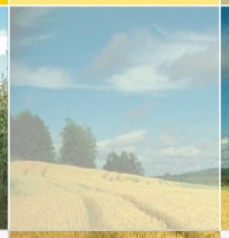
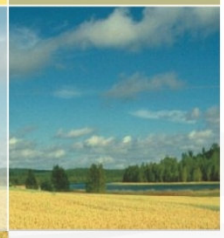
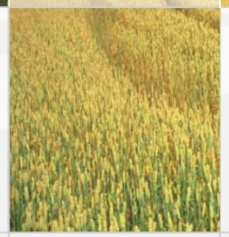
Wonders of Biotechnology







Praj Matrix- The Innovation Center

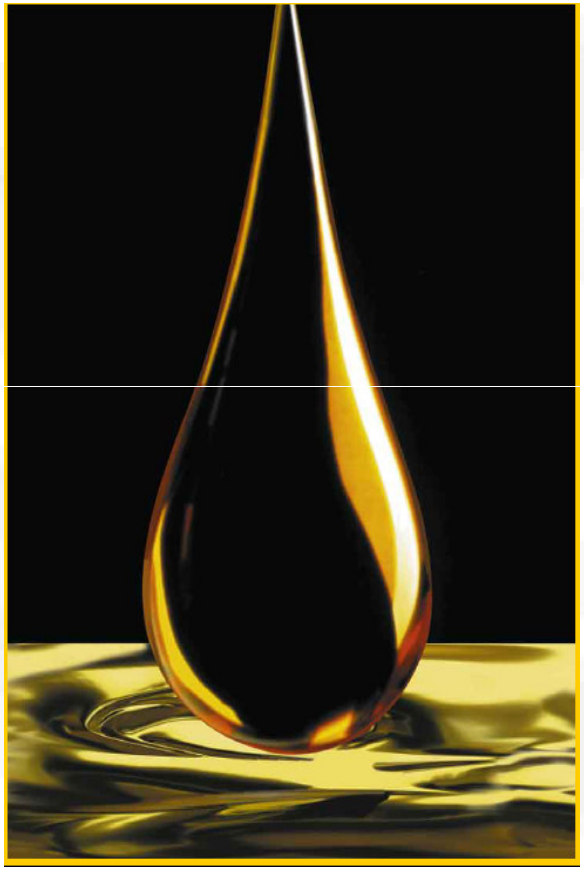
Dr. Balu Sarma
Dr. Ashvini Shete
Dr. Mangesh Kulkarni

November 28th '10

Contents

- Need for Alternative Transportation Fuels
- Production of Alternative Fuels using Renewable Resources
- Biodiesel and Ethanol

Modern Energy



- Modern energy created our prosperity
- Without it everything ends:
  - Automated Transportation
  - Electricity
  - Most Agriculture
  - Potable Water etc.

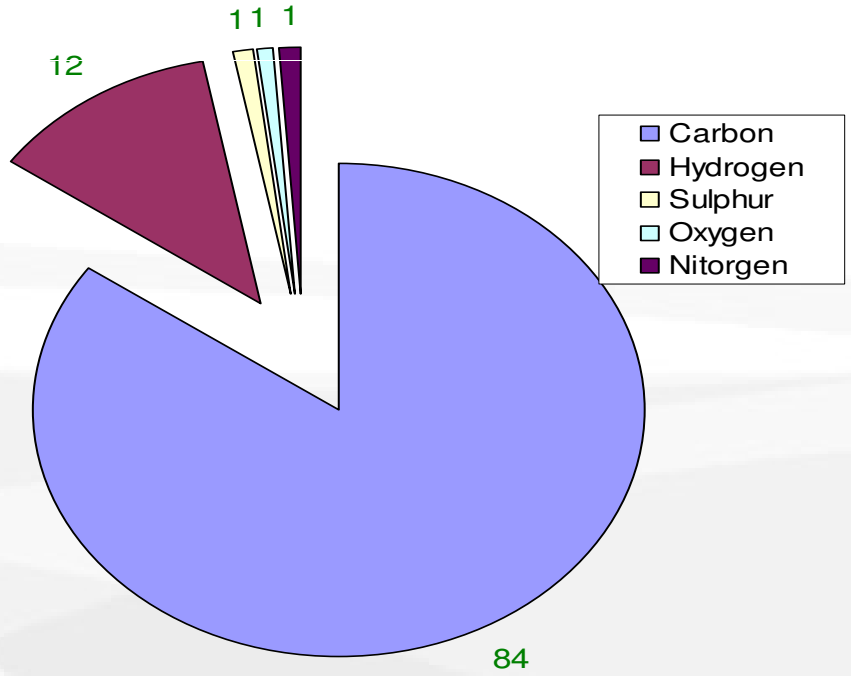
Crude oil is a major source of modern energy

What is Crude Oil?

Crude oil is the term for "unprocessed" oil, the stuff that comes out of the ground. It is also known as petroleum.

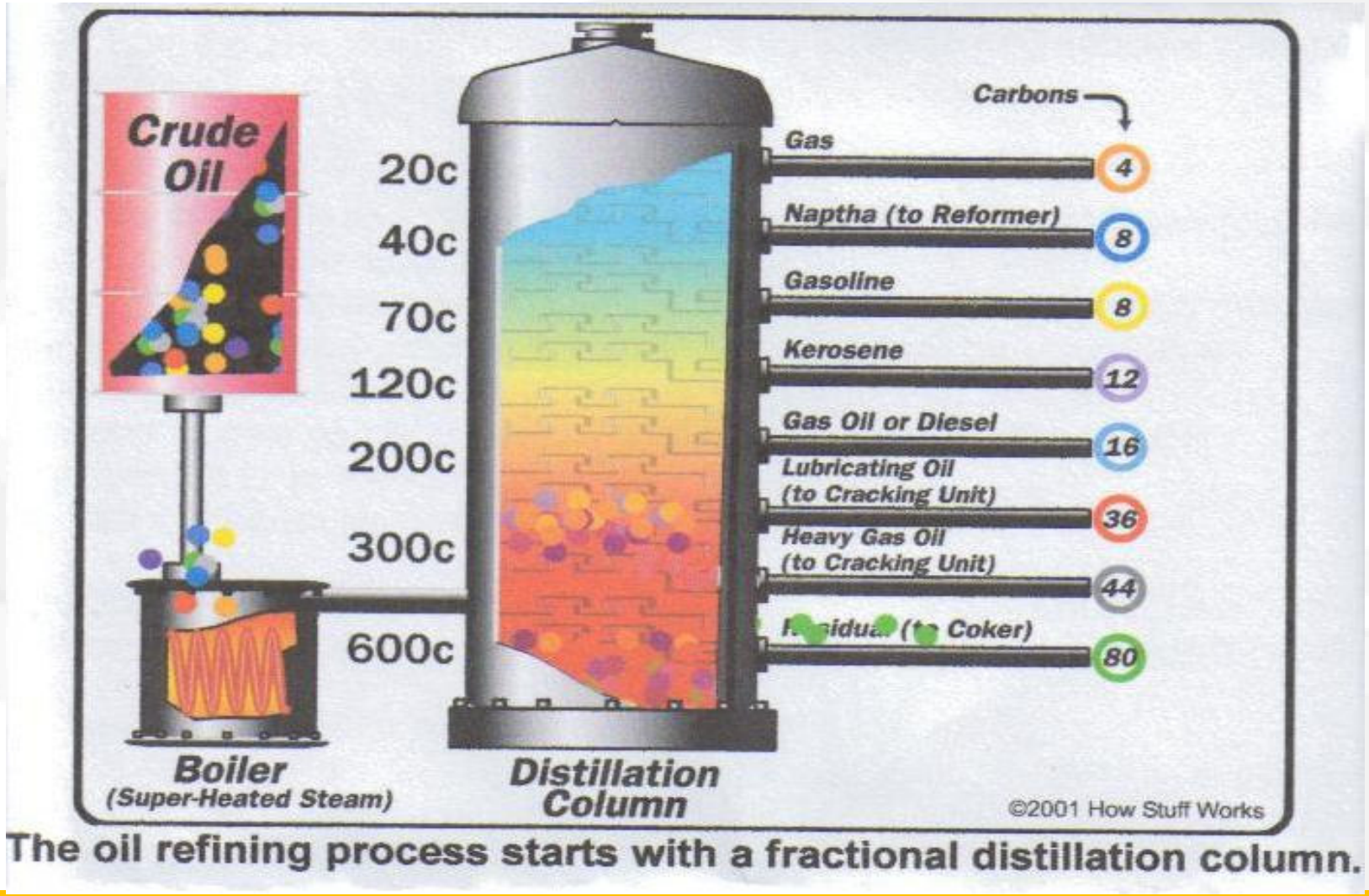
Crude oil is a fossil fuel, meaning that it was made natural-ly from decaying plants and animals living in ancient seas millions of years ago

Crude Oil Components



http://science.howstuffworks.com/environmental/energy/oil-refining1.htm

Crude Oil Refining Process



The oil refining process starts with a fractional distillation column.

http://science.howstuffworks.com/environmental/energy/oil-refining1.htm

Diesel consumption for Transportation

Petroleum diesel consumption for transportation

Contry/Region	Petroleum Diesel Consumption (MT/Yr)	% Diesel Consumption for Transportation	Transportation Petroluem Diesel Consumption (MT/yr)
Canada	23.4	46	10.8
USA	178.4	65	116.0
EU	258.5	59	152.5
World	934.3	60	560.6

Source: IEA 2004a data, balance of consumption utilized for industry, agriculture and public services

India: Annual diesel consumption ~ 40 million tonnes
- 70% of crude oil is imported.

