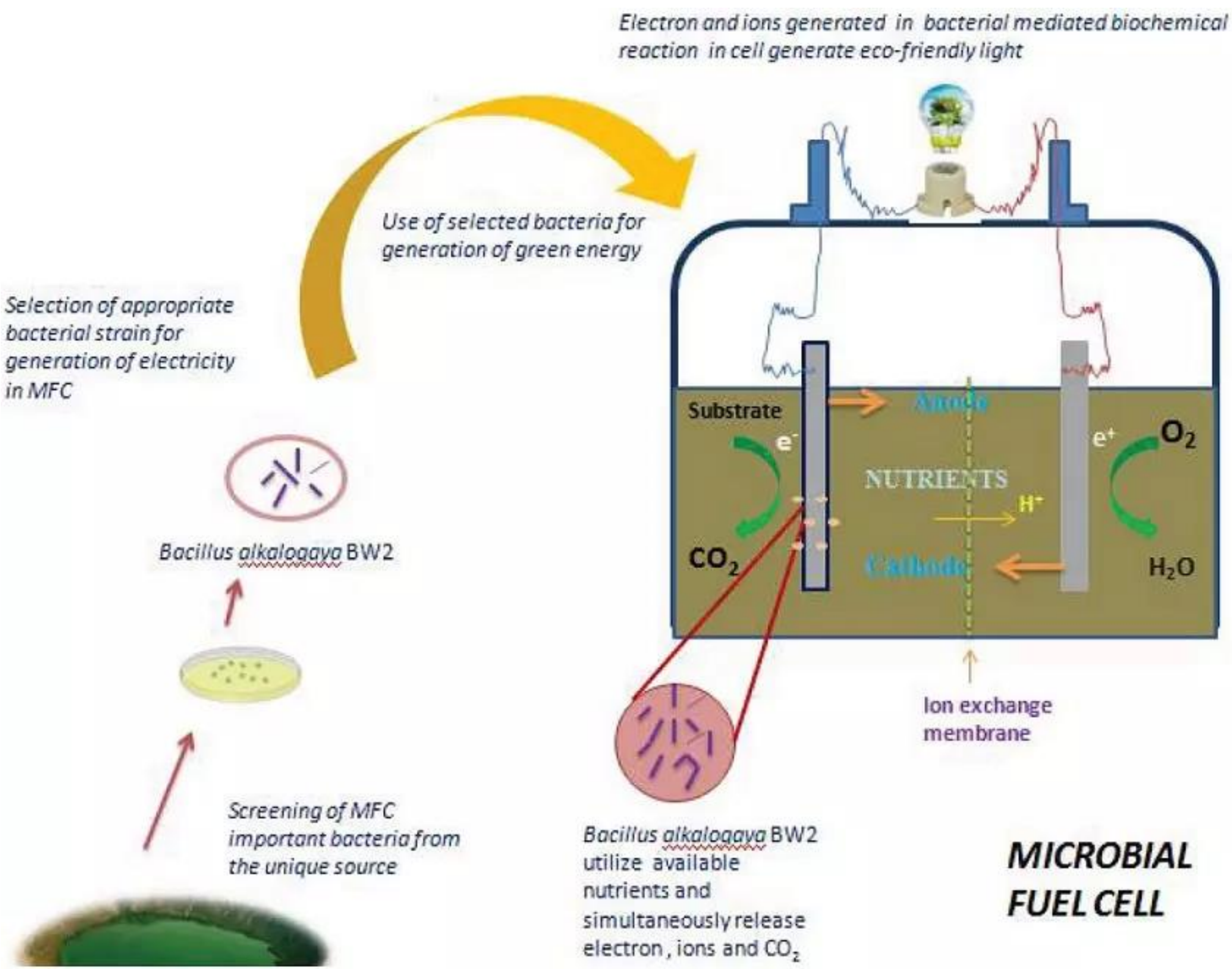

Global Biodiesel Feedstocks Market
Market forecast to grow at a CAGR of 3.7%
USD 43.1 Billion
USD 51.6 Billion
2023
2028
https://www.researchandmarkets.com/reports/5003975


