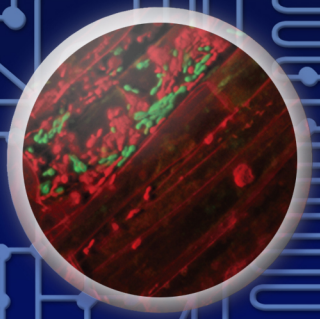


U.S. Department of Energy Office of Science

Biological and Environmental Research

The Biological and Environmental Research (BER) program advances fundamental research and scientific user facilities to support Department of Energy (DOE) missions in scientific discovery and innovation and energy and infrastructure security.

BER seeks to understand the biological, biogeochemical, and physical principles needed to predict a continuum of processes occurring across scales, from molecular and genomics-controlled mechanisms at the smallest scales to environmental and Earth system change at the largest scales. Starting with the genetic potential encoded in organisms' genomes, BER research aims to define the principles underlying the systems biology of plants and microbes as they respond to and modify their environments. Knowledge of these principles is underpinning renewable energy innovations and deeper insights into natural environmental processes. BER also advances understanding of how the Earth's dynamic, physical, and biogeochemical systems (atmosphere, land, oceans, sea ice, and subsurface) interact and affect future Earth system and environmental change. This research improves Earth system model predictions and provides valuable information for energy and resource planning.

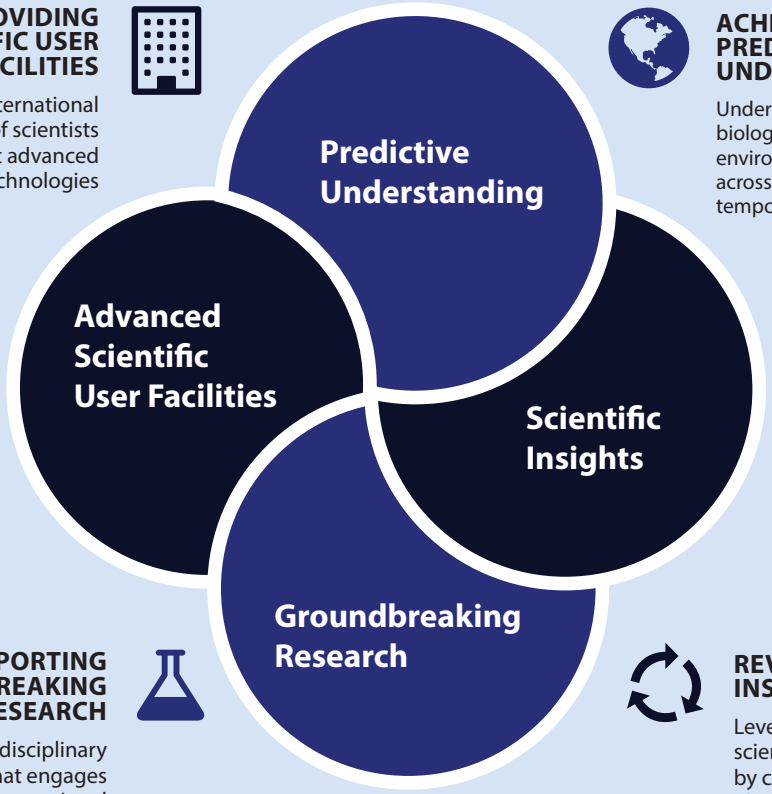
Research Approach for DOE Science, Energy, and Environmental Missions

PROVIDING SCIENTIFIC USER FACILITIES

Empower an international community of scientists with the most advanced technologies

ACHIEVING PREDICTIVE UNDERSTANDING

Understand complex biological and environmental systems across many spatial and temporal scales



SUPPORTING GROUNDBREAKING RESEARCH

Conduct interdisciplinary research that engages scientists from national laboratories, academia, and industry

REVEALING INSIGHTS

Leverage diverse scientific insights by coupling theory, observations, experiments, models, and simulations

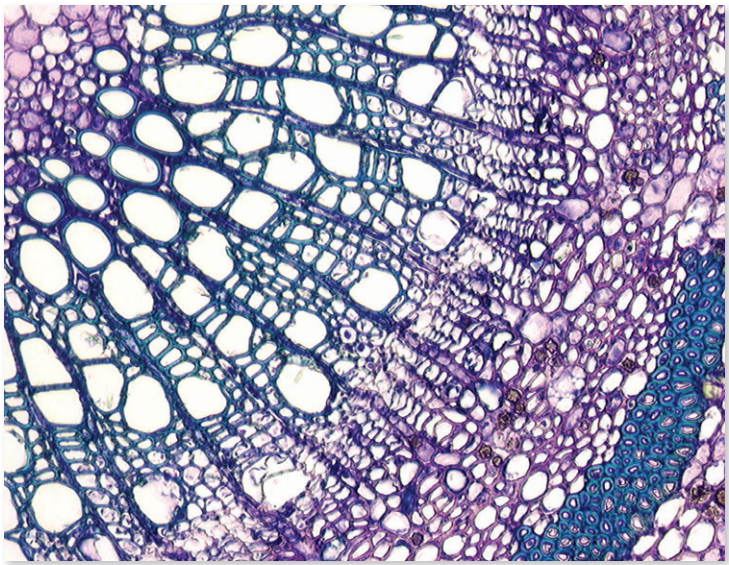
U.S. DEPARTMENT OF ENERGY | Office of Science

