ALGAL BIOTECHNOLOGY

Technology added utilization of algal strains

Biotechnology and Algae

The term “algae” encompasses a variety of organisms found throughout the world in or near bodies of water. Algae species are estimated to number in the tens of thousands. Though most algae are photosynthetic or autotrophic, some are heterotrophic, deriving energy from the uptake of organic carbon such as cellulosic material

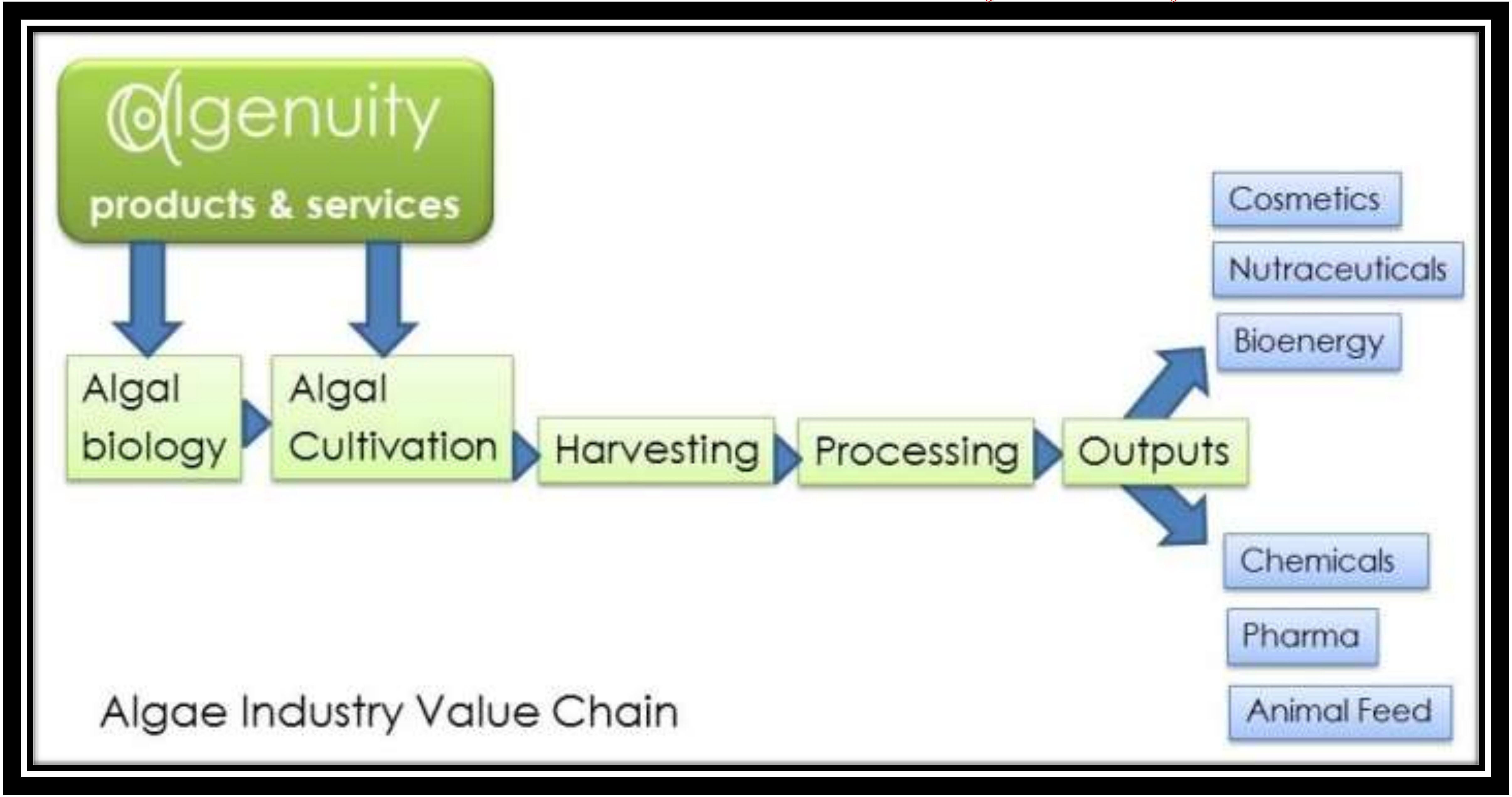
- Because algae are naturally able to replicate rapidly and produce oils, proteins, alcohols, and biomass, they have attracted the attention of researchers and industrial producers seeking alternatives to oil
- Algae thrive on organic carbon or CO_2 and nutrients such as nitrogen and phosphorus. Growth conditions and the availability of sunlight, carbon and nutrients affect the metabolism of algae and whether they produce lipids or carbohydrates
- However, manipulation of nutrients has not proved successful in increasing algal productivity
- Researchers, have found that when algae naturally produce hydrocarbons, molecules that can most readily substitute for today's petroleum uses.

