Hearing Charter

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES

Biological Research for Energy and Medical Applications at the Department of Energy Office of Science

Thursday, September 10, 2009
2 p.m. – 4 p.m.
2318 Rayburn House Office Building

Purpose

On Thursday, September 10, 2009 the House Committee on Science & Technology, Subcommittee on Energy and Environment will hold a hearing entitled *"Biological Research for Energy and Medical Applications at the Department of Energy Office of Science."*

The Subcommittee's hearing will receive testimony on the biological research activities of the Department of Energy (DOE) Office of Science conducted through the Biological and Environmental Research (BER) and Nuclear Physics (NP) programs. It will also examine how these areas are related to the work of other DOE program offices and other federal agencies.

Witnesses

- **Dr. Anna Palmisano** is Director of BER. Dr. Palmisano will provide an overview of the program and discuss its coordination with other DOE program offices and federal agencies.

- **Dr. Jay Keasling** is CEO of the Joint BioEnergy Institute (JBEI) at Lawrence Berkeley National Laboratory. Dr. Keasling will testify on the status of the three major bioenergy centers and the efficacy of this model for bioenergy research.

- **Dr. Allison Campbell** is Director of the WR Wiley Environmental Molecular Sciences Laboratory (EMSL) at the Pacific Northwest National Laboratory. Dr. Campbell will explain EMSL's role in meeting DOE's mission needs with a particular focus on environmental remediation.

- **Dr. Ari Patrinos** is President of Synthetic Genomics, Inc. Dr. Patrinos will testify on the private sector's perspective of the BER program in bioenergy, as well as his experience as a former Director of BER.

- **Dr. Jehanne Gillo** is Facilities & Project Management Division Director of NP. Dr. Gillo will testify on the status of the isotope development and production program recently transferred from the DOE Office of Nuclear Energy.

Background

The origins of biological research conducted by the Department of Energy date back to 1946. The U.S. had recently developed and deployed the atomic bomb in World War II and was subsequently examining the potential peaceful uses of nuclear energy, which led to major concerns regarding health effects from exposure to radiation. Research in these health effects produced advances in genetics and developments in nuclear medicine, such as radioisotopes for common medical tests and positron emission tomography (PET) scanners that are still used to diagnose millions of patients each year.

Perhaps the most significant event in the last two decades of the DOE Office of Science's Biological and Environmental Research (BER) Program was its initiation of the Human Genome Project in 1990 in collaboration with the National Institutes of Health (NIH). A genome is a complete genetic sequence of the DNA of an organism. Built on the advances in technology development at DOE's national laboratories, the Human Genome Project led to the determination of the complete DNA sequence of humans by 2003, two years ahead of schedule. Work to support the project was conducted by teams of scientists in the public and private sectors from around the world, and their results have provided new opportunities for discovering and understanding fundamental principles of life.

Biological Systems Science

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Biological Systems Science			
Genomic Science	164,085	169,858	165,626
Radiological Sciences	46,674	50,768	46,615
Ethical, Legal, and Societal Issues	5,000	5,000	5,000
Medical Applications	8,191	8,226	8,226
Biological Systems Facilities and Infrastructure	80,011	80,300	84,300
SBIR/STTR	—	8,663	8,709
Total, Biological Systems Science	303,961	322,815	318,476

Table 1: Budget table for the DOE Office of Science's Biological Systems Science program. FY 2008 and FY 2009 are appropriated levels, and FY 2010 is the Administration's request level. This does not include funding from the American Recovery and Reinvestment Act of 2009, of which the Department currently plans to allocate $13.5 million in the Genomic Science subprogram for capital equipment at the Bioenergy Research Centers and $13.1 million in Biological Systems Facilities and Infrastructure for additional support of the Joint Genome Institute.

BER then shifted the focus of this new capability to rapidly sequence an organism's complete genome to the fields of microbial and plant biology with an emphasis on organisms with energy and environmental relevance. The Biological Systems Science program within BER – first authorized in the Energy Policy Act of 2005 – brought together genomic research in microbial and plant biology with protein science, computational biology, and environmental science to

support the energy, national security, and environmental missions of DOE. The ability to study an organism beginning with its DNA sequence has provided new understanding of fundamental biological processes related to biofuels production, carbon sequestration, and environmental clean-up. Details on current and proposed funding for Biological Systems Science can be found in Table 1.