BIOFUEL MARKET GLOBAL FORECAST TO 2028 (USD BN)
CAGR OF
6.2%
The global biofuel market is expected to be worth USD 225.9 billion by 2028, growing at a CAGR of 6.2% during the forecast period.
168.6
167.4
6.2%
225.9
2022
2023
2028
North America
Europe
Asia Pacific
RoW


Azadi Ka Amrit Mahotsav
World Biofuel Day
LET'S SPREAD AWARENESS TO MAKE OUR PLANET A BETTER PLACE WITH BIOFUEL
10th August

Microbial fuel cell

- Fuel cells are a novel addition to the inventory of alternate energy sources having minimal or no net-CO_2 emission.
- Microbial Fuel Cells (MFCs) have been described as "bioreactors that convert the energy in the chemical bonds of organic compounds into electrical energy through catalytic activity of micro-organisms under anaerobic conditions".
- MFC technology represents a novel approach of using bacteria for generation of bioelectricity by oxidation of organic waste and renewable biomass.
- The operational and functional advantages of MFCs are:
  - MFCs use organic waste matter as fuels and readily available microbes as catalysts.
  - MFCs do not require highly regulated distribution systems like the ones needed for Hydrogen Fuel Cells.
  - MFCs have high conversion efficiency as compared to Enzymatic Fuel Cells, in harvesting up to 90% of the electrons from the bacterial electron transport system.
- The principle of working of MFCs is based on the tenets of microbial physiology coupled with electrochemistry.



Electron and ions generated in bacterial mediated biochemical reaction in cell generate eco-friendly light
Use of selected bacteria for generation of green energy
Selection of appropriate bacterial strain for generation of electricity in MFC
Bacillus alkalogaya BW2
Screening of MFC important bacteria from the unique source
Substrate
Anode
e-
e+
O_2
NUTRIENTS
H^+
CO_2
Cathode
H_2O
Ion exchange membrane
Bacillus alkalogaya BW2 utilize available nutrients and simultaneously release electron , ions and CO_2
MICROBIAL FUEL CELL

Working Principle of MFC

• When bacteria are placed in the anode chamber of a specially-designed fuel cell that is free of oxygen, they attach to an electrode.

• Because they do not have oxygen, they must transfer the electrons that they obtain from consumption (oxidation) of their food somewhere else than to oxygen-- they transfer them to the electrode.

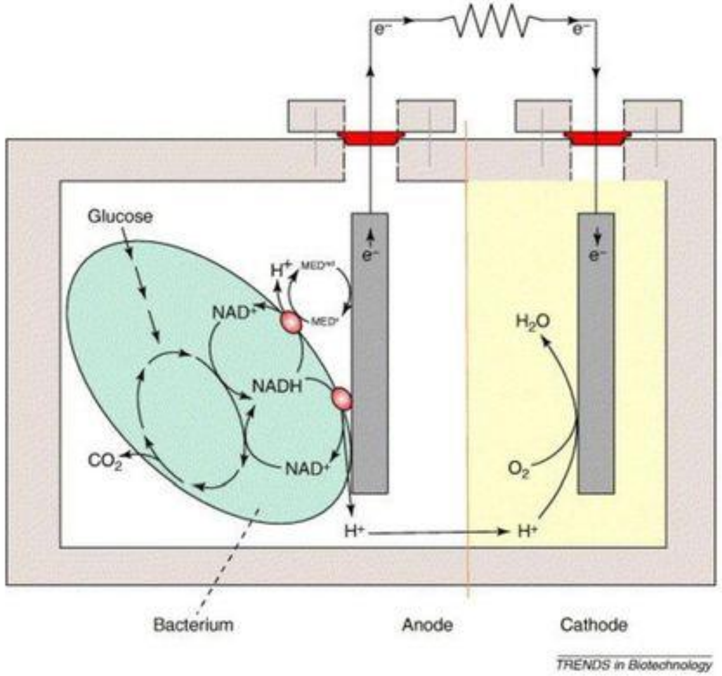
• In a MFC these electrons therefore go to the anode, while the counter electrode (the cathode) is exposed to oxygen. At the cathode the electrons, oxygen and protons combine to form only water. The two electrodes are at different potentials (about 0.5 V)

WORKING OF MFC

- Anode and Cathode separated by Cathode specific membrane
- Microbes at anode oxidize the organic waste and generates electrons and H+ ions
- H+ ions move to the cathode compartment through the membrane
- The electrons flow from the bacteria to the anode, sometimes assisted by a mediator or by direct mechanism.
- Then Electrons transferred to the cathode compartment through external circuit to generate current
- The electrons from the cathode combine with dissolved oxygen and the H+ ions to form pure H_2O.

