

# ALGAE CENTER OF EXCELLENCE

JUNE 2020



**ALGAE FOR  
FOOD + FEED**  
THE GLOBAL INITIATIVE



# THE FUTURE OF ALGAE

Algae have been used by humans for a variety of purposes for thousands of years. Algae are currently used as a material and ingredient in many existing products today, including food, feed, cosmetics, and skin care, nutritional supplements, fertilizers, soil amendments, textiles, plastics, and biofuels. Despite the many uses, algae have yet to reach their full potential. Research and development (R&D), multidiscipline collaboration, and production scale demonstration must continue to occur for algae products to be competitive with existing global markets. Algae have ultra-high productivity and the potential to act as a carbon sink. Production of algal biomass can have low environmental impacts by reducing the use of potable water, arable land, and energy. A summary report from Center for Climate and Energy Solutions found that algae products, both in the food, feed, fuel, and chemical sector, could reach a potential market size of \$320 billion by the year 2030<sup>1</sup>. From a greenhouse gas perspective, by 2030, these industries could help mitigate 3.2 billion metric tons of CO<sub>2</sub> into the atmosphere. In addition, algae and algae bioproducts are also utilized to help restore ecosystems through removal of harmful blooms and contaminated waters as well as wastewater treatment. It is clear there are tremendous opportunities to not only valorize current algae products, but to invest in R&D for new breakthrough products as well as soil and water restoration applications. The US is currently a global leader in algae R&D, and the opportunity to create the next generation of new, innovative, and sustainable products is in America's heartland - spurring job creation as part of the new bioeconomy. The first step toward achieving this potential begins with the proposed Algae Center of Excellence (ACE).

The Agriculture Improvement Act of 2018 (Farm Bill) included in its 'High-Priority Research and Extension Initiatives' an Algae Agriculture Research Program to address challenges in farm-scale algae production and support development of algae-based agriculture solutions. The Farm Bill envisions a new Algae Center of Excellence, using academic and industry excellence across the nation to focus on R&D and commercialization of innovative and sustainable production of food, feeds, energy, materials, biofertilizer, wastewater treatment, carbon capture and use, and other applications. In the private sector, businesses and organizations are looking toward technologies that are more sustainable and will help meet the demand as the global population increases. It is clear that algae will be a critical industry in the next generation of innovation in the United States.

## PARTNER WITH US

The steering committee for the Algae Center of Excellence is currently seeking partners to help launch the center. Partners would be individuals or organizations that understand the global need to:

- Develop new sustainable products
- Sustainably increase our food and feed supply
- Combat environmental destruction

Partners are motivated to grow the US based algae industry so that it can meet these needs and expand the US bioeconomy.

<sup>1</sup> Bobeck et. al., "Carbon utilization – a vital and effective pathway for decarbonization." Summary Report. Center for Climate and Energy Solutions, August 2019.



## MISSION OF THE ALGAE CENTER OF EXCELLENCE

The mission of the ACE is to support the development, scale up and commercialization of innovative, sustainable and eco-restorative solutions for the production of food, feed, and bioproducts from algae.

This ACE will engage academic, National Lab, and industry communities across diverse fields of biology, agronomy, chemistry, engineering, nutrition, and economics. A primary objective of ACE is to facilitate the interactions of this diverse set of scientific and business disciplines to tackle the significant research objectives and commercial deployment challenges that cannot be addressed by any one discipline alone. Algae offer enormous potential for the sustainable production of food, feed, and biomaterials, and one that complements traditional agriculture – algae production has low environmental impact reducing the use of potable water, arable land, and fossil-based energy. Algae and algae bioproducts are also utilized to help restore ecosystems through removal of harmful blooms and contaminated waters as well as wastewater treatment. However, algae strains lack the centuries of domestication and industrialization that terrestrial crops have had.