Biotechnology research goals therefore include finding ways to increase the –

- Reproductive rate
- Improve metabolism of inputs
- Enhance the production of desired oils, fuel-grade alcohols, or proteins in useful species

Researchers have found that many algae species are adaptable to genetic engineering, expressing complex proteins and accumulating recombinant proteins to very high levels

UTILIZATION OF ALGAE IN DIFFERENT AREAS



THE BASIS OF ALGAL TRANSGENIC

- **Normally more than just on species generates a desired product or show another trait by of interest.**
- **Therefore careful selection of an appropriate target organism stands at the ginning of every algal transformation project**

1) Genome projects: Algal genome research is needed as the basis for a new level of efficiency & success in the application of biotechnology & gene technology to algae & their products

2) EST Project: Expressed Sequenced Tag(ESTs) in algae

a) **Select marker genes:** The use of selectable marker genes is normally required in all experiment that aim to generate stable transgenic algae

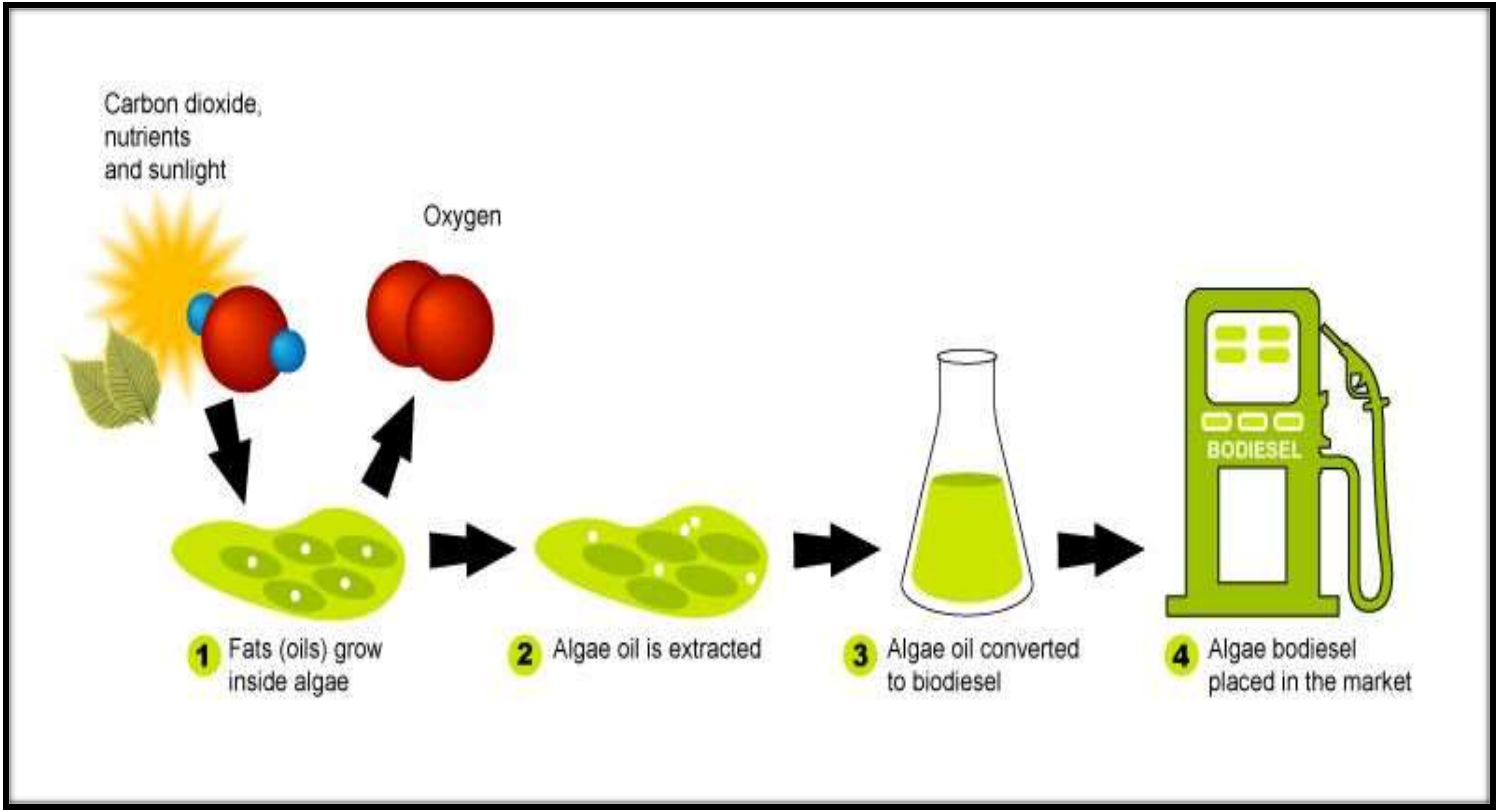
- Selectable marker gene are often antibiotic resistance genes which are dominant marker

