Preface and Editorial Plan

There is a strong correlation between per capita energy consumption and standard of living as envisaged by per capita gross domestic production (GDP). As a result, global energy consumption is going up rapidly. Over the past century, a majority of chemical and energy needs of our industrial society has been met by fossilized carbon sources (coal, crude oil, natural gas). Increasingly, there is a realization that utilization of the fossilized carbon sources has adverse environmental consequences in the form of increasing concentration of greenhouse gases. We are also becoming aware of the limited nature of these resources. As a result, considerable efforts are being made to produce chemicals and fuels from renewable carbon resources.

The renewable carbon is basically produced in two systems—terrestrial and aquatic. Both of these capture solar energy and atmospheric carbon dioxide as a part of natural carbon cycle. The production of terrestrial biomass is highly developed and it is an important component of our food chain. Significant amounts of terrestrial biomass such as forest products, agricultural residues, and plant products can be, and are being, made available for transformation into fuels and chemicals. The amounts of terrestrial biomass that can be spared for these activities are large yet limited and these can support only a fraction of renewable carbon needs. Aquatic biomass production, on the other hand, is less developed but it has a huge potential for delivering renewable carbon. Serious efforts are, therefore, underway targeting cultivation of photosynthetic autotrophic microbes for the production of biomass and lipids. In this category, algae appears to offer the most potential for capturing solar energy and atmospheric carbon dioxide, and delivering sufficient quantities of biomass/lipids that can offset the fossilized carbon utilization in a meaningful manner without impacting food supplies adversely. But several advances both technologically as well policy-wise are needed before algae can realize its full potential. It is also clear that a biorefinery approach must be undertaken in order to get renewable energy and chemicals from algae economically.

In a refinery, multiple products are produced to take advantage of all the components in the raw materials thus making economic production feasible. This allows one to take advantage also of market shifts, seasonal or otherwise. A classic example of a biorefinery is the wetting milling of corn where seasonal variations of market demands is accommodated by producing shifting production between corn ethanol and high fructose corn syrup, while producing corn oil, gluten, corn steep liquor, corn protein hydrolyzate, etc. A successful biorefinery operation requires not only a set of efficient and productive processing technologies, it also requires an effective system of collection and transportation of raw materials, economic analysis of integrated systems to establish the optimal plant sizes based on local conditions, public education, and favorable policy environment.

Microalgae have been explored as sources of fuels and chemicals for the past forty years. Because of the very large scale of demands of fuels and chemicals, the production systems being sought are those that can be easily scaled-up and those that result in very large scale production of biomass. Different algal platforms (photoautotrophic vs. heterotrophic, even mixotrophic, oleaginous vs. starch producers) are being considered. Similarly, production reactors ranging from outdoor open raceways utilizing natural sunlight to indoor photobioreactors with artificial lights are being investigated. In this volume, several different aspects of algal production systems are reviewed. These provide a background of the state of the art that can form a basis for discussing the advances relating to the algal platforms for production of fuels and chemicals in multi-authored multi-volume edited-series which will document new advances involving algae-based technology. The following topics are planned to be covered in the subsequent volumes on Algal Biorefineries:

- Algal selection and metabolism
  - Classical selection methods with aim to produce useful products
  - Metabolic engineering to improve photosynthetic efficiency and carbon dioxide capture
  - Metabolic engineering to direct carbon flow to carbohydrates or to lipids
  - Genetic approaches of monitoring cultures in open bioreactors
- Cultivation of algae and algal substrates
  - Algal strains—sources, characterization, selection, preservation
  - Nutritional and environmental requirements
  - Closed bioreactors—photosynthetic efficiency, volumetric yields and products formed
  - Open bioreactors—volumetric and surface area productivity, stability of operation, start-up issues, strategies for monoculture operation, contamination control, seasonal effects on composition of algae
  - Cultivation in cold climates
  - Heterotrophic and mixotrophic cultivation of algae
  - Carbon dioxide delivery and pH control
  - Light attenuation and shading effects in bioreactors
  - Temperature control in algal bioreactors
  - Concentration, harvesting and processing of cells
  - Ecological control of contamination in open bioreactors
  - Strategies of cultivation

- Products from algae
  - Algal lipids and their uses
  - Carbohydrates from algae and their utilization
  - Extraction of lipids and carbohydrates from algae
  - Algal cake utilization
  - High value products from algae and their fractionation
- Environmental and social issues in algal biorefineries
  - Water needs, conservation, and reutilization
  - Solvents used in extraction and air quality
  - Land quality and use
  - Impact of local and migratory birds
- Process improvement and economics
  - Process optimization and increase of efficiency
  - Systems simulation of multiproduct batch/continuous facility
  - Systems analysis (systems biology models of algae metabolism and their exploration at optimization)
  - Life-cycle assessment
  - Costing and economic analysis

The following volumes may include other biomass resources, such as short rotation forestry (willow, poplar, eucalyptus), wood wastes (forest residues, sawmill and construction/industrial residues, etc.), sugar crops (sugar beet, sweet sorghum, jerusalem artichoke), starch crops (maize, wheat), herbaceous lignocellulosic crops (miscanthus), oil crops (rapeseed, sunflower), agricultural wastes (straw, slurry), municipal solid waste and refuse, and industrial wastes (residues from the food industry). It will also discuss other processing technologies such as pretreatments (physical/chemical/microbial and enzyme) and other conversion technologies: Fermentation of Sugar/Starch Crops, Fermentation of Lignocellulosic Biomass, Transesterification of Triglycerides, Gasification: Formation of Syngas, Fast Pyrolysis, Fischer-Tropsch Synthesis, Hydrogenation, Conversion of Syngas to Methane and Anaerobic Digestion.

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Finally, we invite contributions from different researchers to this Series.

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