# CABBI

CENTER FOR ADVANCED BIOENERGY
AND BIOPRODUCTS INNOVATION

## FIVE-YEAR TARGETS

- A regionally adaptive, national-scale platform for grass-based biorefining using feedstocks with improved yield and resource-use efficiency.
- A broad set of platform microorganisms, as well as automated tools that engineer them, to develop value-added products from plant-produced feedstocks or substrates.
- An integrated economic and environmental framework for determining feedstock supply and sustainability.

2022

# RESEARCH FOCUS AREAS

## FEEDSTOCK PRODUCTION

*Growing the right crops.*

CABBI is founded on the "plants as factories" paradigm, in which biofuels, bioproducts, high-value molecules, and foundation molecules for conversion are synthesized directly in plant stems. CABBI researchers are focusing on sorghum, sugarcane, energy cane, and miscanthus, high-yielding grasses that grow throughout the rain-fed eastern United States, including on marginal soils.

## CONVERSION

*Turning plants into high-value chemicals.*

CABBI is working with yeasts (*Saccharomyces cerevisiae*, *Issatchenkia orientalis*, *Rhodosporidium toruloides*, and *Yarrowia lipolytica*) to more fully understand their metabolism and physiology. The Center is applying this knowledge to engineer organisms for production of high-value bioproducts such as biodiesel, organic acids, jet fuels, lubricants, and alcohols. CABBI is also accelerating engineering of microbial strains by developing an automated "biofoundry."

## SUSTAINABILITY

*Improving the environmental and economic bottom line.*

CABBI is developing new techno-economic and life-cycle analyses and integrating systems-level modeling to examine economic and ecological tradeoffs associated with products and processes generated through the Center. Using production-scale field experiments, we gain mechanistic understanding of the plant, soil, microbe, and climate interactions that underlie the productivity and ecosystem services of different feedstocks and the technological and economic pathways to a sustainable and resilient bioeconomy.

## DOE BIOENERGY RESEARCH CENTERS (BRCs): DEVELOPING A VIABLE AND SUSTAINABLE DOMESTIC BIOFUEL AND BIOPRODUCTS INDUSTRY FROM DEDICATED BIOENERGY CROPS.

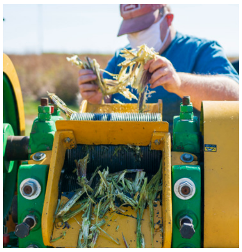
- Center for Bioenergy Innovation (CBI), Est. 2017 (previously BioEnergy Science Center, 2007-17)
- Great Lakes Bioenergy Research Center (GLBRC), Est. 2007
- Joint BioEnergy Institute (JBEI), Est. 2007
- **CABBI,** Est. 2017

## NEW FEEDSTOCK VARIETIES LAY THE FOUNDATION FOR PLANTS AS FACTORIES

*CABBI researcher Kiyoul Park examines sorghum plants in a greenhouse. Credit: University of Nebraska*

CABBI is creating next-generation feedstock varieties by modifying carbon allocation and metabolism to make novel bioproducts in plant tissues — as well as increasing productivity, resource-use efficiency, and stress resilience. Genetic modifications that produce novel fatty acids and promote growth have been used to create new lines of sugarcane and sorghum. These advances are important steps toward engineered grasses that can produce lipids at low cost. To apply these improvements, we have expanded our knowledge about the genomes of target feedstocks, with a major advance in miscanthus in 2020. We are increasing gene-editing efficiency and characterizing the natural variation in target traits of these C4 grasses. Computer, lab, and field experiments have improved our understanding of yield resilience and resource-use efficiency, such as how to enhance photosynthesis.

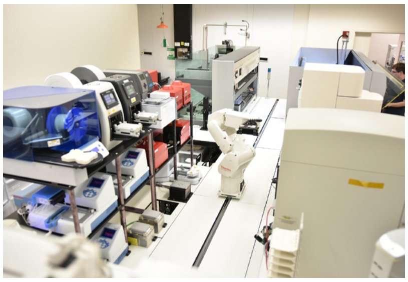
## COLLABORATIVE PROJECT DEMONSTRATES THE 'FEEDSTOCKS TO FUEL' PIPELINE



*Oilcane juicing at the Illinois Energy Farm. Credit: Jenna Kurtzweil, CABBI*

A collaborative pipeline project with oilcane, an oil-rich sugarcane variety, successfully demonstrated the steps from germplasm production to field trials to products. Field trials in Illinois, Mississippi, and Florida allowed for comparisons of crop development and sugar and oil content. The oilcane was delivered to the Integrated Bioprocessing Research Laboratory for processing at an industrially relevant scale. After the juice was extracted, oils and sugars were separated and the sugar was fermented into ethanol. Total oil recovered per unit of land from oilcane was higher than soybeans. Leftover dry materials were processed to release cellulosic sugars and additional oil. Once the oil was recovered, the sugars were fermented with yeast to produce lipids. CABBI will test engineered yeasts and other feedstocks in the pipeline to develop the most valuable stream of bioproducts such as triacetic acid lactone and 3-hydroxypropanoic acid.

## NEW TOOLS & TECHNIQUES ENABLE HIGH-THROUGHPUT STRAIN DEVELOPMENT



*The iBioFAB biofoundry in the Carl R. Woese Institute for Genomic Biology on the University of Illinois Urbana-Champaign campus. Credit: CABBI*

New CABBI tools are improving the efficiency of metabolic engineering in yeasts, paving the way for novel strains to enhance bioproduct production. We created a comprehensive toolkit for genetic manipulation of *Issatchenkia orientalis*, a low-pH tolerant yeast used to produce organic acids. We developed a genome-scale metabolic model for *Yarrowia lipolytica* to simulate new ways to make products before initiating lab experiments. Beyond microbes, chemical and biological catalysis techniques were developed to upgrade our bioproducts to valuable industrial end products. To streamline work at our iBioFAB biofoundry, we designed quick methods to find engineered strains with more free fatty acids than the wild type. And our new web-based software improved the efficiency of Golden Gate assembly, a fundamental tool for synthetic biology and genetic engineering.