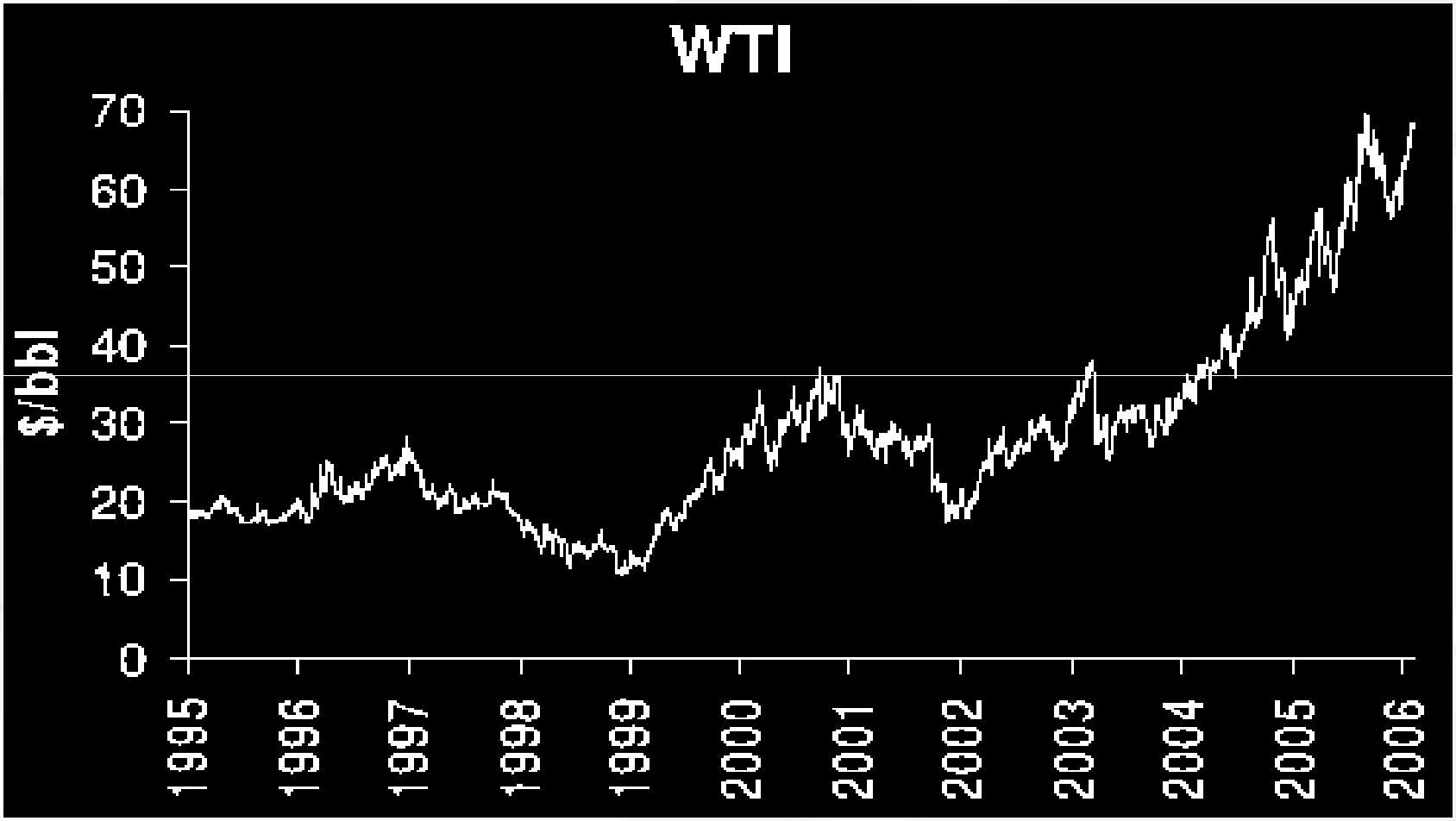
Every day we spend 1000 Cr for importing crude oil

Crude Oil Reserves

Crude oil	Proved Reserves (billion tonnes)	R/P Ratio (years)
Middle East	89.4	93.4
USA	3.8	9.8
Total World	137	43

http://stason.org/TULARC/vehicles/gasoline-faq/4-2-When-will-we-run-out-of-crude-oil.html

Crude Oil Prices



Crude oil prices

Source: Simmons and Company, 2006

Principal Pollutants

Sources of the principal pollutants

	CO (%)	NOx (%)	HC (%)
Gasoline vehicles	90	52	40
Domestic	5	3	2
Power stations	1	26	< 1
Industry	4	11	56
Others	-	8	1

www.efoa.org

Global concern !!!

- *Reduce use of fossil fuels*
- *Invest in alternative renewable fuels.*

Biomass As A Source of Energy

Biomass Production in India

Average Production of Various Types of Agro Field & Industrial Residue	
Type of Agro residues	**Quantity (Million Tonnes / annum)**
Straws of various pulses & cereals	225.5
Bagasse	56
Rice Husk	10
Groundnut Shell	11.1
Stalks	2
Various Oil Stalks	4.5
Others (wood chips, wood dust, Agro waste etc)	65.9
Total	**375**

- **Total Biomass production in India = 375 Million MT per annum**
- **Production of Agro straws is much higher among all biomass materials**
- **Possible Biomass based energy production is estimated at 16000 MW and Bagasse based and Bagasse based Cogeneration potential is estimated at 3500 MW which can be increased upto 5000 MW**

Non Edible Oils in India

Table 1.2: Potential non-edible oilseed plants in India.

No.	Botanical Name	Common Name	Distribution	Potential (Metric tones)	Oil (%)	Use
1	*Azadirachta indica*	Neem	Throughout India, mostly in dry forests of Andhra Pradesh, Tamilnadu and Karnataka	5,00,000	35-40	Medicinal, biopesticides
2	*Pongamia pinnata*	Karanja	Throughout India	2,00,000	27-39	Soaps, lubricants, illumination, industrial
3	*Shorea robusta*	Sal	Central Himalayas and foothills of Himalayas, in sub temperate regions.	62,00,000	13	Cocoa butter substitute, soap, vanaspati
4	*Madhuca indica*	Mahua	Central India, Planes of north India.	5,20,000	35	Cocoa butter substitute, soap, vanaspati
5	*Schleichera trijuga*	Kusum	Forests of sub-Himalayan tracts, in north and east part of India	45,000	34	Soap, medicinal, illumination, lubricant
6	*Calophyllum inophyllum*	Undi	Along sea coasts	11,467	50-73	Illumination, soap

Why consider biomass as energy?

- Need to find a substitute to worlds finite non-renewable energy sources
- Help to reduce the gaseous emissions, eg. Green house gases, particulates
- Improve security of transport fuel supply
- Less dependency on imported fuel

Biodiesel, Ethanol

Biodiesel

Mono alkyl ester of long chain fatty acids derived from renewable lipid sources such as vegetable oils or animal fats.

It can replace diesel fuel

How to make biodiesel?

Feedstocks for Biodiesel

Soybean seeds (USA)

Rape Seed (Europe)

Palm Oil Fruit (South East Asia)

Feedstocks for Biodiesel in India

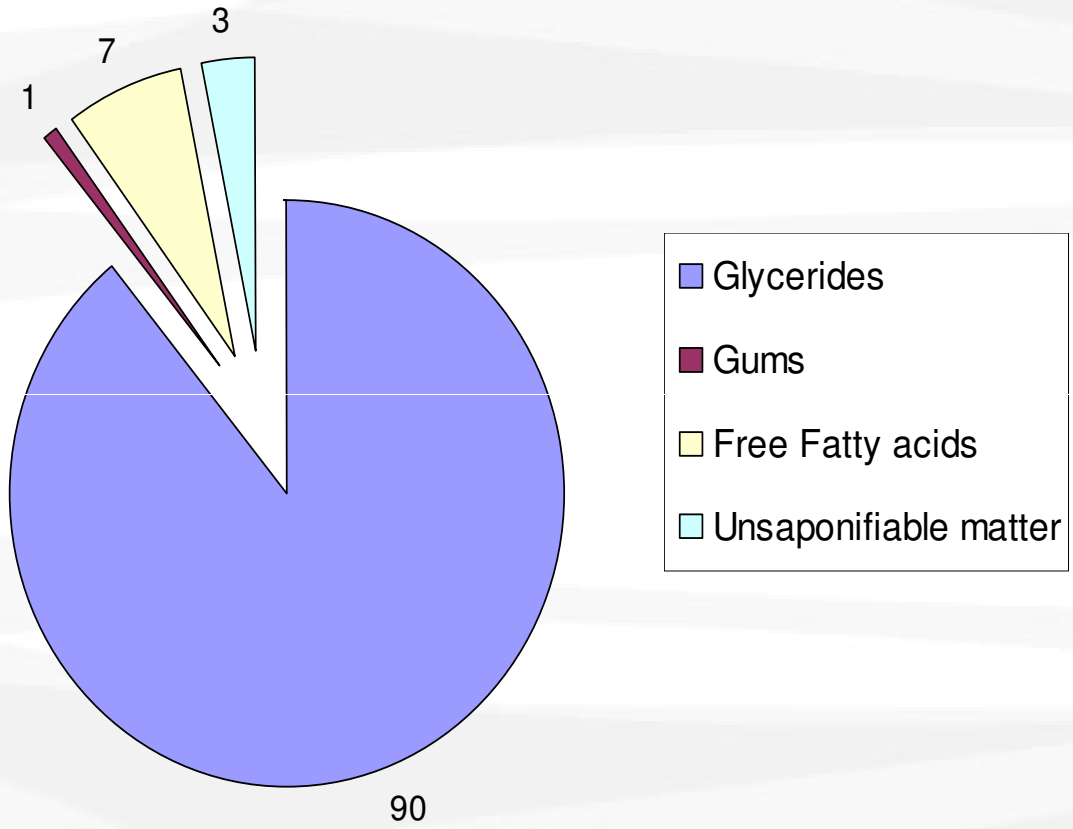
Karanja (Pongamia Pinnata)

