

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, energy security, and environmental responsibility.

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 by 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 climate and environmental change. This research improves climate 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

Predictive Understanding

Advanced Scientific User Facilities

Scientific Insights

Groundbreaking Research

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

DOE Mission-Inspired Science

Addressing critical national needs



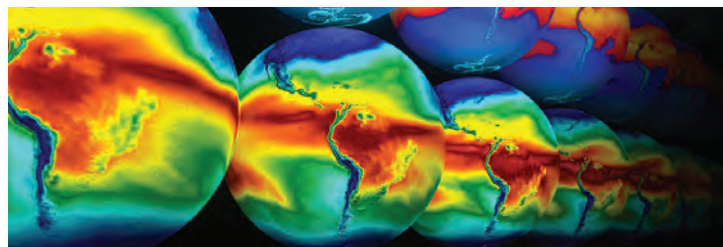
Genomic Science

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 basic 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.



Sustainable Biofuels

BER is using the power of genomics and systems biology to accelerate breakthroughs needed to develop cost-effective, sustainable, and commercial production of cellulosic biofuels using microbes, plants, and fungi. Basic research activities range from creating new energy crops and methods for deconstructing lignocellulosic material into chemical building blocks to creating and inserting new metabolic pathways into microbial hosts for production of advanced biofuels and other bioproducts.



Climate Science

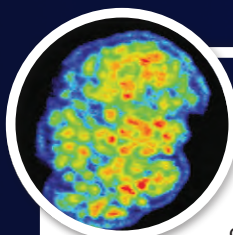
Addressing the greatest uncertainties in climate science will help inform decision-making about energy use and climate change. To resolve these uncertainties, BER supports research to study the interactions between energy and the climate system, improve the world's most powerful climate models to run efficiently on DOE computers; understand carbon cycling in terrestrial ecosystems; examine interactions among aerosols, clouds, precipitation, and radiation; and simulate sea-level change processes.



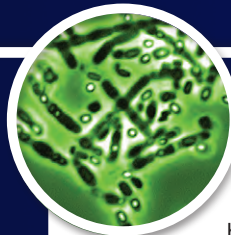
Environmental System Science

BER supports research to predictively understand the response of terrestrial ecosystems to climate change and the role of subsurface biogeochemical processes in the fate and transport of nutrients and contaminants. Spanning the subsurface to the top of the vegetative canopy and from molecular to global scales, this research examines the interdependencies of biogeochemical, genomic, ecological, and geohydrological processes in diverse environments ranging from the Arctic to the tropics.

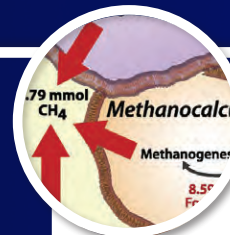
Research Snapshots



Researchers used microscopy, stable isotope labeling, nanoSIMS analysis, and computational modeling to examine metabolic activity and energy transfer from methane-oxidizing archaea to sulfate-reducing bacteria. Findings revealed direct interspecies electron transport (movement of electrons from one cell type to another) through the external environment via nanowires. This transfer mechanism enables symbiotic consumption of methane from deep sea vents. [McGlynn, S. E., et al. 2015. *Nature*. DOI: 10.1038/nature15512]



Scientists obtained a protein crystal structure at 3 Ångstrom resolution by injecting bacterial cells into an X-ray free-electron laser beam. This new ability to collect diffraction patterns from crystals of unprecedentedly small dimensions demonstrates possibilities for studying crystals and other ordered structures in their native environments in living cells. [Sawaya, M. R., et al. 2014. *Proceedings of the National Academy of Sciences (USA)*. DOI: 10.1073/pnas.1413456111]



Researchers mapped metabolic networks in methanogenic microbial communities using a combination of metagenomic sequencing and metatranscriptomic and metabolic analyses. They identified the multidimensional interspecies interactions that define composition and dynamics in such communities, which drive most environmental biogeochemical processes. [Embre, M., et al. 2015. *Proceedings of the National Academy of Sciences (USA)*. DOI: 10.1073/pnas.1506034112]

User Facilities

Empowering an international community of scientists with the most advanced technologies



DOE Joint Genome Institute (JGI)

Sequencing more than 140 trillion DNA bases per year, DOE JGI in Walnut Creek, California, provides state-of-the-science capabilities for genome sequencing, synthesis, and analysis. With more than 950 collaborators worldwide on active projects, DOE JGI is the preeminent resource for sequencing plants, microbes, and microbial communities foundational to energy and environmental research.