b) **Promoters & reporter genes:** Often selectable marker genes cannot be expressed under their own promoters especially.

- There, more suitable that normally strong constitute or inducible & if possible endogenous promoters are necessary for these & other chimeric gene constructs

CURRENT RESEARCH

- Biotechnology is already employed in sequencing and annotating the genomes of algal species
- Genomic data aids researchers in understanding the metabolic processes through which algae convert carbon and nutrients into lipids or carbohydrates
- Greater understanding of algal metabolism and reactions to growth conditions will inform further research
- Genetic engineering techniques currently used in algal biotechnology, including enable algae to more predictably produce desired lipids for biofuels, alcohols, proteins, enzymes and other molecules, or carbohydrate-rich biomass for bioprocessing



Carbon dioxide, nutrients and sunlight
Oxygen
BODIESEL
1 Fats (oils) grow inside algae
2 Algae oil is extracted
3 Algae oil converted to biodiesel
4 Algae bodiesel placed in the market

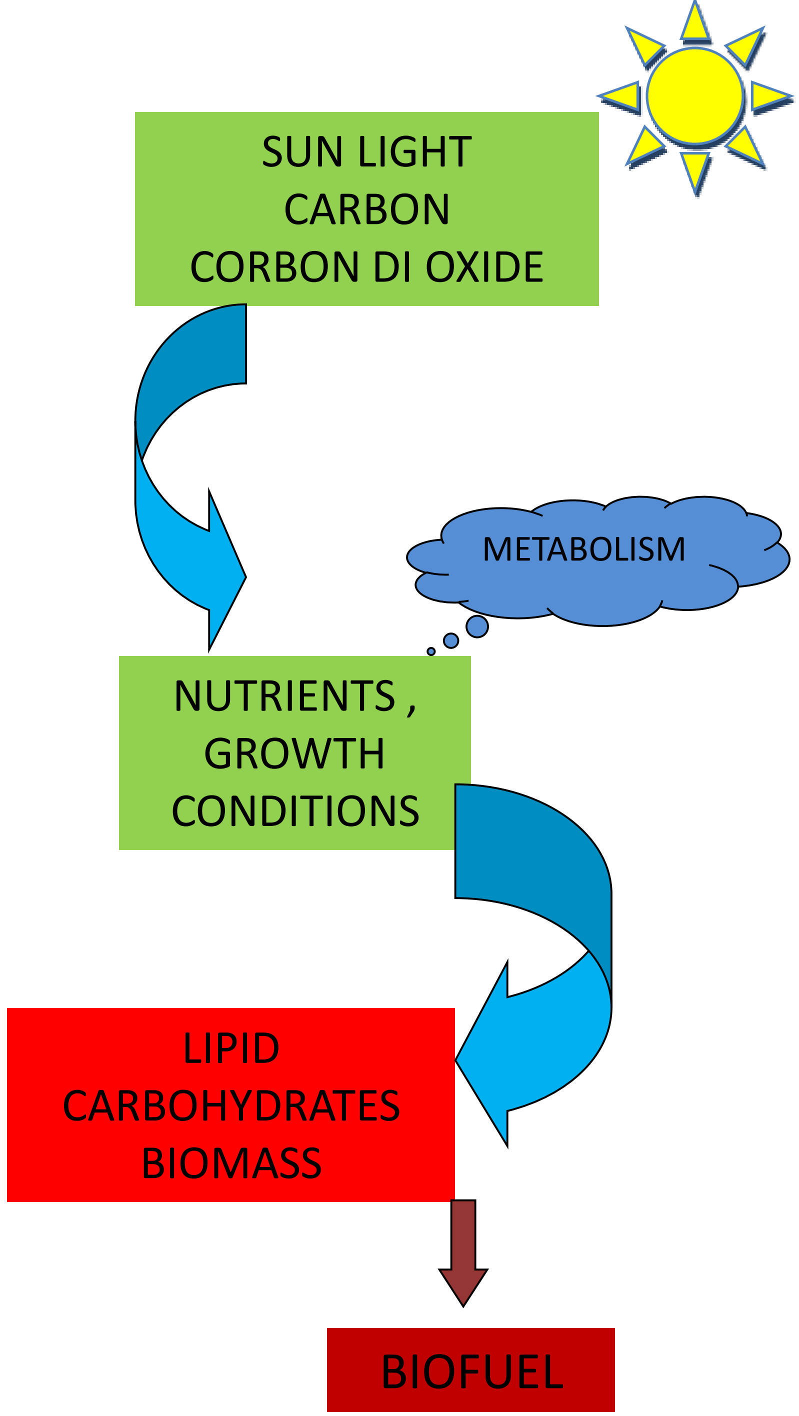
Commercial Development

- Biofuel companies are currently seeking to scale commercial production of algae and are pursuing several engineering approaches – using closed systems and open pond systems – to the design of an economical system for growing algae.
- In closed systems, engineers can precisely regulate algae growth conditions. Closed systems include both photobioreactors for photosynthetic algae strains and traditional bioreactors (enclosed tanks such as those used in fermentation and other microbial growth) for algae strains that feed on sugars

Factors affecting

Open pond systems have been used in many settings, but can be sensitive to various environmental factors

- invasion by other algae strains
- variations in nutrient availability
- heat and light