The Algae Center of Excellence will help facilitate the rapid commercialization of algae, addressing the most important applied research topics, as well as commercial scale-up challenges, while training a workforce essential for global growth in this new industry and providing economic development in rural communities. The Center will also facilitate the transfer of technology from research to commercial deployment, by including commercial algae producers in all aspects of the Center, including leadership.

## PROPOSED STRUCTURE OF ACE

The ACE is envisioned as a “distributed” center, with facilities and labs spread throughout the country – including universities, government laboratories and private companies – all working in close collaboration, coordinated by the ACE leadership team. Having distributed collaborative research at the interface of algal biology and ecology, biochemistry, chemical engineering, food science, animal health, soil health, and economics, will allow for more rapid commercialization and development of solutions; taking advantage of existing expertise and infrastructure found throughout the country. The approaches described here will require integrative research across multiple research institutions interacting closely with industry to identify and address the most critical challenges facing algae commercialization. The impact of a single national collaborative center integrating these capabilities would be unique and would powerfully leverage our previous national, state, and regional investments into this emerging field. The ACE already has participating members from these sectors that are committed and enthusiastic about such a joint effort to shape this growing industry and are committed to interfacing with government agencies to make sure the work is complementary to ongoing government-sponsored R&D efforts. The Center will act as a catalyst to accelerate the commercial deployment of algae to meet our future food, feed and other needs. ACE will focus the efforts of a diverse community to ensure that this interdisciplinary approach results in major benefits for the nation while training a new generation of scientists, engineers and entrepreneurs in algae science and commerce.





# ACE DEMONSTRATIONS OF SUCCESS

- Through strategic allocation of funds to critical research and development, ACE will reduce the overall algae production cost for food, feed and associated bioproducts. The ultimate goal is to achieve competitive production costs, for algae food, feed, and bioproducts.
- ACE will facilitate the introduction of multiple algae derived bioproducts to the market, boosting regional and national economies and generating new jobs in rural areas.
- ACE will provide access to equipment, expertise, and testing that will help companies accelerate scale production.
- ACE will accelerate the launch of a modern crop to the global market – a crop that is sustainable, does not compete with existing crops, and uses minimal natural resources.
- ACE will document life-cycle and economic benefits of algae production for food, feed, and bioproducts.
- ACE will facilitate the development and introduction of new algae aquaculture feed ingredients that reduce or eliminate the need for fishmeal and fish oil in feed formulations.
- ACE will facilitate the development and introduction of new algae feed ingredient products with animal health, meat quality and sustainability benefits.
- ACE will facilitate the development and introduction of new algae food ingredients that are nutritious and beneficial to human health.
- ACE will help expand implementation of algae-based environmental restoration activities to combat and mitigate harmful algal blooms, including wastewater treatment, soil amendments, etc.
- Projects funded through ACE will incorporate strong connections between the algae producers, researchers, and product specialists which will drive commercialization.



The ABO Summit (<https://www.algaebiomasssummit.org/>) will serve as the annual gathering to review and report progress and make allocation decisions.



# PROPOSED ACTIVITIES OF ACE

## ROAD MAPPING TO IDENTIFY NEW RESEARCH DIRECTIONS AND TECHNOLOGIES

- Identify potential cutting-edge research opportunities for improving commercial production of algae bioproducts through workshops and road mapping sessions with extended stakeholder groups, especially commercial sector partners
- Propose action plans for identified applied research activities
- Identify and incorporate new technologies into applied research projects by integration of scientific discipline
- Identify innovative technologies that can be scalable to mitigate HAB events

## DEVELOP MULTI REVENUE STREAMS FROM BIOMASS FOR IMPROVED ECONOMIC VIABILITY

- Develop economic and environmentally sound ways of using the residual process byproducts
- Develop new industrial enzymes and enhanced animal feeds
- Develop chemical technologies (e.g. pyrolysis, polyol production, fatty acid fractionation, etc.) for conversion of biomass into feed or bioproducts