Mechanism of electron transfer

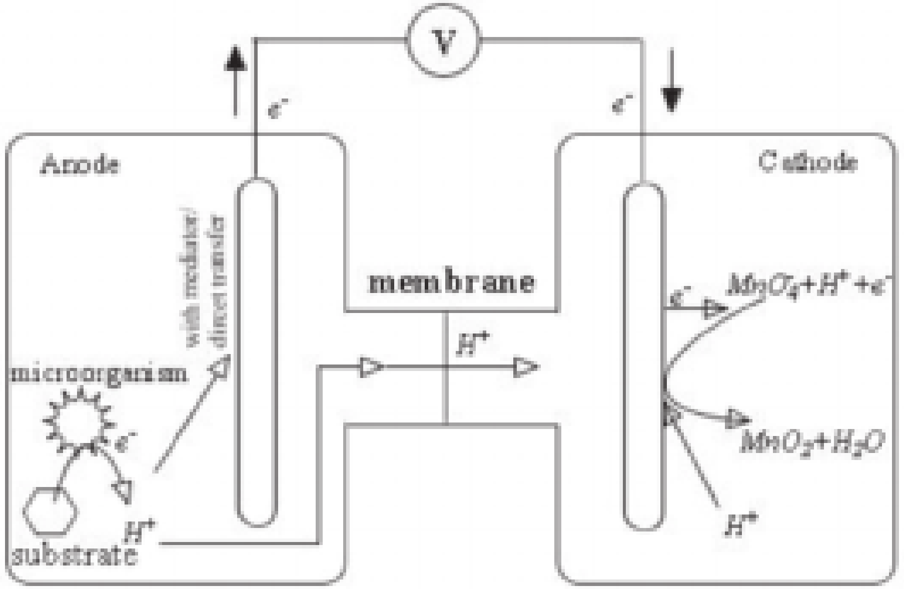
* Basic respiration in the cell, involves the transfer of electrons from a low redox potential electron donor to a electron acceptor at a high redox potential.
* Nicotinamide adedine dinucleotide
  $NAD^+ \longrightarrow NADH$
* Hydrogen atoms removed from carriers (NADH) simultaneously are seperated from electrons.
* While electrons transferred to next electron acceptor (carrier), protons are pumped outside the cell.
* This is occured by tricarboxylic acid (TCA) cycle in the cell.