SUN LIGHT
CARBON
CORBON DI OXIDE
METABOLISM
NUTRIENTS ,
GROWTH
CONDITIONS
LIPID
CARBOHYDRATES
BIOMASS
BIOFUEL

Example Activity

Aquatic species Programme

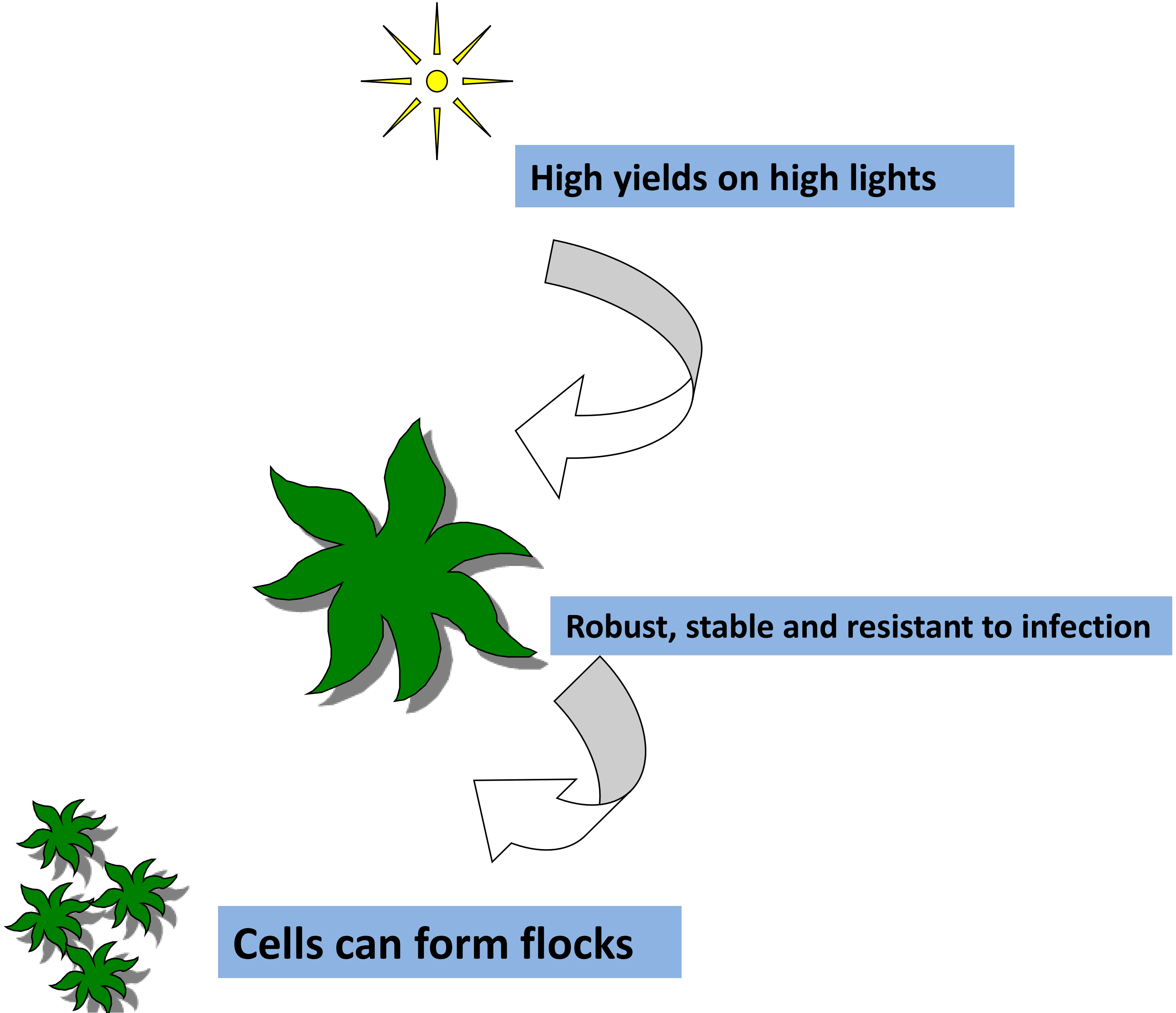
- Primary Goal- Biodiesal from Algae
- Use of CO2 from coal fired powerplants
- Collection of Algae from out door, year round production, Isolation of high efficient CO2 utilization
- Isolation of enzymes and characterization
- Genetic manipulation (First successful genetic manipulation in Diatoms, no increase in oil)

ASP recommended future research

- Put more emphasis on basic research
- Take advantage from plant biotechnology
- Start with what work in the field
- Maximize photosynthetic efficiency
- Look for intermediate technology development opportunities such as waste water treatments

Breakthrough needed

- Who do we grow? Genus/Species
- Best method of cultivation
- Algal harvesting
- ➢ Algal fuel generation and conversion
- ➢ Lipid extraction
- ➢ Biodiesel production
- ➢ Residual utilization (Anaerobic digestion, Animal feed preparation)
- ➢ Utilization of algal fuels


High yields on high lights
Robust, stable and resistant to infection
Cells can form flocks

UTILIZATION OF ALGAE THE PRESENT SITUATION

1. **Algae as food -The algae are eaten in salads as vegetable in soups and in desserts in a number of oriental countries such as ,China, Japan, Britain ,France and USA.**

- **Spirogyra, Ulva is regularly eaten in India and Europe**
- **Mucilage balls of Nostoc are boiled and eaten in Brazil**
- **Porphyra, Laminaria and Alaria are commonly consumed in Korea, Japan, Chile and Scotland**
- **They are rich sources of fatty acid or lipids which are are isolated from Phaeodrclylum , Tricornutum. As a food the nutritional value of Chlorella is very high. It contain protein(50%) carbohydrates(20-30%) fats(20%) vitamins (A,B,C) and minerals**