Jatropha Curccus

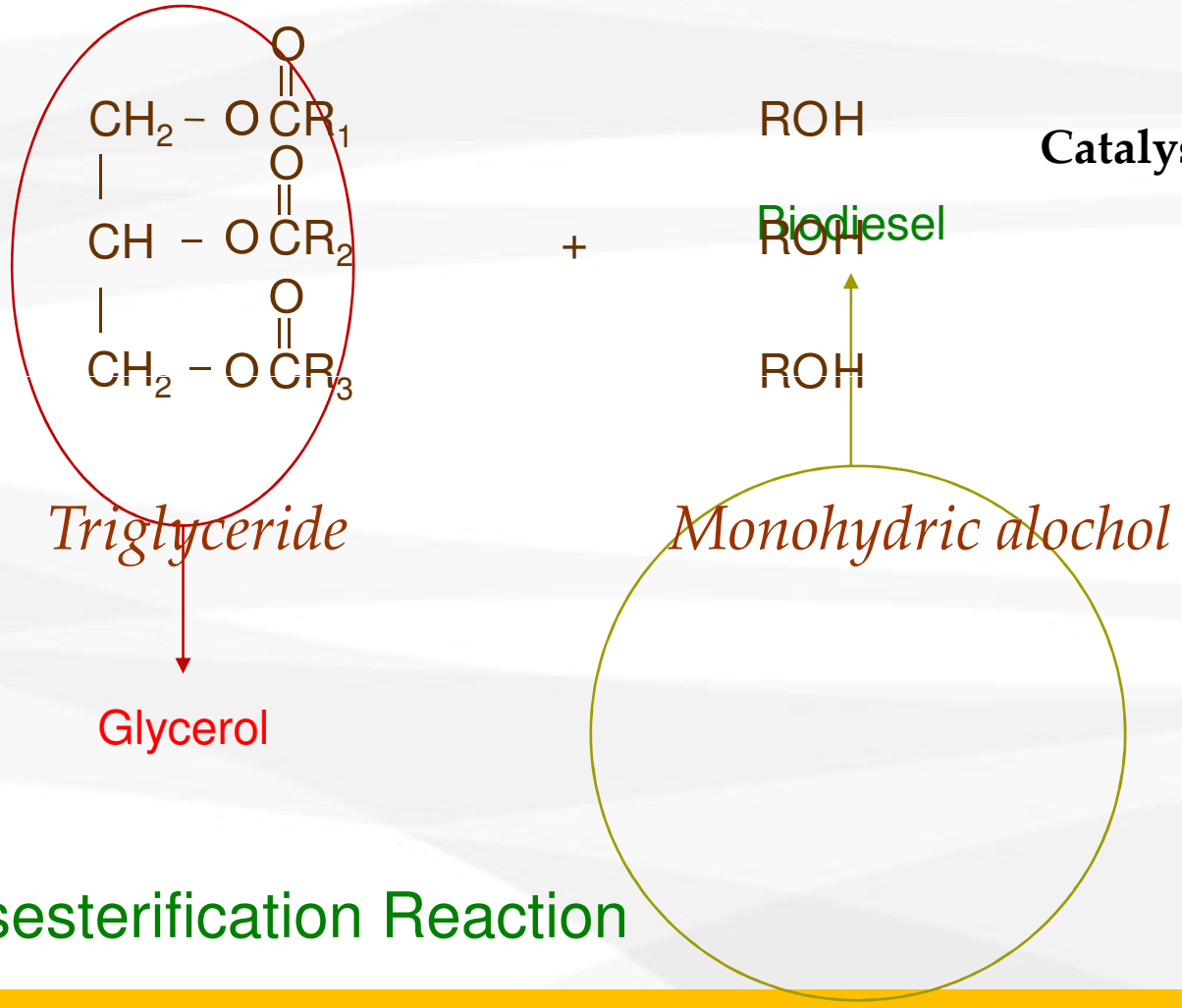
Mahua

Oil Extraction Process

Components of vegetable oil



Making Biodiesel



Transesterification Reaction

Biodiesel- Challenges

- Feedstock (Food Vs Fuel Issue in case of edible oils)
  - 85% contribution to the cost of biodiesel

Look for new, economical feedstock for biodiesel

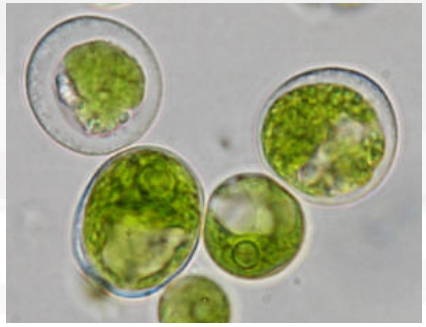
- Utilization of crude glycerol

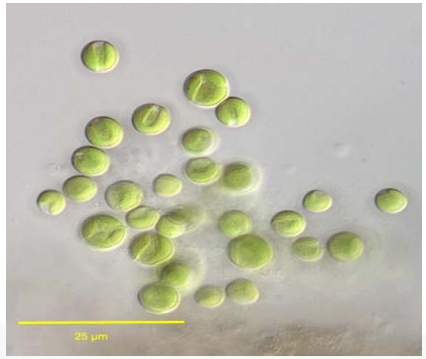
Generate Value added products from Glycerol

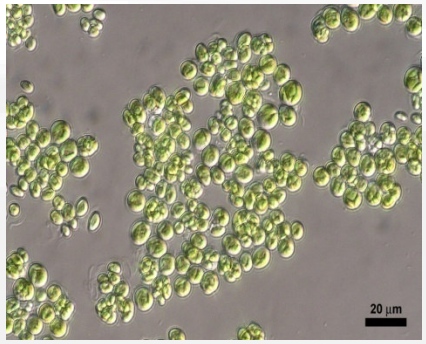
New Sources of Vegetable Oils

Algae

- Algae are "plant-like" organism
- Photosynthetic group of organism
- Algae are mostly found in aquatic ecosystem
- Algae synthesizes lipids (oils) , starches, and proteins
- Algae can grow under natural and artificial light







Important classes of Algae for oils

- The Diatoms (Bacillariophyceae)
- The green algae (Chlorophyceae)
- The blue-green algae (Cyanophyceae)
- The golden algae (Chrysophyceae)

Algae for Biodiesel

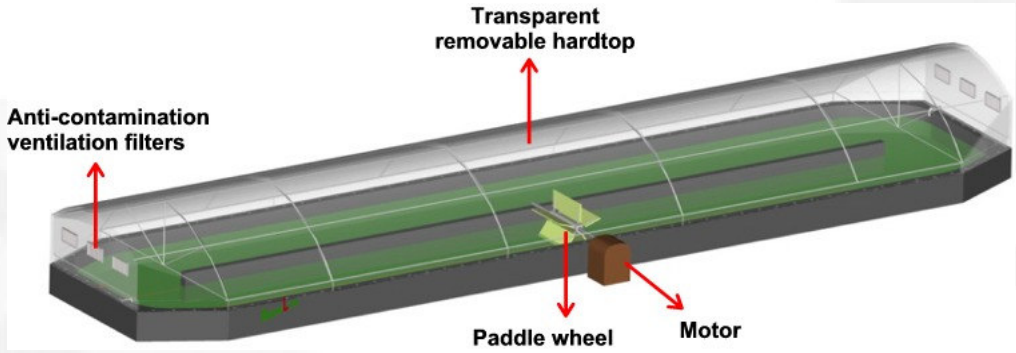
- Can yield average 35% oil by weight
- Can double their numbers in a single day.
- Are much more efficient converters of solar energy than any known plant

Comparison of Oil Yields for Various Crops

Crop	Oil yield (L/ha)	Percent of existing US cropping area
Corn	172	846
Soybean	446	326
Canola	1190	122
Jatropha	1892	77
Coconut	2689	54
Oil Palm	5950	24
Microalgae[c]	58,700	2.5