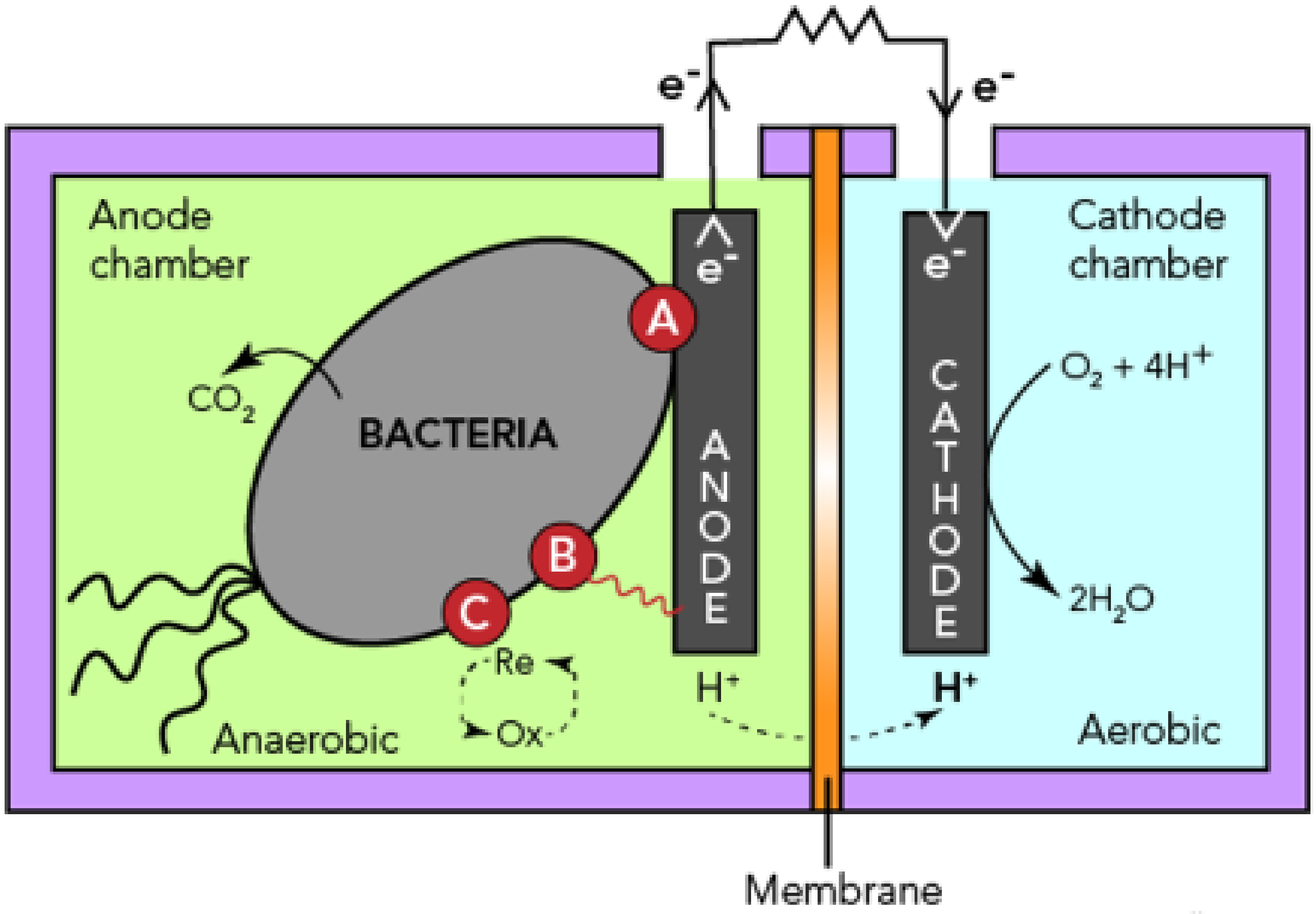
Biochemical basis

- Chemotrophic microbes utilize organic and other biodegradable compounds, under diverse conditions. The electrons resulting from the oxidation are conveyed to an electron transport chain, across appropriate electron carriers depending on the terminal electron acceptor molecule. In aerobic organisms, this terminal acceptor is oxygen which takes up the electrons and gets reduced to water.
- The chemiosmotic hypothesis states that electron transfer chains of bacteria are coupled to the translocation of protons across the membranes which is in turn linked to ATP synthesis by the proton electrochemical potential across the energy transducing membrane.
- The bacterial cell membrane functions as an energy transducing membrane operating according to the chemiosmotic principle. **The translocation of protons towards the outside of the membrane results in the establishment of a proton electrochemical gradient**. The pH gradient adds up to this membrane potential and results in the **proton motive force**. The re-entry of these protons across the ATP-synthase enzyme is accompanied by ATP synthesis. The ATP synthesized thus is used by the bacteria for their survival.

- A typical MFC consists of two compartments - the anodic and cathodic half-cells - which are separated by a selectively permeable, cation-specific membrane or a salt-bridge.
- The anodic chamber consists of microbes suspended under anaerobic conditions in the anolyte and the cathodic chamber contains the electron acceptor (oxygen).
- In essence, the electron donor is physically separated from the terminal electron acceptor across the two chambers. Most of the electrons released from the process of oxidation are conveyed to the anode.
- Electron transfer to the anode can be accomplished by electron mediators or shuttling agents, directly by the cell or by means of 'nanowires'.
- These electrons are directed to the cathode across an external circuit and for every electron conducted, a proton is transported across the membrane to the cathode for completing the reaction and sustaining the electric current.



Two-chambered microbial fuel cell



e^-
e^-
Anode chamber
Cathode chamber
e^-
e^-
A
CO_2
BACTERIA
ANODE
CATHODE
$O_2 + 4H^+$
B
C
$2H_2O$
Re
H^+
H^+
Anaerobic
Ox
Aerobic
Membrane