CABBI Progress in 2019-20

Between July 2019 and June 2020, the $115M Center for Advanced Bioenergy and Bioproducts Innovation, led by the University of Illinois at Urbana-Champaign:

- Added Penn State (and Co-PI Costas Maranas) as a new partner, making the total number of CABBI institutions 21.
- Also added Co-PIs Zengyi Shao at Iowa State and George Huber at Wisconsin after the departure of Nathan Price at Institute for Systems Biology and the retirement of James Dumesic at Wisconsin.
- Completed its Year 2 U.S. Department of Energy external review.
- Brought together its second Governance Board meeting in November 2019. This group is chaired by Illinois Vice Chancellor for Research, Susan Martinis
- Hosted its third annual science retreat online due to the COVID-19 pandemic. It was attended by more than 250 people including members of the CABBI Strategic Advisory Board (representatives from the other three national Bioenergy Research Centers as well as academic, government, and industry experts in the bioenergy and bioproducts).
- Added an internal research data and project website — and shareable research datasets on its public website.
- Dealt with COVID-19 pandemic delays, and ensured the safety and productivity of CABBI scientists with thoughtful planning for a return to necessary field and lab work.

Research progress in the Sustainability Theme included:

- With the Illinois Energy Farm, Iowa Sustainable Advanced Bioeconomy Research Farm, and partners and collaborators from a wide range of geographic locations such as Mississippi, Texas, and Florida, CABBI has collected field-scale data on the processes by which energy crops undertake carbon, nitrogen, and water cycling and generate ecosystem services. These data are being used to improve the accuracy of models that analyze the environmental and economic sustainability of bioenergy cropping systems on diverse locations and land types in the rainfed United States. An example is data gleaned from research examining nitrogen response across *Miscanthus × giganteus* established over multiple years and at multiple sites.

Research progress in the Conversion Theme included:

- New CABBI tools have improved the efficiency of synthetic biology in a variety of yeasts. We reported two new CRISPR/Cas9 systems — for gene disruption in *Issatchenkia orientalis* and for modular, targeted gene knockouts in *Rhodosporidium toruloides*, a promising organism that grows on lignocellulosic sugars. These systems pave the way for further genome and metabolic engineering for bioproduct production. New lab techniques are being aided by model-guided strain design. Scientists developed web-based software that improves the efficiency of Golden Gate assembly, a fundamental tool for genetic engineering. The Center has also integrated its biofoundry with a machine-learning algorithm that designs and executes experiments, analyzes resulting data, and determines the best target points for achieving an improved pathway.
- Getting the most value out of CABBI feedstocks requires new, cost-effective methods for processing biomass into useful chemicals. Techniques must be developed to extract oils and sugars — and to valorize lignocellulosic biomass — without compromising bioproduct quality. Improvements in a process using sequential deacetylation, followed by hot water pretreatment and disk refining, can make cellulosic ethanol production from sugarcane bagasse economically feasible. Novel pretreatment steps with engineered yeast strains can incrementally improve ethanol yields from sugarcane bagasse. And chemical-free, continuous hydrothermal pretreatment of sorghum biomass minimizes inhibitor formation and can be successfully scaled up — a promising industrial application.

Research progress in the Feedstock Production Theme included:

- CABBI is creating next-generation feedstock varieties by modifying carbon allocation and metabolism to produce lipids in vegetative tissues, as well as increasing productivity, resource use efficiency, and resilience to stress. Genetic modifications producing novel fatty acids and counteracting growth inhibition in model species are being translated into new lines of sugarcane and sorghum. These advances are an important step toward engineered feedstocks that can produce lipids at low cost. To implement these improvements, we are generating structural and functional knowledge of the genomes of our target feedstocks. We also are increasing the efficiency of gene editing and characterizing natural variation in target traits of these C4 grasses. Additionally, in silico and in planta experiments are improving our understanding of yield resilience and resource use efficiency.

As of mid-June, the Center now employs about 300 people, including 63 faculty-level researchers nationwide, 142 postdocs and technicians, 77 graduate students, more than two dozen undergraduates, and nine support staff.

CABBI scientists disclosed four new inventions during the past year (and three provisional patents), and they published more than 45 papers. The Center was well represented at the DOE Genomic Science Meeting in February with 20 posters.