Source: Biotech Adv:25 (2007) 294-306

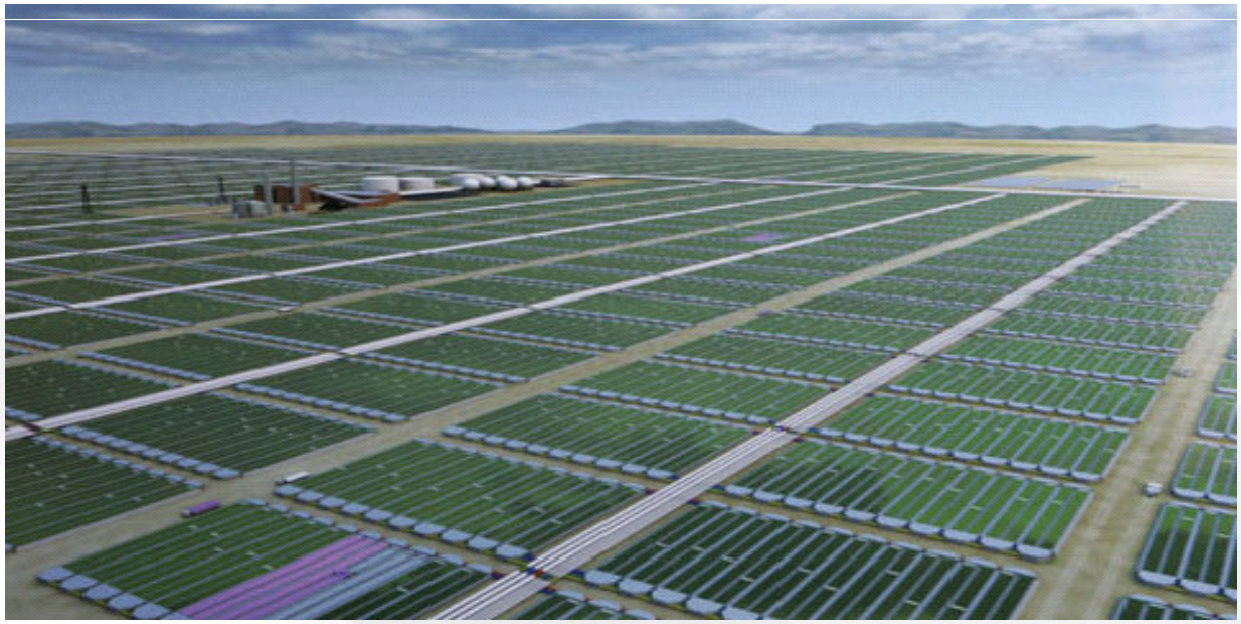
Algal production



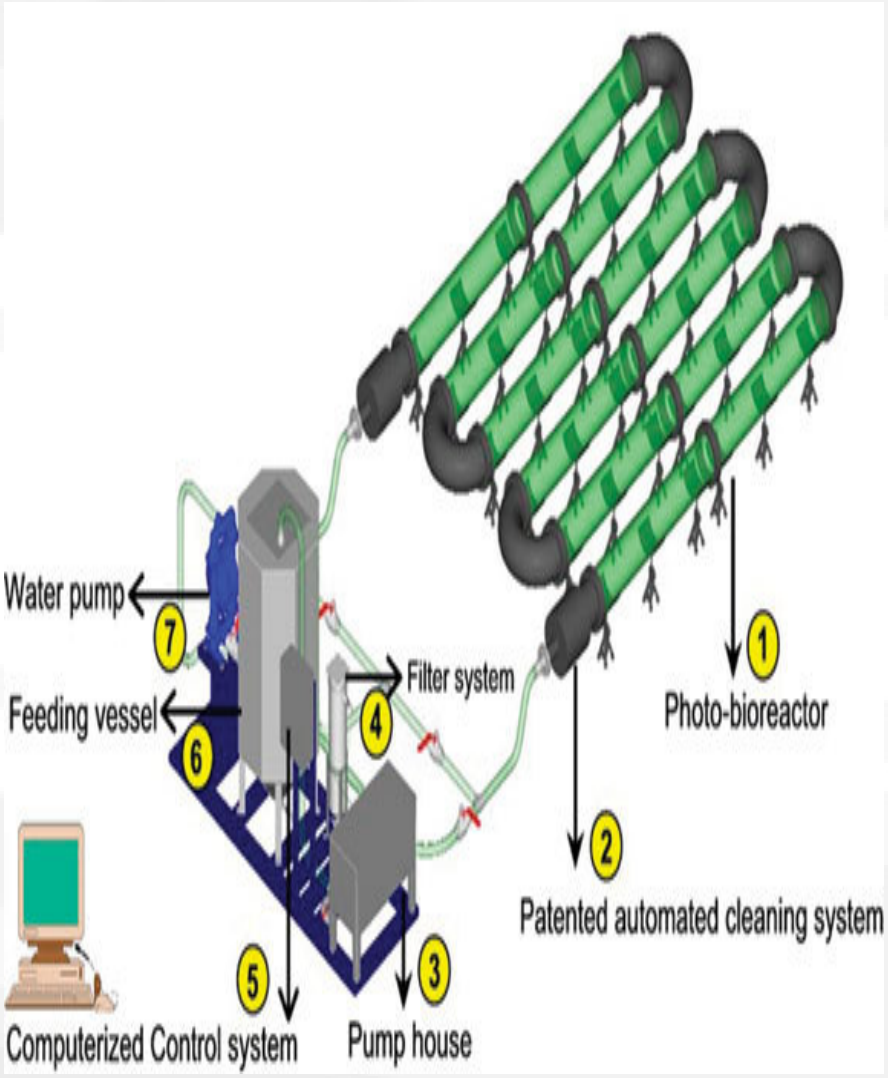
Raceway ponds:

- Algae, water and nutrients circulate around the race track

MOV05592.MPG



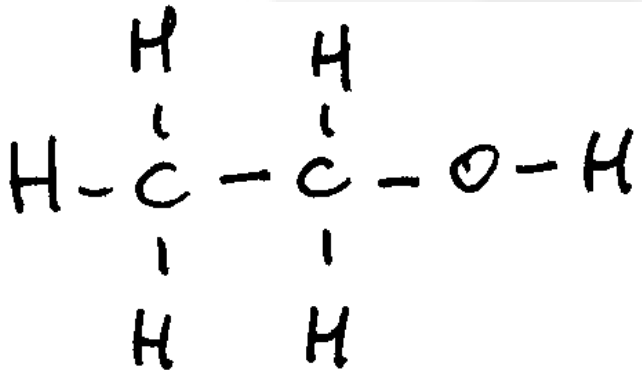
Photobioreactor



Algae - Challenges

- Oil yield in a large scale ponds
- Open pond- Contamination issues
- Economical method for removing algae from water
- Extraction of oil from algae

Ethanol



Use of Ethanol

- Solvent in chemical industry
- Biofuel : As an additive in petrol
- Potable

How to make Ethanol ?

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2CH_3CH_2OH + 2CO_2 + \text{heat}$$

glucose — ethanol — carbon dioxide

1 kg ⟶ 511 g + 489 g + 147 Kcal

Expressed in moles, the equation is as follows:

glucose ⟶ ethanol + carbon dioxide + heat

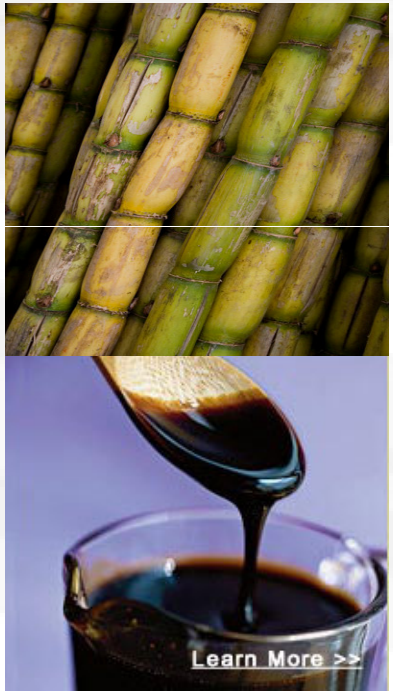
1 mole ⟶ 2 moles + 2 moles

(180 g) (92 g) (88g) (26.4 Kcal)

