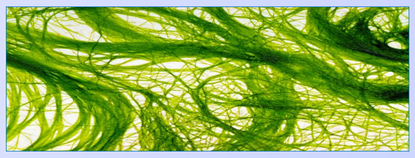
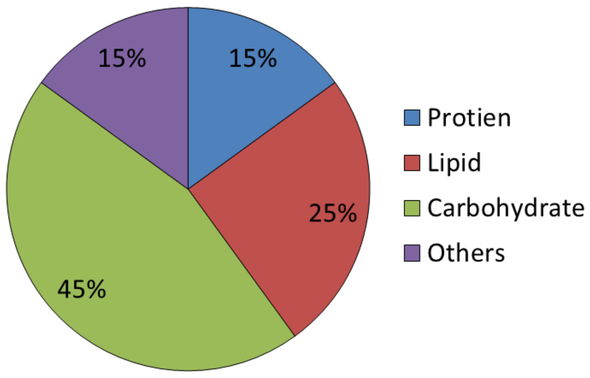


MICROALGAL BIOFUELS

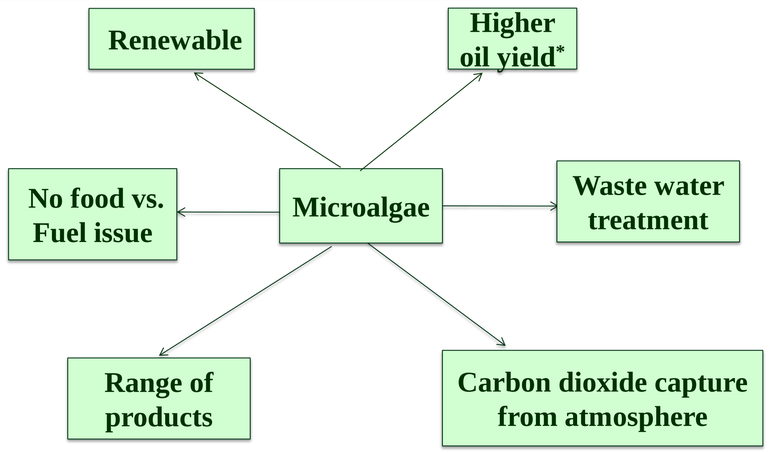
Department of Chemical Engineering
Indian Institute of Technology, Bombay

WHAT IS MICROALGAE?

- Unicellular species
- Existing individually, or in groups
- Dimension: Few microns to few millimeters
- Cell composition: Specific to the species

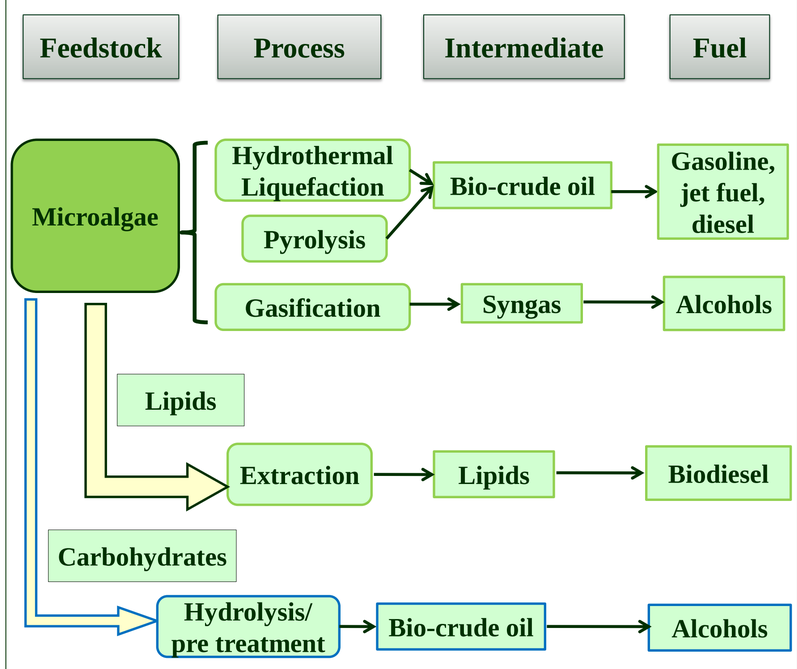


WHY MICROALGAE?



