Office of Biological and Environmental Research

science.energy.gov/ber/

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, 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.

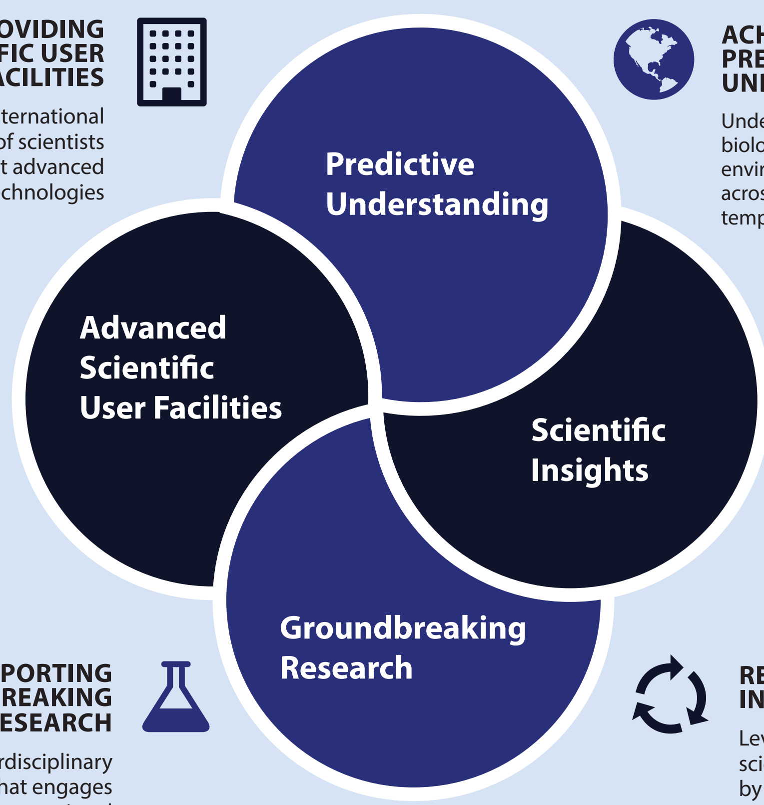
Research Approach for DOE Science, Energy, and Environmental Missions

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



SUPPORTING GROUNDBREAKING RESEARCH

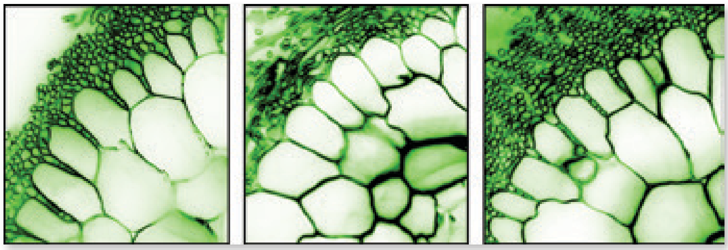
Conduct interdisciplinary research that engages scientists from national laboratories, academia, and industry

REVEALING INSIGHTS

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

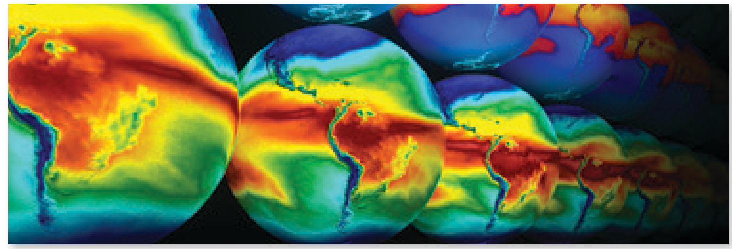
DOE Mission-Inspired Science

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.



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.

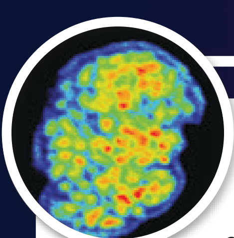
Sustainable Biofuels

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.

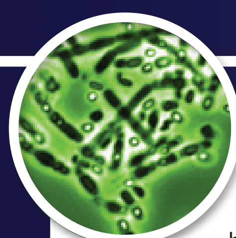
Environmental System Science

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.

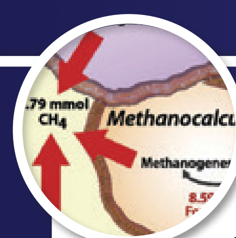
Research Snapshots



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. [Embree, 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

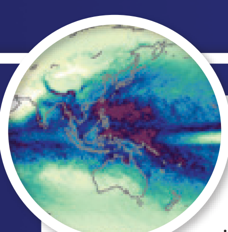
DOE Bioenergy Research Centers

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 (CH_4) production mechanisms and transport pathways in Arctic tundra watersheds. They found that the majority of subsurface CH_4 was transported upward by plants and ebullition (bubbling), thus bypassing the potential for CH_4 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]

Office of Biological and Environmental Research Staff

U.S. Department of Energy Office of Science science.energy.gov/ber/

Email addresses for BER staff follow the format: firstname.lastname@science.doe.gov

ASSOCIATE DIRECTOR OFFICE

Associate Director of Science for Biological and Environmental Research
Sharlene Weatherwax, 301-903-3251

Senior Technical Advisor
Mike Riches, 301-903-3264

Senior Technical Advisor
Tristram West, 301-903-5155

AAAS Fellow
Adam Rosenblatt, 301-903-1964

Management Analyst
Kathy Holmes, 301-903-3251

Program Analysts
Joanne Corcoran, 301-903-6488
Leslie Runion, 301-903-9135

Program Support Assistants
Terry Lagana, 301-903-3213
Nver Mekerdijian (Contractor), 301-903-3281

BIOLOGICAL SYSTEMS SCIENCE DIVISION (BSSD)

Todd Anderson, Director, 301-903-3213

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.