PRAJ Matrix
the innovation center

Sugar

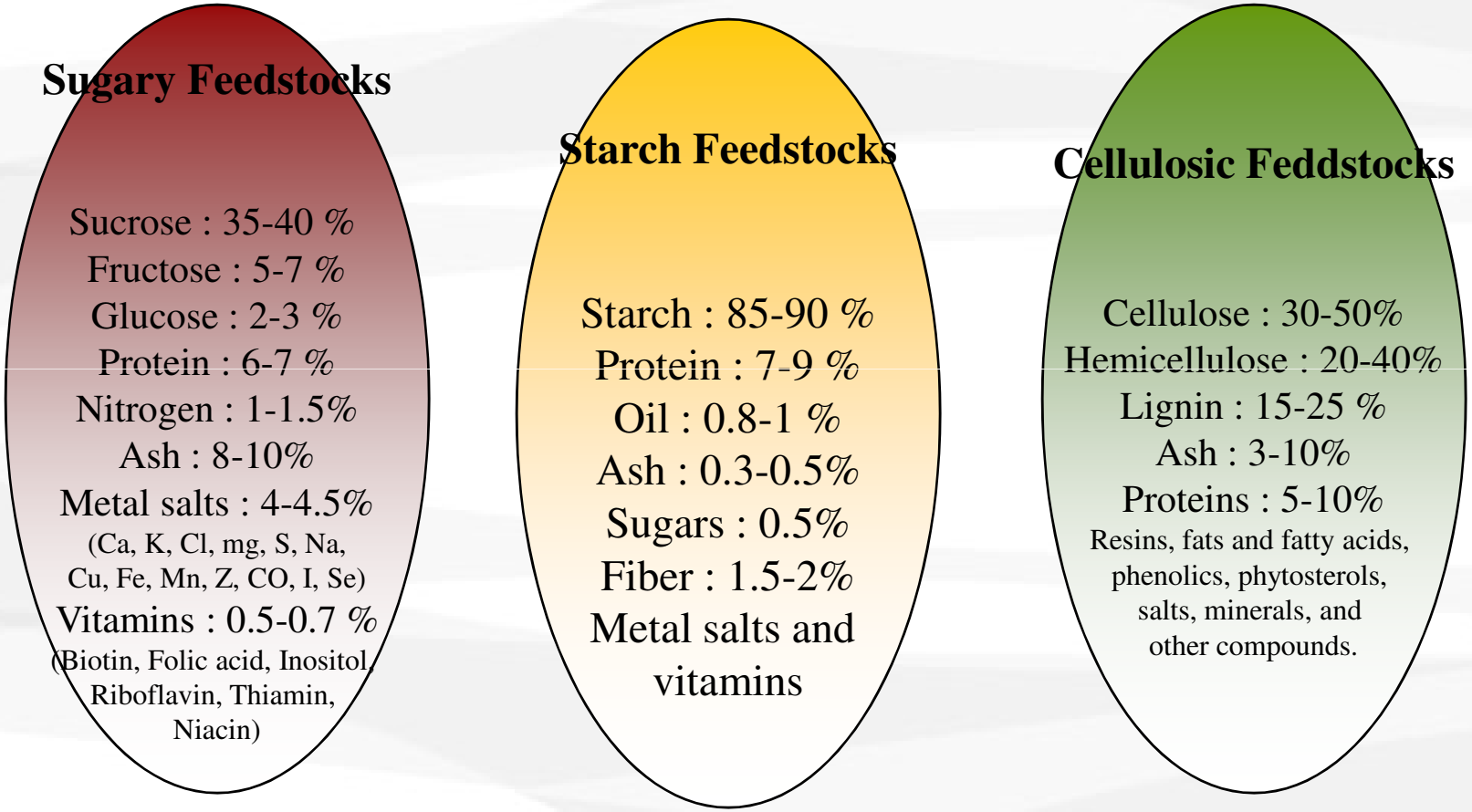
Sugary Feedstocks



Starchy Feedstocks

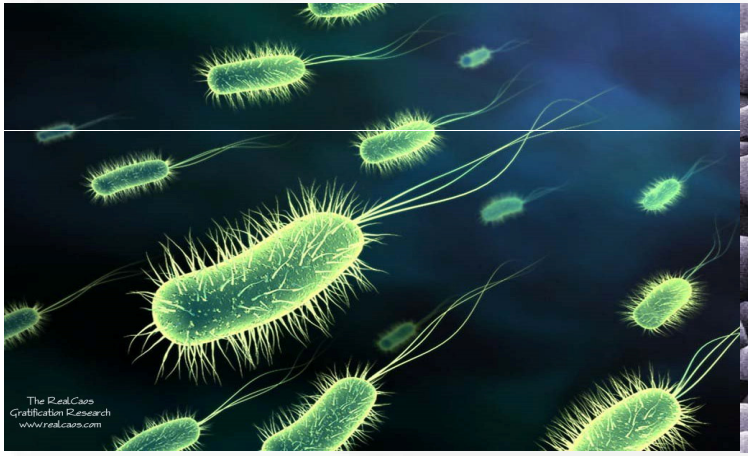
Cellulosic Feedstocks

Chemical Composition of Feedstocks

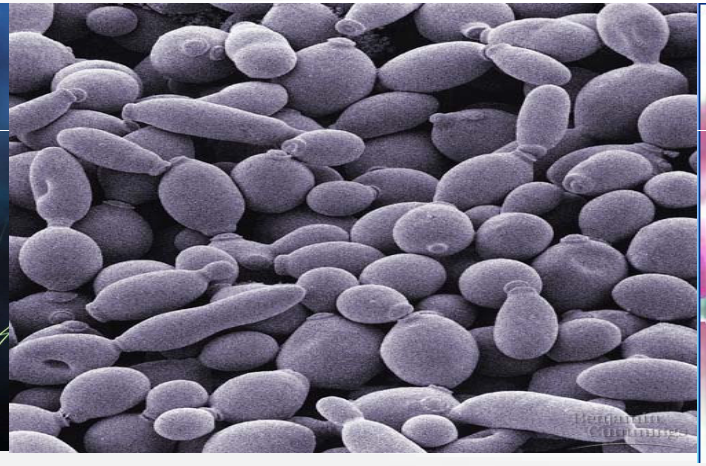


Who can Produce Ethanol ?

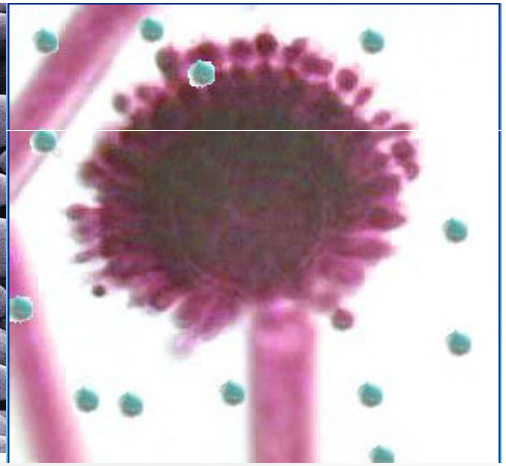
Bacteria



Yeast

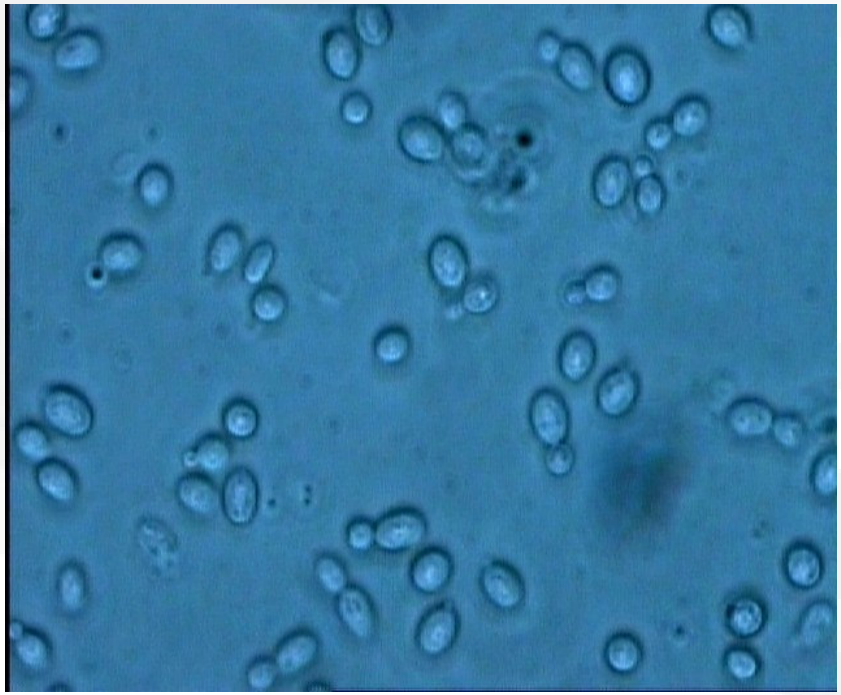


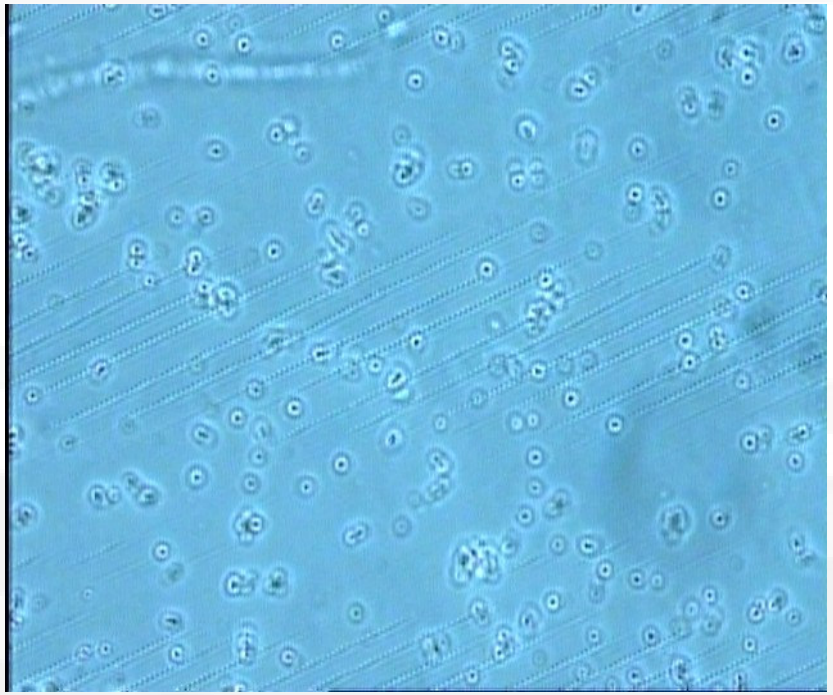
Fungi



Industrially Used Microbes for Ethanol Fermentation

Yeast Film.avi





Why any microbe should produce ethanol ?