*13.7 l/m^2 as compared to less than 0.6 l/m^2 for other sources such as soybean, coconut, and palm oil [1]

BIOFUELS FROM MICROALGAE



BIODIESEL FROM MICROALGAE

Biodiesel: A mixture of fatty acid alkyl esters

Neutral lipids in microalgae: TG: Triacylglyceride, DG: Diacylglyceride, MG: Monoacylglyceride

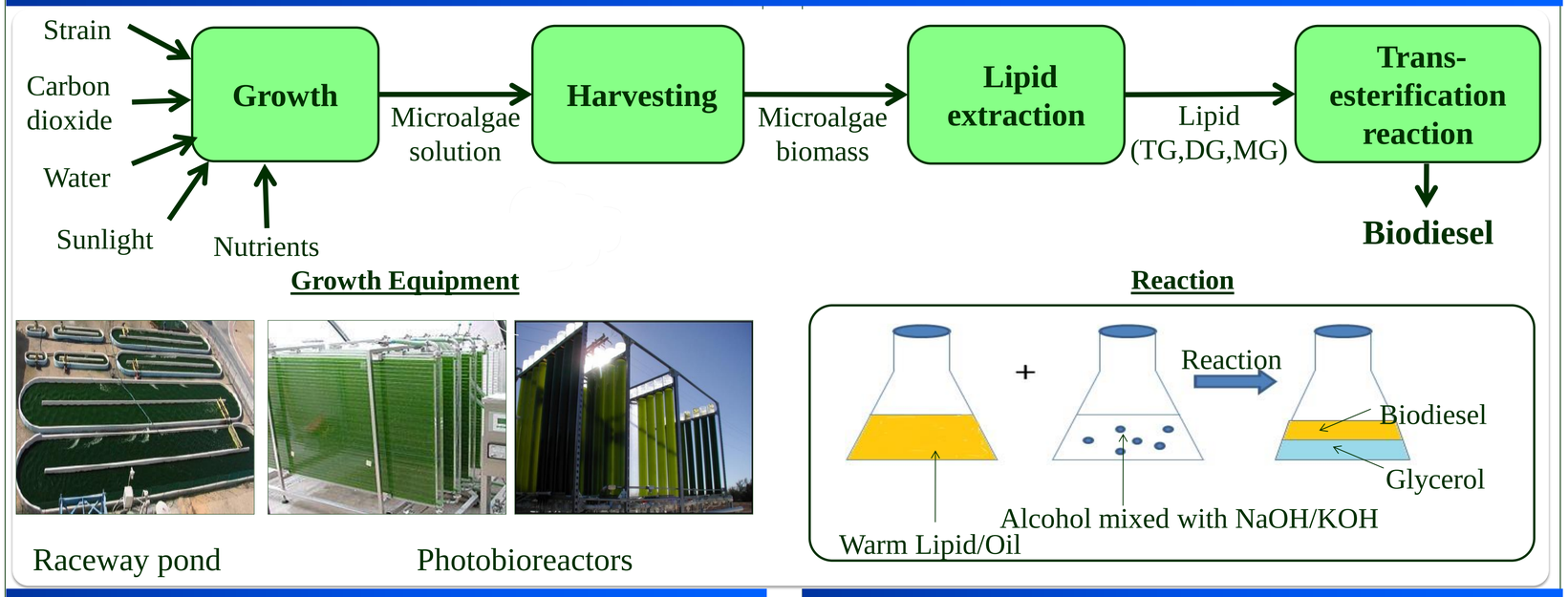
$$\text{Lipid} + \text{Alcohol} \xrightarrow{\text{Catalyst}} \text{Biodiesel} + \text{Glycerol}$$

$$TG + CH_3OH \overset{k1,k2}{\Leftrightarrow} DG + R_1COOCH_3$$

$$DG + CH_3OH \overset{k_3,k_4}{\Leftrightarrow} MG + R_2COOCH_3$$

$$MG + CH_3OH \overset{k_5,k_6}{\Leftrightarrow} GL + R_3COOCH_3$$

BIODIESEL FROM MICROALGAE: PROCESS



MAJOR CHALLENGES

➢ High area requirement

One-way journey from Mumbai to Pune (150 km)

Facility required

Open pond: **13,043 m^2** (twice a football ground)