Genomic Science

The Genomic Science subprogram includes three major components:

- Bioenergy Research Centers - Bioenergy research is now a primary focus in the BER program. In 2006 BER solicited applications for several Bioenergy Research Centers. The Centers were to be focused on achieving significant breakthroughs in the development of cost-effective technologies to make production of cellulosic (plant-fiber based) biofuels commercially viable on a national scale. Each Center was chosen for its unique set of skills to address 3 major challenges – the development of next-generation bioenergy crops; the discovery and design of enzymes and microbes with novel biomass-degrading capabilities; and the discovery and design of microbes that create fuels directly from biomass. Three were finally selected in the summer of 2007, and include the:

    - **BioEnergy Science Center (BESC)** led by the Oak Ridge National Laboratory. This center focuses on the resistance of plant fiber to breakdown into sugars and is studying the potential energy crops poplar and switchgrass. Partners of BESC include Georgia Institute of Technology Atlanta; DOE's National Renewable Energy Laboratory, Golden, CO; University of Georgia in Athens; University of Tennessee, Knoxville; Dartmouth College, Hanover, NH; ArborGen, Summerville, SC; Verenium Corporation, Cambridge, MA; Mascoma Corporation, Boston, MA; The Samuel Roberts Nobel Foundation, Ardmore, OK; and Ceres, Inc., Thousand Oaks, CA.

    - **Great Lakes Bioenergy Research Center (GLBRC)** led by the University of Wisconsin, Madison in close partnership with Michigan State University. Other partners include Illinois State University, Normal; Iowa State University, Ames; Lucigen Corporation, Middleton, WI; and both DOE's Oak Ridge National Laboratory (ORNL) and Pacific Northwest National Laboratory (PNNL). This center is studying a range of plants and, in addition to exploring plant fiber breakdown, aims to increase plant production of starches and oils, which are more easily converted to fuels. GLBRC also has a major focus on sustainability, examining the environmental and socioeconomic implications of moving to a biofuels economy.

    - **Joint BioEnergy Institute (JBEI)** led by Lawrence Berkeley National Laboratory and headed by Dr. Jay Keasling. JBEI is using well-characterized genomes and genetic-engineering tools established for rice and Arabidopsis (a small flowering plant related to mustard). These two model species are ideal research subjects because they go from seed to mature plant in weeks or months,

rather than the year or more required for energy crops such as switchgrass and poplar. Genetic insights from rice (a model for grasses) and Arabidopsis (a model for trees) are thus expected to accelerate the development of new energy crops. JBEI is also exploring microbial-based synthesis of fuels beyond ethanol. Partners of JBEI include DOE's Sandia National Laboratories; University of California, Berkeley; University of California, Davis; Carnegie Institution for Science, Palo Alto, CA; and DOE's Lawrence Livermore National Laboratory, Livermore, CA.

The Centers consist of multidisciplinary teams of scientists from 18 universities, 7 DOE national laboratories, 2 nonprofit organizations, and a range of private companies. They were soon authorized in the Energy Independence and Security Act of 2007 in which the Secretary was directed to establish at least seven bioenergy research centers to accelerate basic transformational research and development of biofuels.

The funding plan for the Centers is for each to receive up to $125 million over a period of 5 years starting in 2008: $25 million in the first year for startup costs and up to $25 million per year for operations during the subsequent 4 years. The Administration's FY 2010 budget request continues this plan, recommending $25 million each or $75 million in total.

- Fundamental Genomic Research – This activity supports fundamental research on microbes and plants, with an emphasis on understanding biological systems across multiple scales of organization, ranging from subcellular protein-to-protein interactions to complex microbial community structures. It investigates how cells are able to balance dynamic needs for synthesis and assembly of cellular machinery in response to changing signals from the environment. A broad diversity of biological functions are examined, from microbial respiration and separation of soil minerals to nutrient uptake and cell-to-cell communication. There is a strong focus on understanding the conversion of carbon from simple forms to advanced biomolecules, as well as a focus on development of new strategies and tools to fully exploit the information contained in complete DNA sequences from microbes and plants for bioenergy, carbon sequestration, and bioremediation applications.

- Computational Biosciences – Advanced computational models and tools are needed to accurately describe the biochemical capabilities of microbial communities and plants. These new tools must be able to integrate diverse data types and data sets into single functioning models. An important task over the next several years will be the extension of database capabilities beyond data generation and storage to cross-database comparative computational modeling so that better microbes for bioenergy, carbon sequestration, or bioremediation purposes can be more readily engineered. This research is closely coordinated with the Office of Science's Advanced Scientific Computing Research (ASCR) program.

Radiological Sciences

The Radiological Sciences subprogram supports fundamental research in radiochemistry to develop new methodologies for real-time, high-resolution imaging of dynamic biological processes. This includes examination of biological systems with benefits for DOE mission needs as well as techniques and tool development that can be applied to nuclear medicine diagnostic and therapeutic research.

This subprogram also supports research that will help determine health risks from exposures to low levels of radiation, information critical to adequately and appropriately protect radiation workers and the general public. It provides a scientific basis for decisions regarding remediation of contaminated DOE sites and for determining acceptable levels of human health protection, both for cleanup workers and the public.