## FOOD AND FEED APPLICATION DEVELOPMENT

- Develop expertise to support product development, product testing, regulatory guidance, development of analytical standards and methods, and resources to accelerate adoption of algae into food and feed
- Provide testing facilities and expertise to assess flavor, texture, nutrition, color, consistency, functionality, and safety
- Provide publicly available data and information on algae for food and feed applications

## BIOPRODUCT APPLICATION DEVELOPMENT

- Develop expertise to support product testing, regulatory guidance, development of analytical standards and methods, and resources to accelerate development of algae based materials and bioproducts
- Provide testing facilities and expertise for material and product functionality, chemistry, safety
- Provide testing facilities for biomaterials applications development

## BIOFERTILIZER/SOIL AMENDMENT AND BIOSTIMULANTS APPLICATION FOR SOIL AND PLANT HEALTH

- Develop expertise in soil health characterization and response to algal biofertilizers and soil amendments
- Develop expertise in rapid *in-situ* measurement of soil biological activity, organic soil carbon and humic substances
- Develop methods and expertise in carbon life-cycle analyses of biofertilizer/soil amendment application on conventional crops
- Provide development and testing facilities for application of biofertilizers/soil amendments and biostimulants to conventional crops to quantify productivity response and soil health response

## RESTORATIVE AND ECO-INDUSTRIAL RURAL DEVELOPMENT

- Develop mitigation and removal strategies for algal blooms to reduce nutrient pollution resulting from agriculture, animal, and industrial waste disposal
- Accelerate the use of algae wastewater treatment for Concentrated Animal Feeding Operations, and industrial wastewater being produced at food/feed manufacturing and processing facilities
- Develop new markets of algal biomass produced in the above processes
- Identify and develop technologies that can valorize the mitigation of HABs by creating usable algae biomass feedstock for commercial use

# PROPOSED ACTIVITIES OF ACE

## DEVELOP AGRONOMIC STRATEGIES

- Serve as a technology core for the advancement of algal products (from seed to sale) from all system types
- Develop and expand use of integrated pest management and environmental mitigation strategies for a variety of commercially important production strains
- Advance de-integration of individual production systems to foster increased algal biomass production
- Advance research in developing more productive and sustainable feedstock options for heterotrophic systems

## DEVELOP A GENETIC TOOLBOX AND METABOLIC ENGINEERING TECHNIQUES FOR COMMERCIALY RELEVANT ORGANISMS

- Develop new methods to control gene expression and cell viability
- Create methods for genetic transformation of heretofore non-transformed species
- Develop combinatorial genetic manipulation for directed evolution in algal species

## DEVELOP METABOLIC ENGINEERING TECHNIQUES FOR IMPROVED INDUSTRIAL CHARACTERISTICS

- Employ a systems-based strategy to optimize feedstock supply
- Define metabolic networks controlling carbon flux and modify metabolic pathways
- Use modern genomics, proteomics and metabolomics technologies to define target pathways and regulatory systems

## OPTIMIZE ECONOMICALLY VIABLE HARVESTING, PROCESSING, AND STORING TECHNOLOGIES

- Optimize efficient harvesting, processing and storing technologies
- Develop standardized best practice procedures for the industry
- Employ genetic engineering and breeding techniques to increase productivity of industrially important strains and/or facilitate downstream processing
- Work within the industry, and specifically the National Labs, to increase access to small to midscale equipment to help scale production

## LIFE CYCLE AND TECHNOECONOMIC ANALYSIS OF ALGAL PRODUCTION

- Define system boundaries, specific requirements, and identify product pathways including potential co-products for a variety of algal organisms
- Develop life cycle inventory (LCI) data on algal production

## SUPPORT CONSUMER RESEARCH AND MARKETING

- Work with the FAO to assess algae for the potential of food and feed applications and food security
- Conduct consumer research on attitudes and acceptance of algae in food, feed and bioproduct applications and disseminate results through awareness campaigns
- Work with the industry and The Algae Foundation ([algae.foundation.org](http://algae.foundation.org)) to further develop education and workforce development programs for the algae industry





# ACE PARTICIPANTS

## STEERING COMMITTEE

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