Previews of Algae Food Development and Recipes

2. Algae in Oil and Gas – The organic compounds derived from dead algae buried in the sediments of oceans, get decomposed to convert into oil and fuel gas by the action of methane producing bacteria

3. In Sewage treatment –

- ***Chlorella* and *Scendesmus* help in grow very well in domestic wastes and convert it into odourless valuable fertilizer**
- **Algae grow in nutrient rich waste water and liberate oxygen for docomposition of organic matter by microorganisms**
- **Some Cyanobactreial species act as remediates for heavy metal pollutants**
- **Composted dried algal biomass is used as poultry feed**

4. Algae in medicine - Algae have been extensively used in the traditional medicines as vermifuges anaesthetics and oilments as well as for the treatment of coughs, hypertension , cancer and a variety of other aliments

- **Laminaria, Codium, Gelidium have high iodine contents**
- **Chlorellin from Chlorella is an antibiotic**
- **The extracts of *Cladophora* and *Lyngbya* possess antiviral and antibacterial properties**
- **Charophytes possess larvicidal properties to destroy mosquito larvae**
- **Some algal species are used in phycotherapy for healing wounds**
- **Agar-agar is used in manufacture of pills and ointments. It is also used as luxatives**
- **Carrageenin act as a blood coagulant and alginic acid used for bleeding control**
- **The extracts of Codium , Digenea have vermifuge effects**


SPIRULINA


BioNutrition
BSF/BSA
MICRO ALGAE
DIETARY SUPPLEMENT
BioNutrition
BSF/BSA
MICRO ALGAE
DIETARY SUPPLEMENT

5. **Algae in Cosmetics - Component of algae are frequently used in cosmetics as thickening agents water binding agents & cosmetics companies claim benefits on the skin or health in general from contents like carrageenam ,other algal polysaccharides algal proteins**


GESICHTS MASKE
BODYLOTION
DUSCHCREME
SHAMPOO
SCHAUMBAD
CREMEPACKUNG
HANDCREME
PEELING
VITAL CREME
Active Creme
HAND CREME

6. Algae in Agriculture

- Chief agent of nitrogen fixation perticularly for rice fields
- Anabaena, Nostoc, Tolipotrix, Aulosira
- Cultivated on mass scale, dried and supplied
- Reclaimation of Usar soil (Alkaline soil)
- Sea weeds are used to add Potassium in soil for vegetable cultivation
- Concentrated liquid extract of some sea weeds are sold as fertilizer and insecticide
- Chara can be encrusted with lime for better binding

7. Algae as Fodder

- Norway, France, Denmark, Newzealand, China and USA use marine algae as fodder
- Fucus, Ascphyllum,Laminaria and Sargassum are processed for cattle, poultry and pigs
- It increases fat in milk and egg yolk

8. Algae In experimental work

- For investigation of photosynthesis – Cholrella, Synchococcus, Anacystis, Spirulina
- Sexual reproduction at cellular and molecular level have been thoroughly understood in Chlamydomonas

9. Diatomite - Diatomite is a commercially significant derivation of diatoms

It is indestructible, siliceous frustules of diatom over a number of years over the sea floors

- Is used as filtration and in several industries as a clearing agent for oils clearing agent in soaps ,tooth pastes and metal polishes for automobiles and silver
- It is also used in the insulation of refrigerators boilers
- As binding agent in hollow tile bricks for constant temperature rooms and sound proof rooms

10. Algae In Industry

1. Aar-agar production
2. Alginic acid and Alginate

- It is a carbohydrate present in middle lamellae and primary walls of the seaweeds
- It is a colloidal substance present in the form of calcium salt as alginate
- It is used as binding and thickening agent in food industry
- Also used in preparation of plastics and artificial fibers

3. Carrageenin

- It is a cell wall mucilaginous polysaccharide obtain from red alga
- It is used in food, textile, pharmaceutical leather and brewing industry