High Availability of sugar : Fruit juices, Jaggery, Cereals, Tubers

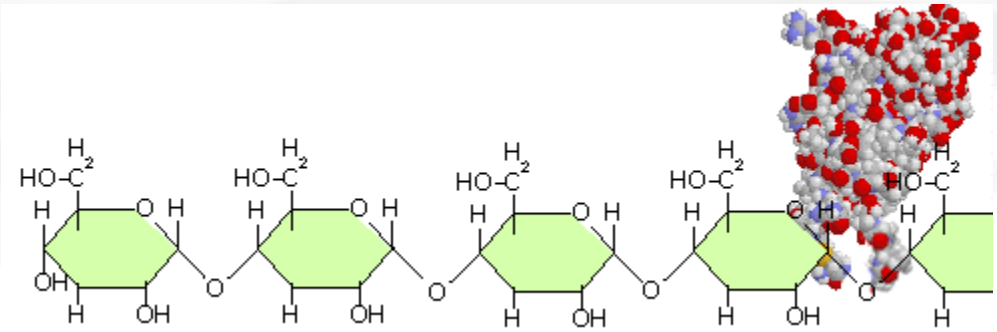
High energy production during ethanol production

Ethanol is exported out of the cell easily

Ethanol is poisonous to other organisms

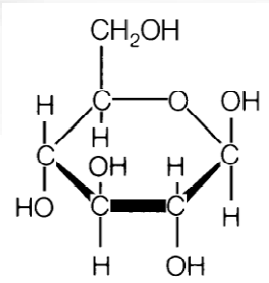
Starch Breakdown

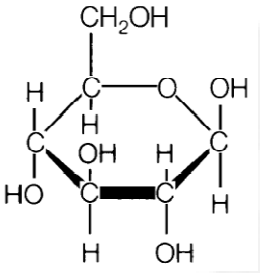
Starch Feed stocks

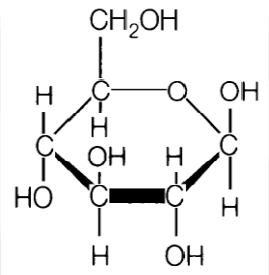


Amylase

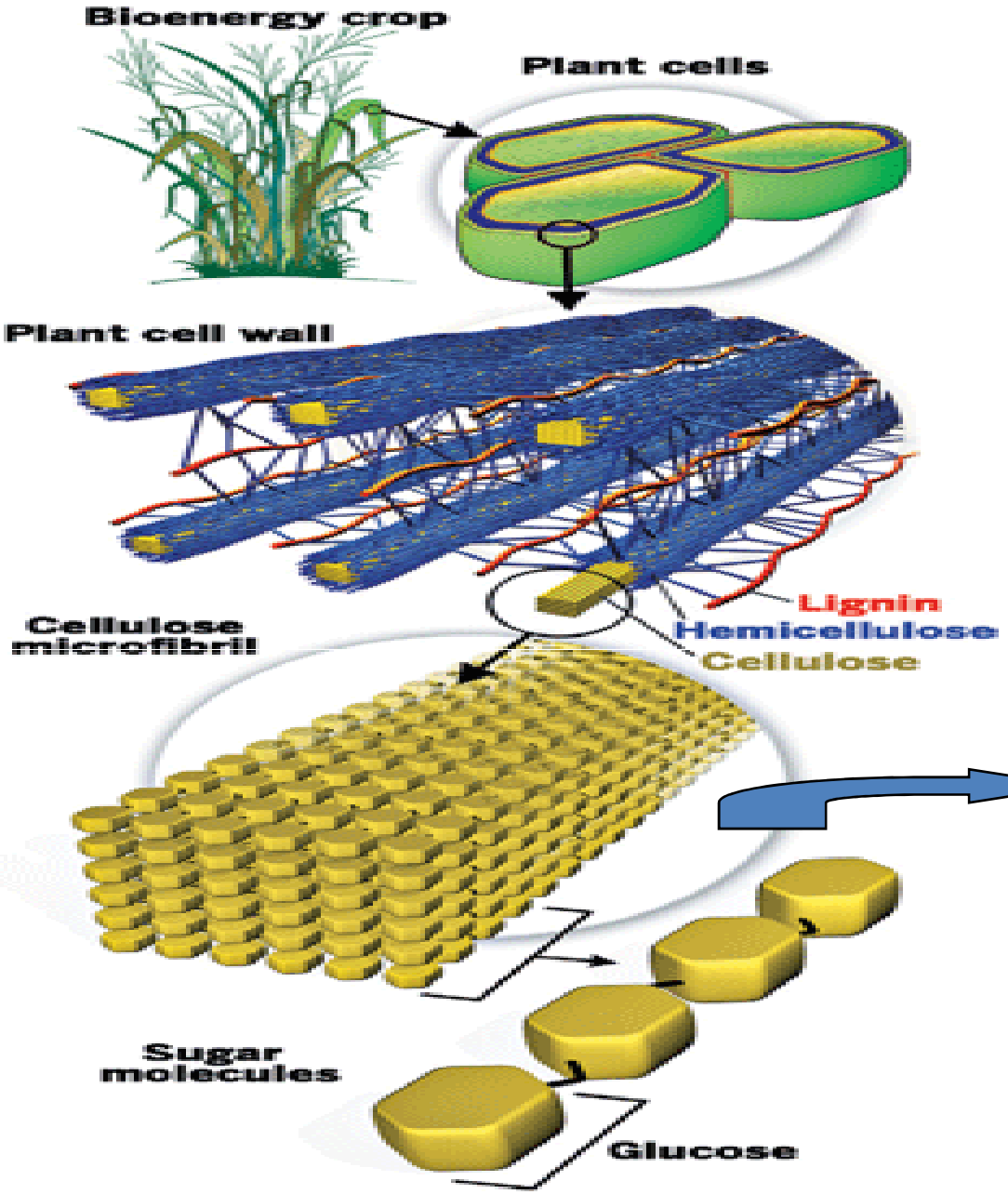
Starch



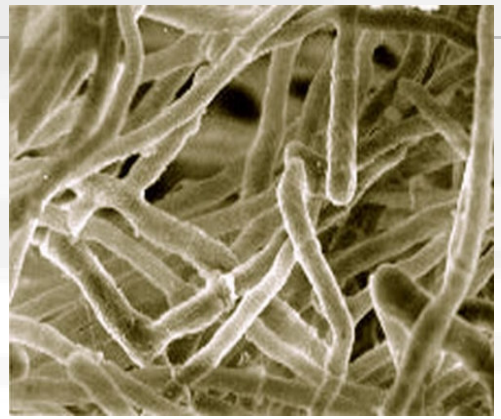




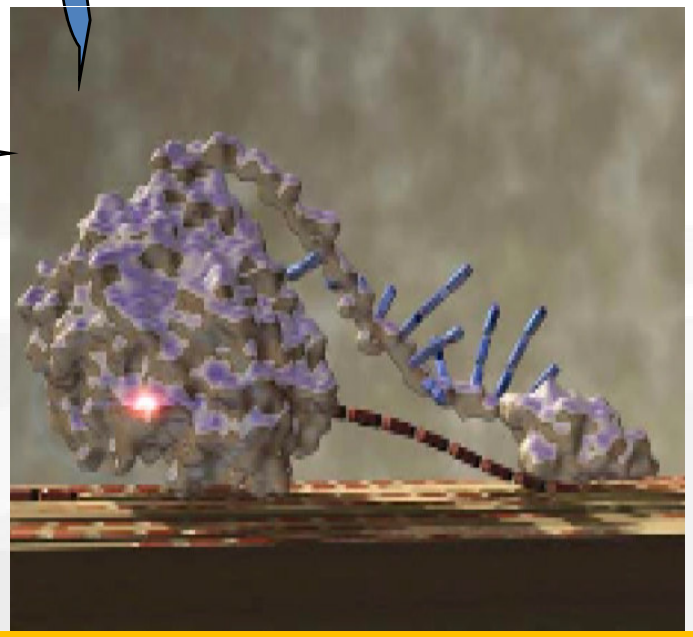
Glucose



Trichoderma reesei



Cellulase Enzyme



Transport

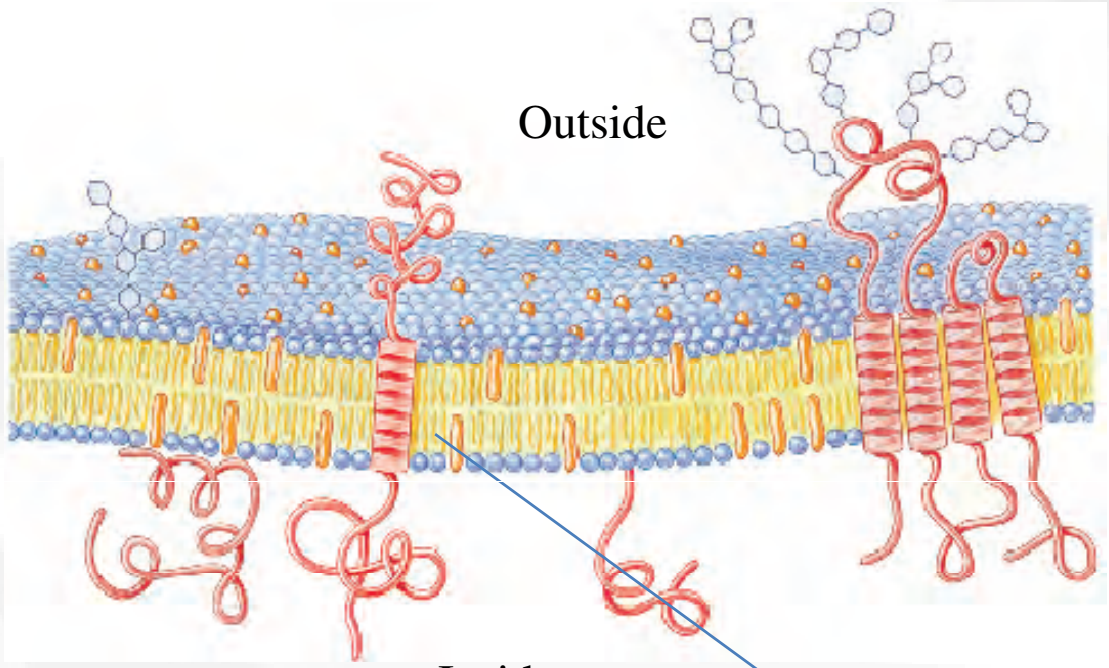
Transport through cell wall

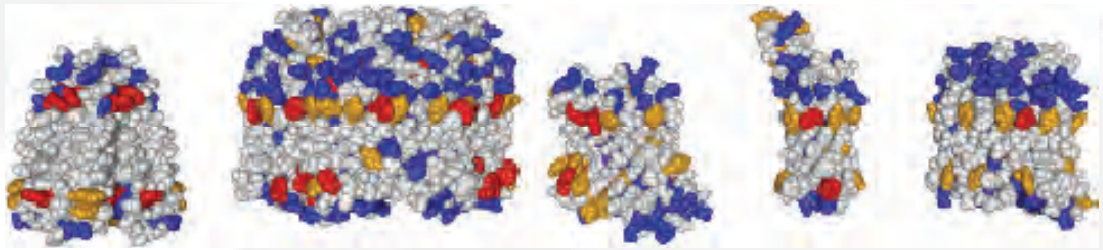
Different receptors for import of different sugars