Photobioreactor: **68,684 liters**

➢ High cost

Cost of microalgae based fuel [2]: **US $ 300-2600/barrel**

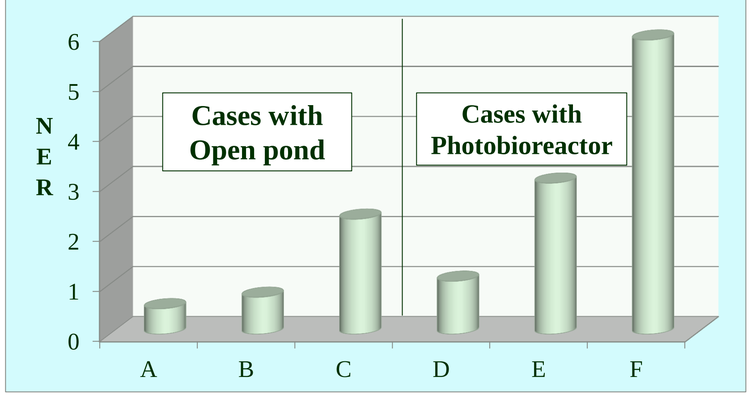
Cost of petroleum[2]: **US $ 40-80/barrel** (@ 2009)

➢ High energy requirement

NER = Net energy for cultivation, harvesting, drying per unit energy content of dry biomass

(NER>1 for most of the cases studied)

NER values from different studies (A-F) [3]



➢ Process-level challenges

- Many alternative process options at each step
- Technological bottlenecks
- Trade-off between economics, efficiency, and environment

POTENTIAL SOLUTIONS

Cellular level

➢ Improvement in strain characteristics

Process level

➢ Optimization of growth environment

➢ Enhancement of performance of processes at each stage

Flowsheet level

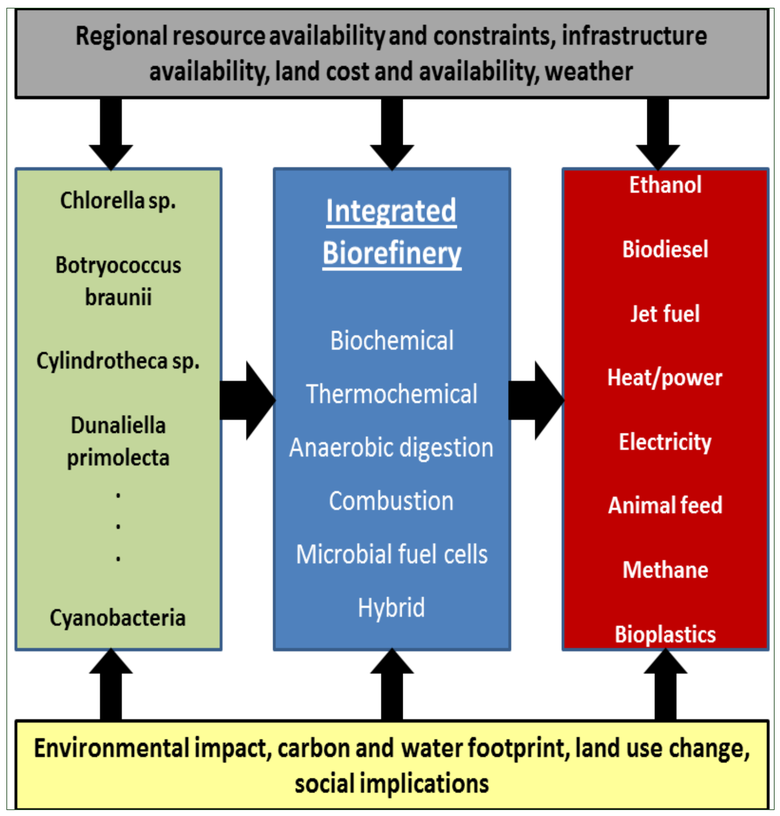
➢ Development of novel processes

➢ Manufacture of varieties of food and energy products from protein and carbohydrate [Biofuels amount to **<10 %** of net value attainable from microalgae] [4]

➢ Production of pharmaceutically valuable compounds

A multi-dimensional engineering research through computational studies

- Explore novel process options: Design
- Improve existing processes: Control
- Develop optimal biorefinery: Synthesis



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[2] Hannon et al., *Biofuels* (1(5)), 2010

[3] Slade and Bauen, *Biomass and Bioenergy* (53), 2013

[4] Wijffels, Barbosa and Eppink, *Biofuels, Bioproducts & Biorefining* (4), 2010

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