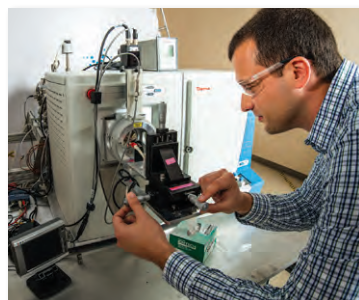
jgi.doe.gov



DOE Atmospheric Radiation Measurement (ARM) Climate Research Facility

The ARM Climate Research 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 Facility measurements have set the standard for long-term climate research observations and provide an unparalleled resource for examining atmospheric processes and evaluating climate model performance.

www.arm.gov



DOE Environmental Molecular Sciences Laboratory (EMSL)

DOE 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



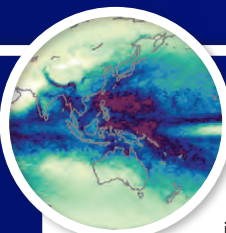
DOE Bioenergy Research Centers

Bringing together top scientists from multiple disciplines, BER established three Bioenergy Research Centers in 2007 to deliver high-return breakthroughs in cellulosic biofuel production.

DOE's Oak Ridge National Laboratory leads the BioEnergy Science Center 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.

The centers are using genomics and advanced analytical technologies to understand (1) how to make grasses, wood, and other cellulosic materials easier to break down into sugars and (2) how to advance the microbial production of advanced biofuels and other bioproducts from biomass.

genomicscience.energy.gov/centers/



Superparameterization of clouds in the Community Atmosphere Model improved representation of moderate and extreme

rainfall intensity in regions of organized convection, particularly in the tropics (e.g., Madden-Julian Oscillation, Inter-Tropical Convergence Zone, and monsoon regions). These enhancements will advance global climate model projections of future climate change. [Kooperman, G. J., et al. 2016. *Journal of Advances in Modeling Earth Systems*. DOI: 10.1002/2015MS000574]



Scientists used stable isotopes to estimate dissolved inorganic carbon and methane (CH₄) production mechanisms

and transport pathways in Arctic tundra watersheds. They found that the majority of subsurface CH₄ was transported upward by plants and ebullition (bubbling), thus bypassing the potential for CH₄ oxidation. [Throckmorton, H. M., et al. 2015. *Global Biogeochemical Cycles*. DOI: 10.1002/2014GB005044]



Researchers used Doppler cloud radar at the ARM Climate Research Facility to examine entrainment (mixing of cloudy air with

clear air) at the top of stratocumulus clouds. The resulting data provide a unique estimate of entrainment rates and processes at temporal resolutions not practical with other observing systems. [Albrecht, B., et al. 2016. *Journal of the Atmospheric Sciences*. DOI: 10.1175/JAS-D-15-0147.1]

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science.energy.gov/ber/

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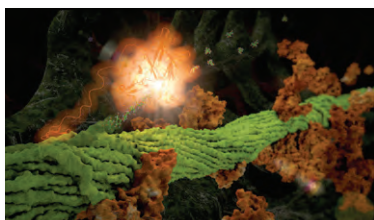
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BSSD aims to achieve a predictive understanding of complex biological systems to enable more confident redesign of microbes and plants for sustainable biofuels production, improved carbon storage, and controlled biological transformation of nutrients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

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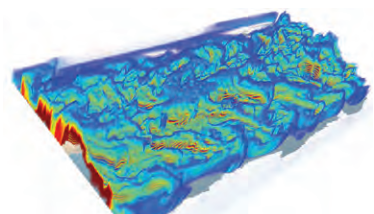
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USER FACILITY

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CESD aims to advance a robust, predictive understanding of Earth's climate and environmental systems through (1) research on clouds, aerosols, the terrestrial carbon cycle, and subsurface biogeochemistry; (2) large-scale climate change and Earth system modeling; (3) studies on the interdependence of climate change and ecosystems; and (4) integrated analysis of climate change impacts on energy and related infrastructures.

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* Interagency personnel agreement

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