CABBI Progress in 2021-22

Between July 2021 and June 2022, the $115M Center for Advanced Bioenergy and Bioproducts Innovation, led by the University of Illinois Urbana-Champaign:

- CABBI submitted an Illinois-led renewal proposal to the U.S. Department of Energy (DOE) for Phase II funding 2022-27. Completed a reverse site visit in May with DOE in Washington, D.C
- Saw two successful transitions in its leadership team. Erik Sacks, an Associate Professor of Crop Sciences, succeeded Anthony Studer as the deputy leader in the Feedstocks Production Theme. Elizabeth Murphy succeeded Jenny Kokini as the Deputy Director for Research, Strategy and Management.
- Hosted its fifth annual science retreat, back in-person after two years of remote meetings. Nearly 200 people were present, 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).
- Expanded the internal research data and project website — and now features 100 shareable research datasets on its public website.
- Held trainings for early career researchers on inclusive mentoring in partnership with the Office of Inclusion and Intercultural Relations and the Office of the Vice Chancellor for Diversity, Equity, & Inclusion.
- Hosted the Research Internship in Sustainable Bioenergy (RISE) program exposing undergraduates currently underrepresented in STEM to a 10-week research experience mentored by a CABBI postdoc or graduate student at six CABBI institutions. Supported the Pollen Power camp for middle school girls and the Internationally Genetically Engineered Machine (iGEM) Competition for undergraduate researchers.
- Completed a safe and productive return to necessary field and lab work for CABBI scientists after COVID-19 restrictions were lifted.

Research progress in the Sustainability Theme included:

- Gained understanding of the relative impacts of CABBI bioenergy crops on ecosystem service production compared to conventional land uses. This enhanced our capacity to optimize and predict the ecological and economic implications of integrating CABBI bioenergy crops into the landscape as well as to develop a framework for using economic and environmental attributes to define socially marginal land that may be suitable for bioenergy crop production in the contiguous United States.
- Expanded and leveraged the BioSTEAM platform for agile biorefinery design and technoeconomic and life-cycle analysis through multiple collaborations within CABBI and with

other BRCs to prioritize research directions and set targets, for products including lactic acid, acrylic acid, and linear alpha olefins.
- Development of the FUN-BioCROP model improved representation of soil microbial dynamics.
- Tightly coupled our modeling work with commercial miscanthus producers, providing the capacity to estimate yield at the subfield scale and validate these estimates using on-farm data. All CABBI models used observations from CABBI field sites for expanded testing and evaluation, including multiple sorghum genotypes and miscanthus in a wider variety of soil types and production settings.
- Analyzed economic incentives for converting various land types for bioenergy crop production and the role of socio-economic factors in affecting perceptions of the availability of marginal land.

Research progress in the Conversion Theme included:

- Developed a robust, versatile, and fully automated end-to-end platform for plasmid construction named PlasmidMaker that enables scarless construction of virtually any plasmids in a high-throughput manner.
- Successfully engineered *Rhodosporidium toruloides* and *Issatchenkia orientalis* strains to produce fatty alcohol, triacetic acid lactone, 3-hydroxypropionic acid, and citramalate using oilcane juice as a substrate.
- To upgrade the triacylglycerides produced by the Feedstock theme, developed a chemomimetic biocatalysis approach for constructing alpha-carbonyl stereocentres by enantioselective coupling of *N*-(acyloxy)phthalimides with acceptor-substituted terminal alkenes that can be derived from fatty acids by combining visible-light-excitation and nicotinamide-dependent ketoreductases.
- Developed a multiplexed proteomics method named TMTproC and used it together with metabolomics and isotope tracer-based flux analysis to explore metabolic flux control in *I. orientalis* and *Saccharomyces cerevisiae*.
- Continued to build kinetic, regulatory, and resource allocation models that allow improved predictions of metabolic flux phenotypes. Developed a deep learning algorithm for protein engineering named ECNet (evolutionary context-integrated neural network) and used it to engineer TEM-1 β-lactamase variants with improved ampicillin resistance with high success rates.

Research progress in the Feedstock Production Theme included:

- Initiated and continued field testing of high-oil sugarcane and sorghum lines.
- Developed a genome-scale metabolic model of sorghum for exploring the theoretical capacity of a leaf to accumulate TAG at economically viable levels.
- Continued enhancements in genome editing efficiency in sorghum, sugarcane, and miscanthus.
- Demonstrated that spatio-temporal 3D-convolution neural network architectures based on UAV time series imagery have significant potential to enhance field plant phenotyping.
- Published CROPSR, the first open-source software tool for genome-wide design and evaluation of guide RNA (gRNA) sequences for CRISPR experiments.

As of mid-June, the Center now employs about 340 people, including 63 faculty-level researchers nationwide, 158 postdocs and technicians, 92 graduate students, 44 undergraduates, and 13 support staff.

CABBI scientists disclosed six new inventions during the past year (three of which have received provisional patents), bringing the total to 26 over 4.5 years. They also published 62 papers in scholarly journals — bringing the 4.5-year total to 240.