Genomic Science
Joseph Graber, 301-903-1239
Pablo Rabinowicz, 301-903-0379
Catherine Ronning, 301-903-9549
Kent Peters, 301-903-5549
Dawn Adin, 301-903-0570
Ramana Madupu, 301-903-1398

Computational Biosciences
Ramana Madupu, 301-903-1398

Plant Feedstocks
Catherine Ronning, 301-903-9549

Biofuels Research and Bioenergy Research Centers
Kent Peters, 301-903-5549
Catherine Ronning, 301-903-9549
Joseph Graber, 301-903-1239
Todd Anderson, 301-903-3213

Bioimaging Technology
Prem Srivastava, 301-903-4071

Radiochemistry and Imaging Instrumentation
Prem Srivastava, 301-903-4071

Radiobiology
Todd Anderson, 301-903-3213

Structural Biology Infrastructure
Roland Hirsch, 301-903-9009
Amy Swain, 301-903-1828

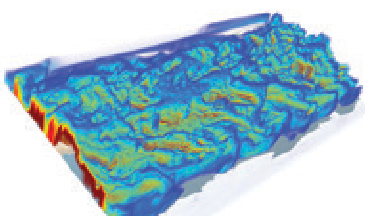
Human Research Subjects Protection
Elizabeth White, 301-903-7693

BSSD Small Business Innovation Research
Prem Srivastava, 301-903-4071

BSSD Scientific Program Specialist
Meredith Rutledge, 301-903-0088

USER FACILITY

Joint Genome Institute
jgi.doe.gov
Daniel Drell, 301-903-4742



CLIMATE AND ENVIRONMENTAL SCIENCES DIVISION (CESD)

Gerald Geernaert, Director, 301-903-4775

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.

Atmospheric System Research
Ashley Williamson, 301-903-3120
Shaima Nasiri, 301-903-0207

Terrestrial Ecosystem Science
Daniel Stover, 301-903-0289
Jared DeForest (IPA)*, 301-903-1678

Subsurface Biogeochemical Research
David Lesmes, 301-903-2977
Paul Bayer, 301-903-5324
Roland Hirsch, 301-903-9009

Regional and Global Climate Modeling
Renu Joseph, 301-903-9237

Earth System Modeling
Dorothy Koch, 301-903-0105

Integrated Assessment Research for Climate
Bob Vallario, 301-903-5758

Climate Information and Data Management
Justin Hnilo, 301-903-1399

CESD Small Business Innovation Research
Rick Petty, 301-903-5548
Renu Joseph, 301-903-9237
David Lesmes, 301-903-2977
Ashley Williamson, 301-903-3120

CESD Scientific Program Specialist
Andrew Flatness, 301-903-0488

USER FACILITIES

Atmospheric Radiation Measurement Climate Research Facility
www.arm.gov
Sally McFarlane, 301-903-0943
Rick Petty, 301-903-5548

Environmental Molecular Sciences Laboratory
www.emsl.pnl.gov
Paul Bayer, 301-903-5324

* Interagency personnel agreement

October 2016

Front cover image credits. Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE) site [Oak Ridge National Laboratory (ORNL)]. Bacteria secreting biodiesel [DOE Joint BioEnergy Institute]. Next-Generation Ecosystem Experiments (NGEE)–Tropics [Lawrence Berkeley National Laboratory (LBNL)]. **Inside pages.** Genomic science [adapted from Plett, J.M., et al. 2014. "Effector MiSSP7 of the Mutualistic Fungus *Laccaria bicolor* Stabilizes the *Populus* JAZ6 Protein and Represses Jasmonic Acid (JA) Responsive Genes," *Proceedings of the National Academy of Sciences (USA)* **111**(22), 8299–304]. Climate science [ORNL]. Sustainable biofuels [U.S. Department of Agriculture]. Environmental system science [LBNL]. Single-cell sequencing [DOE JGI]. North Slope of Alaska Atmospheric Observatory [DOE ARM Climate Research Facility]. Mass spectrometer [DOE EMSL]. NanoSIMS analysis [McGlynn, S.E., et al. 2015. "Single Cell Activity Reveals Direct Electron Transfer in Methanotrophic Consortia," *Nature* **526**, 531–35]. Cell protein [adapted from Sawaya, M.R., et al. 2014. "Protein Crystal Structure Obtained at 2.9 Å Resolution from Injecting Bacterial Cells into an X-Ray Free-Electron Laser Beam," *Proceedings of the National Academy of Sciences (USA)* **111**, 12769–74]. Mapping metabolic networks [Embree, M., et al. 2015. "Networks of Energetic and Metabolic Interactions Define Dynamics in Microbial Communities," *Proceedings of the National Academy of Sciences (USA)* **112**(50), 15450–455]. Superparameterization [Kooperman, G. J., et al. 2016. "Robust Effects of Cloud Superparameterization on Simulated Daily Rainfall Intensity Statistics Across Multiple Versions of the Community Earth System Model," *Journal of Advances in Modeling Earth Systems* **8**, 140–65]. NGEE–Arctic site in Alaska [ORNL]. Stratocumulus clouds [iStock Photo]. **Back cover.** Simulation of cell wall degradation [Thomas Splettstoesser, www.scistyle.com]. Specific humidity variable generated by global climate model [from the Ultrascale Visualization-Climate Data Analysis Tools (UV-CDAT) image gallery, courtesy Thomas Maxwell, NASA Center for Climate Simulation. UV-CDAT is a multi-institutional effort led by DOE].