Office of Biological and Environmental Research

science.osti.gov/ber/

DOE Mission-Inspired Science

Addressing critical national needs



Genomic Science

Encoded in the genomes of plants, microbes, and their communities are principles that offer a wealth of potential for biobased solutions to national energy and environmental challenges. To harness this potential, BER systems biology research builds on the foundation of sequenced genomes and metagenomes, focusing on a tightly coupled approach that combines experimental physiology, omics-driven analytical techniques, and computational modeling of functional biological networks.

Bioenergy Research Centers

Advances basic research to underpin production of biofuels and bioproducts from inedible lignocellulosic plant biomass (see sidebar on p. 3).

Systems Biology for Bioenergy

Improves fundamental understanding of microbes with bioenergy-relevant traits for deconstructing biomass and synthesizing biofuels and bioproducts.

Plant Science for Bioenergy

Elucidates and validates the functional roles of genes, gene families, and associated pathways to enhance understanding of critical processes in DOE-relevant plant systems.

Sustainability Research for Bioenergy

Investigates plant-soil-microbe interactions in laboratory and field settings to enhance biomass productivity under changing biotic and abiotic conditions.

Biosystems Design

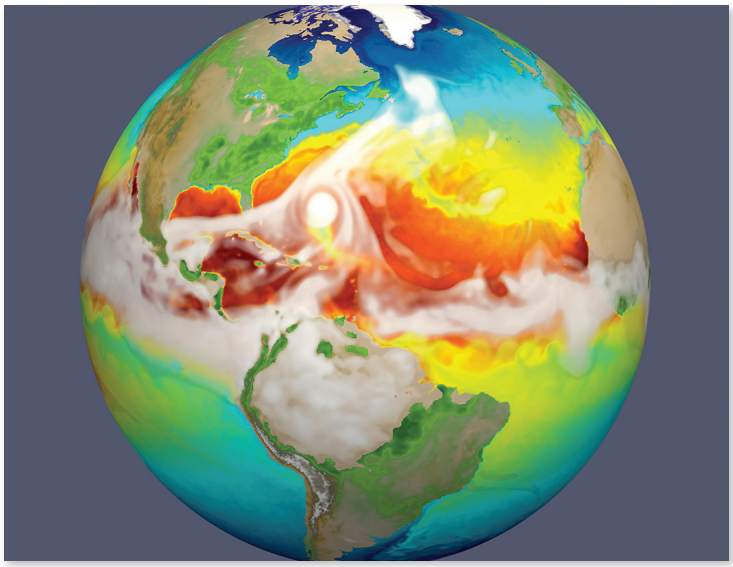
Develops knowledge for engineering useful traits into plants and microbes to produce biofuels and bioproducts and to advance biotechnology.

Environmental Microbiome Science

Links structure and function of microbial communities in the field with key environmental or ecosystem processes.

Computational Biology

Provides new computational approaches and hypothesis-generating analysis techniques, data, and simulation capabilities such as the DOE Systems Biology Knowledgebase (KBase) to accelerate collaborative, reproducible systems science.



Earth and Environmental Systems Sciences

Addressing the key uncertainties arising from the interactions and interdependencies of Earth system components will help inform the development and deployment of advanced solutions to U.S. energy challenges. To resolve these uncertainties, BER supports research to understand and predict how environmental stressors and feedbacks affect and interact with the U.S. energy system and how the combination of natural and human-derived processes lead to variabilities and trends within the integrated Earth system.

Atmospheric Research

Improves understanding of key cloud, aerosol, precipitation, and radiation processes that affect Earth's radiative balance and hydrological cycle, especially processes that limit the predictive ability of regional and global models.

Environmental System Science

Advances a robust, predictive understanding of terrestrial ecosystem and subsurface system processes, including interdependent physical, biogeochemical, ecological, hydrological, and geomorphological processes for use in models scaling from Earth system to local-scale models.

Earth and Environmental Systems Modeling

Focuses on development of the Energy Exascale Earth System Model (E3SM), E3SM and multimodel simulations and analysis, and basic research in multisector dynamics and its role within the physical-human system. Research priorities include the water cycle and extremes, biogeochemical cycles and feedbacks, high-latitude processes, modes of variability, and integration of energy and connected systems into representations of the coupled Earth system.