Medical Applications

The Medical Applications subprogram utilizes resources and expertise in engineering and materials science primarily available at DOE national laboratories rather than NIH facilities to develop unique neuroprostheses - medical devices that connect directly to the human brain, spinal cord, or nerves. It has focused in particular on the development of an artificial retina to restore sight to the blind. DOE's goal for this project is to create the technology underpinning a device that will allow a blind person to read large print, recognize faces, and move around without difficulty. The DOE-funded phase of the artificial retina project will be completed in FY 2010.

Biological Systems Facilities and Infrastructure

- Joint Genome Institute – The Joint Genome Institute (JGI), based in Walnut Creek, CA and operated by the University of California, is the only federally funded large center focusing on genome discovery and analysis in plants and microbes for energy and environmental applications, including bioenergy, carbon cycling and sequestration, and soil remediation. JGI incorporates expertise from five DOE partner laboratories—Lawrence Berkeley (LBL), Lawrence Livermore (LLNL), Los Alamos, Oak Ridge, and Pacific Northwest—along with the HudsonAlpha Institute for Biotechnology. Its workforce draws most heavily from LBL and LLNL. Through the development of genome assembly methods, tools for comparative gene analysis, and integration of data from multiple technology platforms, JGI enables researchers and plant breeders to identify traits and genes for specific bioenergy applications or environmental conditions. The Institute provides these services to the broad scientific user community, including the Bioenergy Research Centers, on a merit-reviewed basis. Synthetic Genomics Inc. (SGI), a privately-held company, is the only other institution with similar capabilities in the world.

- Structural Biology Infrastructure – The Structural Biology Infrastructure program develops and supports access to DOE's national user facilities for the Nation's systems biologists. BER coordinates with NIH and the National Science Foundation (NSF) the

management and maintenance of 22 experimental stations at several DOE light and neutron sources used to examine biological materials and processes. BER assesses the quality of the instrumentation at its experimental stations and supports upgrades to install the most effective instrumentation for taking full advantage of the facility capabilities as they are improved by DOE. This activity enables a broad user community to conduct the high-resolution study of biological molecules involved in cellular architecture, environmental sensing, and carbon capture.

Isotope Development and Production for Research and Applications

In FY 2009, the Isotope Development and Production for Research and Applications subprogram was transferred to the DOE Office of Science's Nuclear Physics (NP) program from the Office of Nuclear Energy. This subprogram provides facilities and capabilities for the production of isotopes to address national needs. Stable and radioactive isotopes are vital to the mission of many Federal agencies and play a crucial role in basic research, medicine, industry, and homeland defense. Isotopes are produced for the National Institutes of Health (NIH) and their grantees, National Institute of Standards and Technology, Environmental Protection Agency, Department of Agriculture, National Nuclear Security Administration (NNSA), Department of Homeland Security (DHS), other DOE Office of Science programs, and other Federal agencies. The subprogram also supports research related to the development of advanced isotope production techniques.

Isotopes are used to improve the accuracy and effectiveness of medical diagnoses and therapy, enhance national security through the development of advanced sensors, improve the efficiency of industrial processes, and provide precise measurement and investigative tools for materials, biomedical, environmental, archeological, and other research. Some examples are: strontium-82 used for heart imaging; arsenic-73 used as a tracer for environmental research, and helium-3 as a component in neutron-detectors that may be used to scan for radioactive weapons.

The consequences of shortages of radioactive and stable isotopes needed for research, medicine, homeland security, and industrial applications can be extremely serious ranging from the inability to treat cancer to the failure of detecting terrorist threats. To address several of these issues before they become larger problems, NP has established a working group with NIH to act on the recommendations of a 2007 National Academies report, *Advancing Nuclear Medicine through Innovation*, which identified areas in isotope production warranting attention. NP has also facilitated the formation of a federal working group on He-3 supply, involving staff from NP, NNSA, DHS, and the Department of Defense.

Isotopes are made available by using NP's unique facilities, including the Brookhaven Linear Isotope Producer (BLIP) at Brookhaven National Laboratory and the Isotope Production Facility (IPF) at Los Alamos National Laboratory. The subprogram also produces isotopes at the reactors at Oak Ridge and Idaho National Laboratories. It operates under a revolving fund as established by the FY 1990 Energy and Water Development Appropriations Act, and maintains its financial viability by utilizing a combination of Congressional appropriations and revenues from the sale of isotopes and services. These resources are used to maintain the staff, facilities, and capabilities

at user-ready levels and to support peer-reviewed research and development activities related to the production of isotopes. Commercial isotopes are priced at full cost. Research isotopes are priced to provide reasonable compensation to the government while encouraging research.