Fact sheet: Lawrence Berkeley National Laboratory

OVERVIEW

Lawrence Berkeley National Laboratory (Berkeley Lab) was founded in 1931 by Ernest Orlando Lawrence, recipient of one of thirteen Nobel prizes associated with Berkeley Lab. It was Lawrence's belief that scientific research is best done through teams of individuals with different expertise, working together. His teamwork concept is a Berkeley Lab legacy that continues today, harnessing the expertise of more than 4,000 scientists, engineers, support staff, and students across the laboratory to tackle some of the world's most challenging problems. Berkeley Lab is managed by the University of California for the U.S. Department of Energy. Berkeley Lab is a major driver of national and international scientific and technological development, with an estimated $1.6 billion annual impact on the national economy.

CORE CAPABILITIES AND PROJECTS RELEVANT TO UC FOOD INITIATIVE

Transformative advances are needed to foster a new class of sustainable agricultural solutions that are economic, effectively utilize resources, and are resilient to climatic changes. Berkeley Lab is developing a Predictive Agriculture Initiative in partnership with UC Davis to meet this challenge. The vision for the Predictive Agriculture Initiative is to develop new scientific approaches to do more with less: increase food production while simultaneously decreasing inputs of water and fertilizers. Meeting this grand challenge requires the development of new understanding and predictive approaches that comprehensively and systematically consider interactions between key biological, hydrological, and climatic components of the agriculture system. It also requires changes in the way such scientific advances are used to guide agricultural practices and policies. In addition to the Predictive Agriculture Initiative, several of Berkeley Lab's core competencies and projects are relevant to the UC Food Initiative.

- **Predicting Plant-Soil-Microbe-Biome Interactions**. Physical, chemical, and biological interactions in the soil and subsurface are critically important for sustaining life, including food production. To ensure the sustainability of such critical terrestrial system services, Berkeley Lab scientists are developing methods to interrogate and simulate how plants and microbial soil communities interact and function in dynamic terrestrial systems, particularly in response to changes in climate and land use. Initial research foci of the Lab's Microbes-to-Biomes initiative are 1) nitrogen and phosphorus bioavailability as controlled from the molecular to biome scale, with the goal to optimize and minimize the need for chemical fertilizer, and 2) the impact of pesticides on the human microbiome and associated health outcomes. Through the Sustainable Systems SFA 2.0 Project, Berkeley Lab scientists are developing the first-ever Genome-Enabled Watershed Simulation Capability, and using the model with advanced lab and field measurements to quantify interactions across scales, from genome through watershed. Such predictive capabilities are a prerequisite for developing transformational agricultural solutions that involve complex interactions between soil, plants, microbes, and climate. The Terrestrial Ecosystems SFA Project is documenting how warming and precipitation influence turnover and nutrient availability in soil systems.

- **Terrestrial Field Observatories**. Field observatories are critical for testing hypotheses and field technologies. Berkeley Lab scientists have developed and continue to maintain, participate in, and manage terrestrial environment observatories that provide a community foundation for a wide range of above-, at-, and below- ground terrestrial ecosystem research. Examples include Berkeley Lab's leadership of the AmeriFlux Network, which includes more than 100 sites distributed across the Americas that measure greenhouse gases, energy, and water fluxes using ground and airborne platforms. Other key observatories

include the Next Generation Ecosystem Experiment sites in Alaska and the Tropics, and the Subsurface Biogeochemistry Field Observatory near Rifle in the Colorado Basin.

- **Hydroclimate Prediction**. Berkeley Lab scientists are developing advanced models to quantify the role of climate feedbacks in anthropogenic climate change, including abrupt and extreme climate changes that pose great risks to sustainable food production. Berkeley Lab scientists are computational and climatology leaders in the national Advanced Climate Model for Energy (ACME) effort, which is addressing how hydrological cycle and water resources interact with the climate system on local to global scales and how biogeochemical cycles interact with global climate change. A critical aspect of Berkeley Lab research is development of models to simulate human-earth system dynamics, and the subsequent impacts of a changing climate on human and terrestrial environments, such as agrosystems.

- **Environmental Remediation and Water Resources.** Berkeley Lab scientists have deep expertise in coupled hydro-biogeochemical processes and their role in water resources and environmental contaminants. This research relies heavily on linking controlled laboratory experiments with field observations at contaminated Department of Energy sites, particularly those expected to be at elevated risk due to the impacts of global climate change or persistent contamination. Specific expertise is associated with the bioremediation of metals and radionuclides and in the removal of arsenic from drinking water by harnessing the arsenic adsorption capacity of rust.

- **Synthetic Biology**: Through the Joint BioEnergy Institute (JBEI), Berkeley Lab is pioneering breakthroughs in synthetic biology to produce renewable, carbon-neutral biofuels from non-food plant fiber. Some of the developed capabilities are potentially extensible to food systems, including the formulation of designer crops and the development of advance phenomics capabilities. Supporting synthetic agricultural biology is Berkeley Lab's leadership in the systems biology Knowledgebase (KBase), an open software and data platform that is transforming scientists' ability to predict and ultimately design biological function.

- **Transformative and Sustainable Solutions.** The Berkeley Lab Institute for Globally Transformative Technologies (LIGTT) enables discovery and deployment of the next generation of technologies to fight the most critical global problems. A technology example is the Berkeley-Darfur Stove, which requires less than half the fuel of traditional cooking methods and reduces women's exposure to violence while collecting firewood and their need to trade food rations for fuel. The Sustainable Berkeley Lab program strives to extend Berkeley Lab's leadership in sustainability-related research to the sustainability of its operations through continuous improvement to reduce waste and its energy and water footprint.

- **Life Cycle Assessment**. Berkeley Lab scientists have extensive experience quantifying and analyzing the linkages that comprise the food-water-energy nexus. Expertise in the areas of optimizing arable land conversion/allocation strategies; transportation and storage logistics for agricultural products; and assessing the life-cycle energy, water, greenhouse gas, and human health impacts of new or improved crops has previously been applied to numerous bioenergy pathways and is critical to better understand the food supply chain's implications for human health and well-being, constrained natural resources, and climate change.

- **Foundational Infrastructure.** Many of the efforts described above are enabled by facilities housed at Berkeley Lab. For example, the National Energy Research Scientific Computing Center (NERSC) enables advanced computation, visualization, and diverse data management; the Joint Genome Institute provides world class sequencing and bioinformatics; the Molecular Foundry houses cutting-edge expertise and instrumentation for nanoscale science; and the Advanced Light Source is a premier soft-X-ray user facility.

UNIVERSITY OF CALIFORNIA **Global Food Initiative**

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