4. Minerals - Source of soda and potash
5. Glue – Funori from red algae

11. Food and feed

- **Algal protein either as a supplement or as an alternative source has received worldwide attention. Some strains of *Anabaena and Nostoc are consumed as human food in Chile*, Mexico, Peru and Philippines. *N. commune with high* amount of fibre and moderate protein is of potential use as a new dietary fibre source and can play an important role**
- ***Spirulina* is used as food supplement because of its excellent nutrient composition and digestibility It has high protein content (60–70%), 20% carbohydrate, 5% lipids, 7% minerals and 6% moisture. It is also a rich source of beta-carotene, thiamine and riboflavin and is one of the richest sources of vitamin B12**
- **It is commercially available in the market in the form of powder, granules or flakes and as tablets and capsules**

12. Fine chemicals

- **A variety of fine chemicals such as pigments, vitamins and enzymes with varied applications can be obtained on a commercially viable scale from cyanobacteria.**
- **A number of cyanobacteria are rich in vitamins and many can excrete them into the surrounding environment**
- **Some marine cyanobacteria are potential source for large scale production of vitamins of commercial interest such as vitamins of the B-complex group and vitamin E**
- **The carotenoids and phycobiliproteins, characteristic of cyanobacteria have high commercial value. They are used as natural food colourants, as food additives to enhance the colour of the flesh of Salmonid fish and to improve the health and fertility of cattle**

- Feed grade Phormidium valderianum is an excellent source of phycocyanin, a blue natural colorant useful as a phycofluor in diagnostics; a technology for its inexpensive production has been transferred to M/S ABL Biotechnologies, Chennai.
- Cyanobacteria being photoautotrophs have the ability to photosynthetically transform simple, labelled compounds such as 14CO2, 13CO2, 33H2O, 15NO3 into complex organic compounds. Isotopically labelled cyanobacterial metabolites such as sugars, lipids and amino acids are commercially available
- Cyanobacteria secrete enzymes that can be exploited commercially. Marine cyanobacteria have been used in large-scale production of enzymes such as beta lactamase, protease and lipase and the technology for beta lactamase has already been transferred to M/S ABL Biotechnologies, Chennai
- Several common and unique sequence-specific endonucleases are known from Anabaena cylindrica (Acy I), Anabaena flos-aquae (Afl I & Afl III), Anabaena variabilis (AvaI & AvaII), Anabaena

- Cyanobacterial isolates with capacity to mineralize organic phosphorus have been reported with alkaline phosphotase activity Enzymes such as chitinase, L-asparaginase, L-glutaminase, amylase, protease, lipase, cellulase, urease and superoxide dismutase have been reported from cyanobacteria
- Photoproduction of ammonia and amino acids by cyanobacteria has also been described Analysis of extracellular growth-promoting substances liberated by *N. muscorum and Hapalosiphon fontinalis* was found to contain amino acids like sereine, arginine, glycine, aspartic acid, threonine, glutamic acid, cystine, proline, valine, ornithine, lysine, histidine and iso-leucine
- In addition, cyanobacteria are a rich source of several polyols, polysaccharides, lipids, fatty acids, halogenated compounds, etc. with varied properties employable as flocculants, surfactants and others

13. Pharmaceuticals

- **Cyanobacteria in general and marine forms in particular are one of the richest sources of known and novel bioactive compounds with wide pharmaceutical applications**
- ***Anti-HIV activity* of marine cyanobacterial compounds from *Lyngbya lagerheimii and Phormidium tenue*. *A* marine cyanobacteria has resulted in recovery of a compound from marine *Oscillatoria laete-virians that shows* anti-candida activity**
- **An immunopotentiating compound with male anti-fertility, without being toxic to other systems in a mice model, was found in the extracts of *Oscillatoria willei***
- **Medically important gamma linolenic acid (GLA) is relatively rich in cyanobacteria namely Spirulina platensis and *Arthrospira sp*. which is easily converted into arachidionic acid in the human body**
- **Prostoglandin E2 has lowering action on blood pressure and the contracting function of smooth muscle and thus plays an important role in lipid metabolism**

14. Biofertilizer

- A variety of cyanobacterial strains colonize rice fields wherein heterocystous species are capable of fixing atmospheric nitrogen
- The use of algae and cyanobacteria in waste treatment is beneficial in different ways since they can bring about oxygenation and mineralization, in addition to serving as food source for aquatic species.
- Treated ossein factory effluent which resulted in reduced calcium and chloride levels and enabled 100% survival and multiplication of *Tilapia fish* with only cyanobacteria as feed source