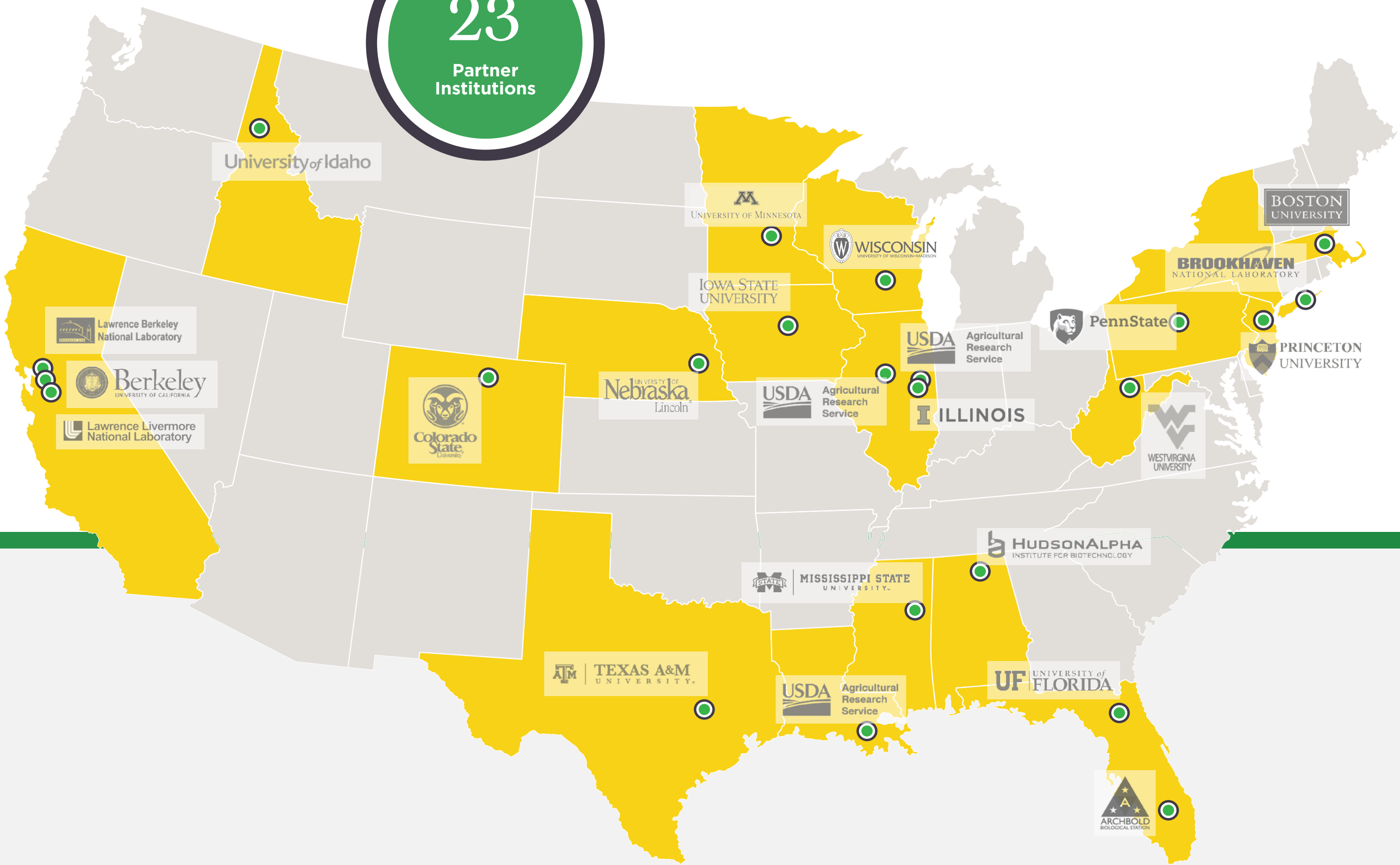
## MODELS HELP PREDICT ENVIRONMENTAL & ECONOMIC IMPACT OF BIOENERGY CROPS

*Adjustments on an eddy covariance tower. Credit: Ingrid Holstrom, CABBI*

CABBI researchers have developed ecosystem models to provide insights about lands that could be used for growing high-yielding bioenergy crops along with soil health improvement and greenhouse gas mitigation. These models are based on multi-year field-scale data collected in Illinois, Iowa, and Florida along with remote-sensing data. From these models and experiments, scientists can better understand how different bioenergy crops and management practices contribute to ecosystem carbon, nitrogen, and water cycling and generate ecosystem services, such as carbon farming and reducing nitrogen losses to air and water. We also developed BioSTEAM, a biorefinery-scale model for rapid techno-economic analysis of different feedstocks and bioproducts to chart innovation pathways for an ecologically and economically sustainable bioeconomy. Using these tools and economic models, researchers have assessed the impact of potential biofuel policies on consumers, agricultural producers, and the environment.

# CABBI PARTNERS

**23**
Partner Institutions




**211** Peer-Reviewed Publications in Four Years

**36** Intellectual Property Filings in Four Years

**66** Faculty-Level Researchers Nationwide

**184** Postdoctoral Researchers & Technicians

**143** Graduate & Undergrad Students

LED BY:

ILLINOIS

cabbi-bio@illinois.edu

https://cabbi.bio

@CABBIbio

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