Data Management

Develops and makes available to the community novel, scale-aware visualization and analysis methods involving observational and model-generated data; tools to quantify uncertainty and adapt to different modeling frameworks, enabling integrated data analysis and intercomparison; and a state-of-the-art federated data archival and dissemination system.

User Facilities

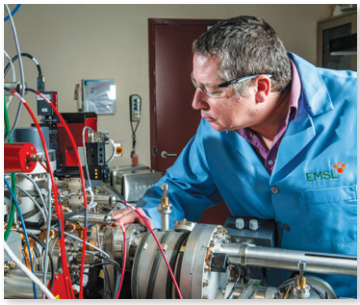
Empowering an international community of scientists with the most advanced technologies

Joint Genome Institute (JGI)

Sequencing more than 200 trillion DNA bases per year, JGI in Berkeley, California, provides state-of-the-science capabilities for genome sequencing, synthesis, metabolomics, and analysis. With nearly 1,600 users worldwide on active projects, JGI is the preeminent resource for sequencing plants, fungi, algae, microbes, and microbial communities foundational to energy and environmental research.
jgi.doe.gov

Atmospheric Radiation Measurement (ARM) User Facility

The ARM user facility provides highly instrumented ground stations at various locations around the globe, mobile measurement resources, and aerial vehicles to continuously measure cloud and aerosol properties and their impacts on Earth's energy balance. ARM measurements have set the standard for long-term climate research observations and provide an unparalleled resource for examining atmospheric processes and evaluating Earth system model performance.
www.arm.gov



Environmental Molecular Sciences Laboratory (EMSL)

EMSL, located in Richland, Washington, provides users with a problem-solving environment by integrating premier instrumentation with high-performance computing and optimized codes. This integration of capabilities enables research teams or individual investigators to unravel the fundamental physical, chemical, and biological mechanisms and processes that underpin larger-scale biological, environmental, and energy challenges.
www.emsl.pnl.gov

Structural Biology and Imaging Resources

BER supports integrated suites of experimental research technologies, methodologies, instruments, and computational capabilities at DOE light and neutron facilities. The spatial and temporal resolutions uniquely provided by these resources enable unprecedented characterization and imaging of interactions among plants, microbes, and the environment. Capabilities to provide molecular fingerprints and mechanistic and dynamic understanding of *in situ* processes help advance various high-priority BER science focus areas.
www.berstructuralbioportal.org

DOE Bioenergy Research Centers

Bringing together top scientists from multiple disciplines, DOE's four Bioenergy Research Centers (BRCs) are developing the science, technology, and knowledgebase necessary to enable sustainable, cost-effective production of advanced biofuels and bioproducts from nonfood plant biomass in support of a new bioeconomy.

The University of Illinois at Urbana-Champaign leads the Center for Advanced Bioenergy and Bioproducts Innovation. DOE's Oak Ridge National Laboratory leads the Center for Bioenergy Innovation in Tennessee. The University of Wisconsin–Madison leads the Great Lakes Bioenergy Research Center. DOE's Lawrence Berkeley National Laboratory leads the Joint BioEnergy Institute in California.

Significant advances in plant breeding, molecular genetics, and genomic technologies provide unique opportunities to build on existing knowledge of plant biology and more confidently predict and manipulate functional properties of biomass feedstock crops. Similarly, continuing advances in omics-enabled technologies and synthetic biology approaches for microorganisms provide opportunities to further develop nonmodel microorganisms for applications in industrial biotechnology and for conversion of biomass into biofuels and bioproducts. Most importantly, integrating plant and microbial systems biology with cutting-edge research in chemical engineering, synthetic biology, and computational biology facilitates the scientific breakthroughs needed to foster the development of a sustainable bioeconomy.

The centers are leveraging these advances to tackle remaining basic science challenges that continue to limit the cost-effective conversion of plant biomass to advanced biofuels and bioproducts. These challenges are in the areas of (1) sustainability, (2) feedstock development, (3) lignocellulosic deconstruction and separation, and (4) conversion to advanced biofuels and bioproducts.

genomicscience.energy.gov/centers/

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BSSD aims to achieve a predictive understanding of complex biological systems to enable more confident redesign of microbes and plants for sustainable biofuels and bioproducts production, improved carbon storage, and controlled biological transformation of nutrients and contaminants in the environment.

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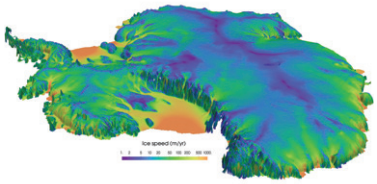

EESSD aims to enhance the seasonal to multidecadal predictability of the Earth system by using long-term field experiments, DOE user facilities, modeling and simulation, uncertainty characterization, best-in-class computing, process research, and data analytics and management to inform the development of advanced solutions to the nation's energy challenges.

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