Different types channels across the wall

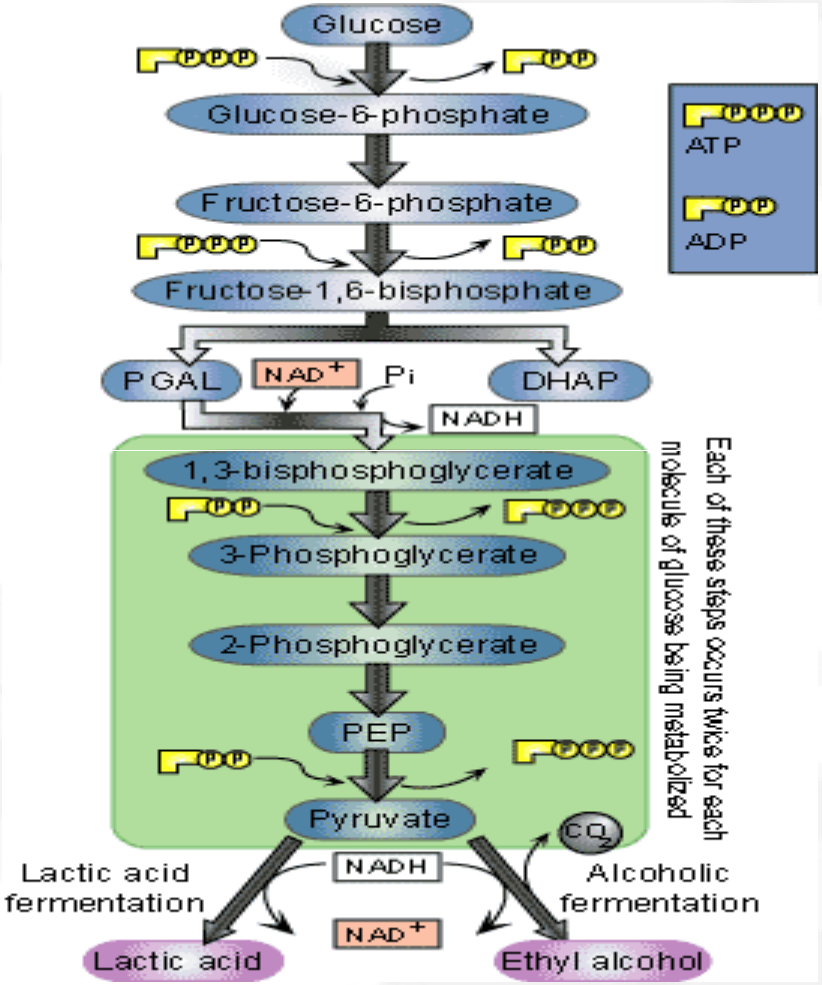
Different types of channels for export of chemicals formed inside the cell

Transport Through Cell Wall

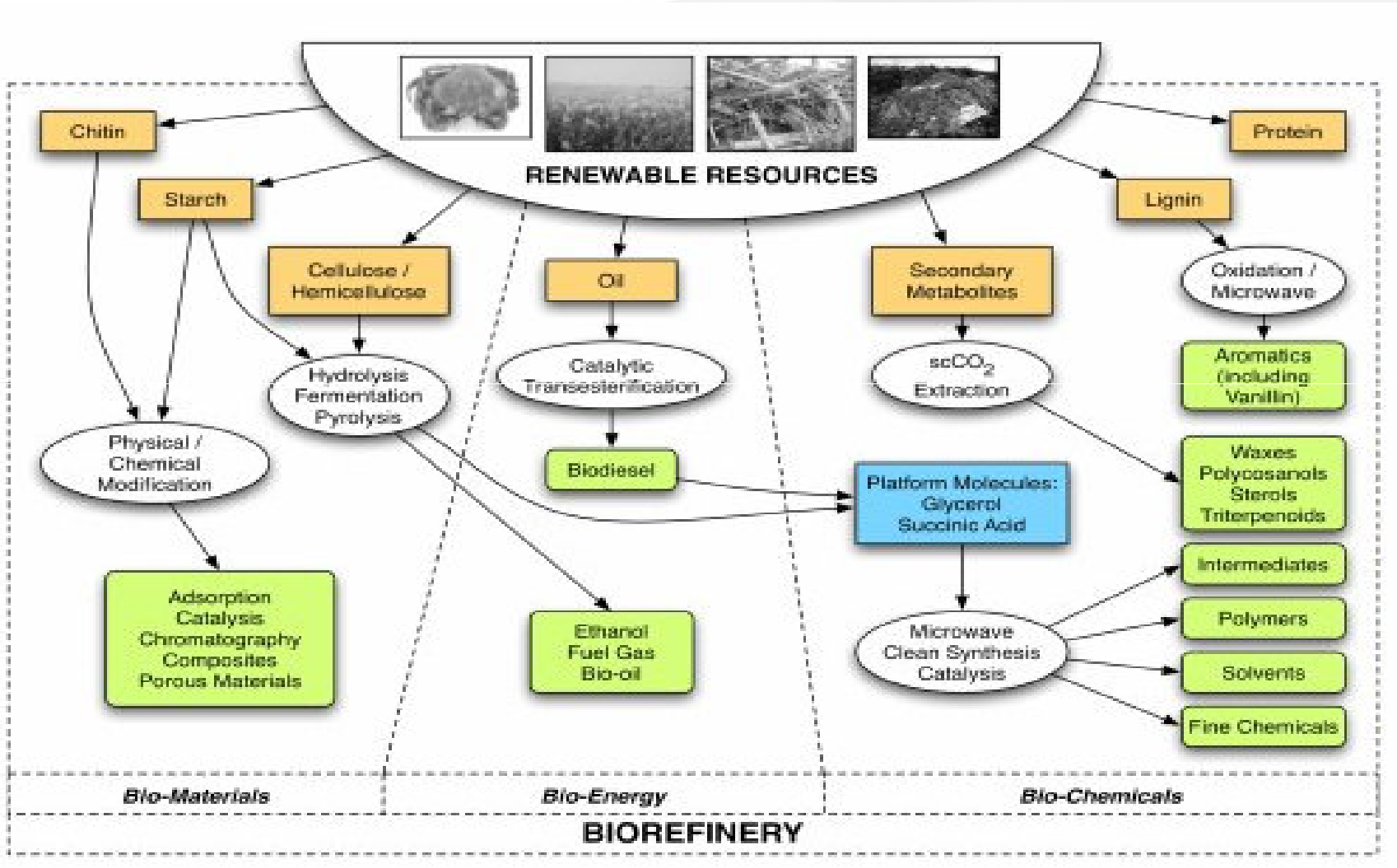




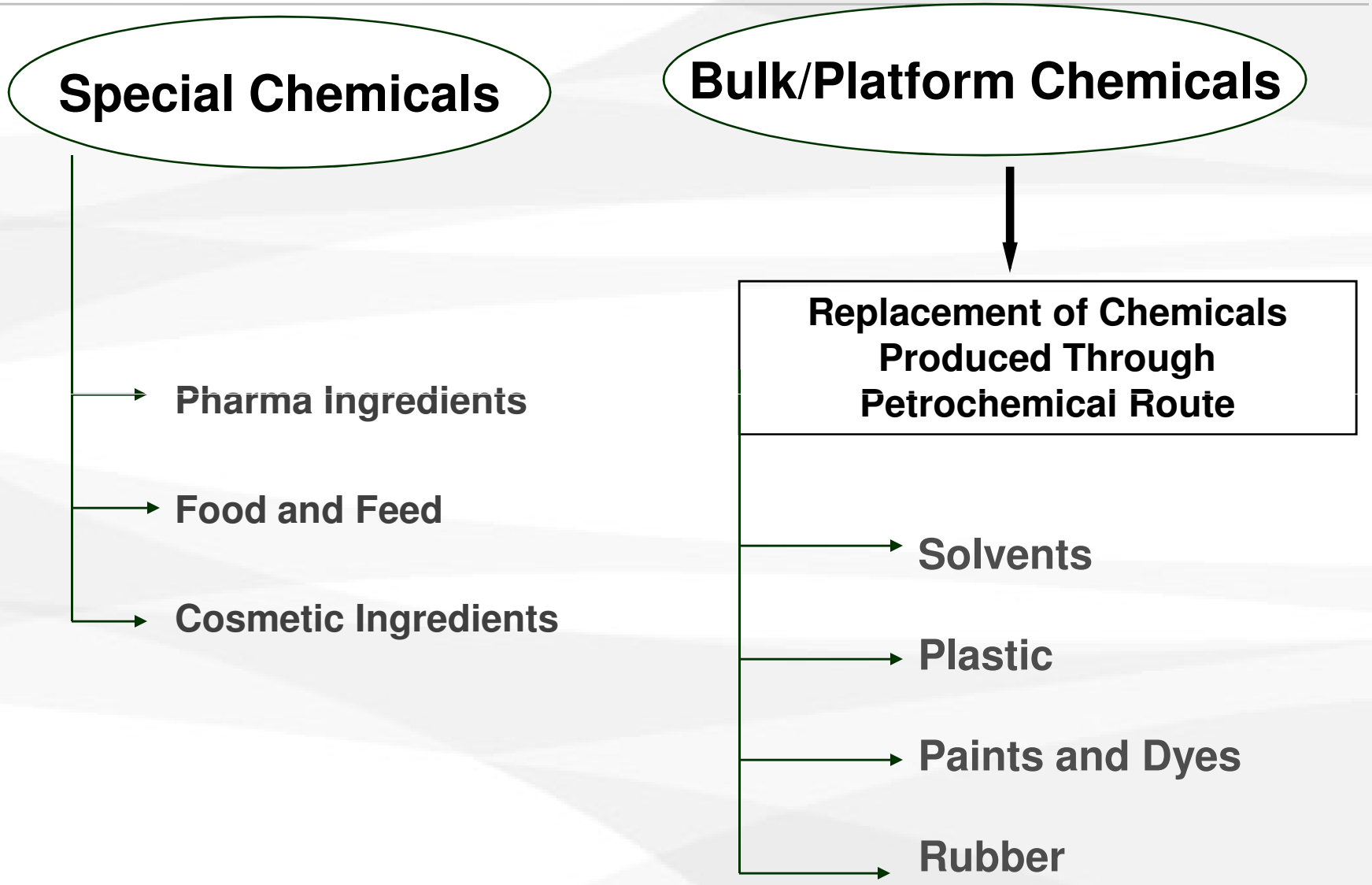
Conversion of Glucose to Ethanol



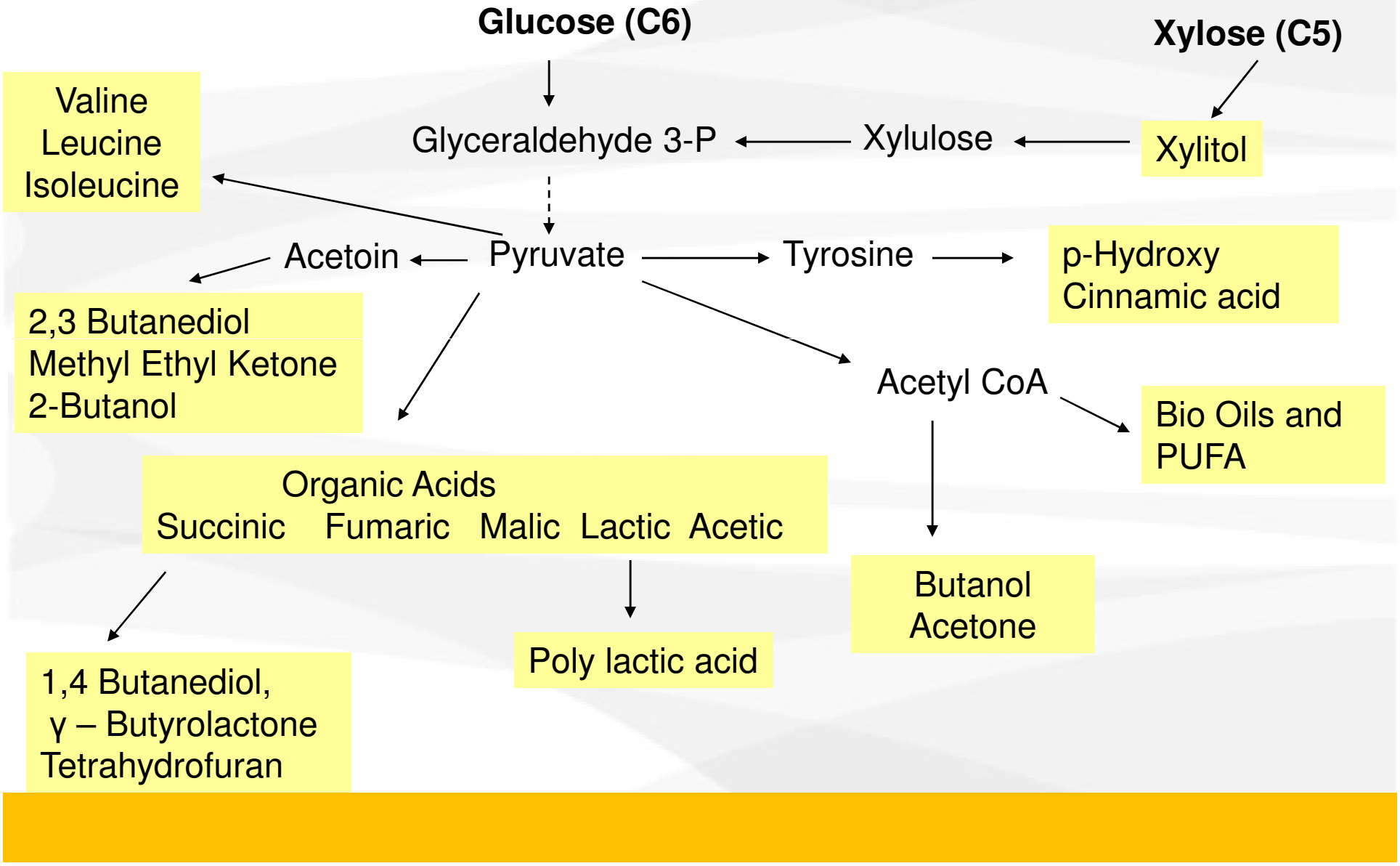
Other Than Ethanol !!!



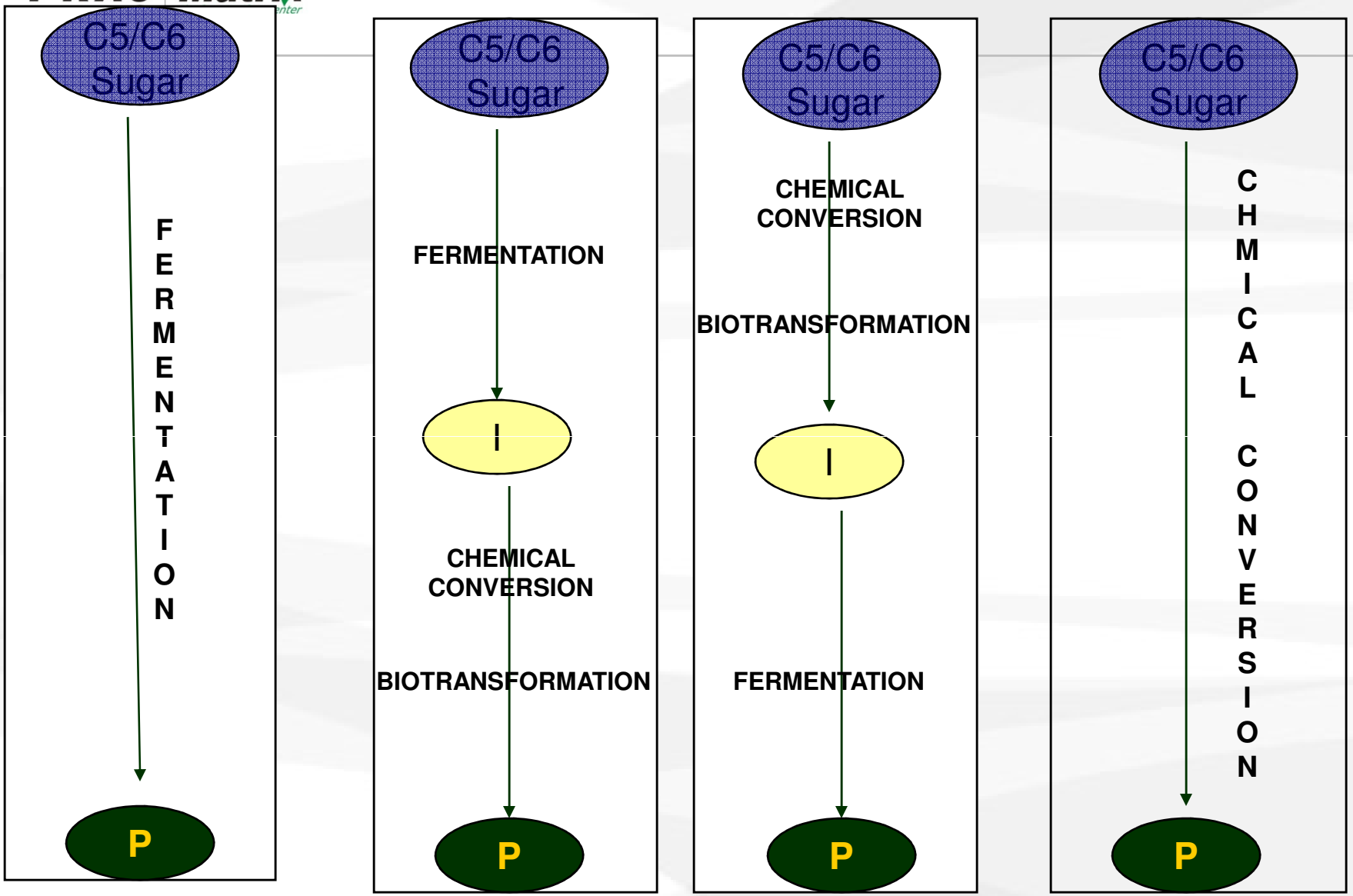
Other Than Ethanol !!!



Other Than Ethanol !!!



Production Routes



Challenges in Ethanol Fermentation

First Generation Technology

Sugary Feedstock :
Dirty Feedstock : Organism can not survive

Starchy Feedstock :
Food Vs Fuel Debate

Availability of feedstock
High water consumption per liter of ethanol
Effluent Disposal

Challenges in Ethanol Fermentation

Second Generation Technology

- Efficient breakdown of feed stock
- Efficient enzymes: Cellulase
- Microorganisms to ferment difficult sugars like xylose and arabinose
- Development of genetically modified organisms which can breakdown cellulose as well as ferment glucose and xylose

Thank You