Minutes of the
Biological and Environmental Research Advisory Committee Meeting
February 18-19, 2009
Bethesda North Marriott Hotel, Rockville, Md.

BERAC members present:

Michelle S. Broido, Chair
Eugene W. Bierly
James R. Ehleringer
Joanna S. Fowler
Andrzej Joachimiak
Margaret S. Leinen
Stephen R. Padgette
Joyce E. Penner
Gregory Petsko
David A. Randall
Karin Remington
Margaret A. Riley
Gary Sayler
Gary Stacey
James M. Tiedje
Warren M. Washington
Raymond E. Wildung
Mavrik Zavarin

BERAC members absent:

S. James Adelstein
Janet Braam
Robert E. Dickinson
Raymond F. Gesteland
David T. Kingsbury
John C. Wooley

About 85 others were in attendance during the course of the two-day meeting.

Wednesday, February 18, 2009
Morning Session

Before the meeting started, a member of the General Counsel's Office of DOE presented the annual ethics briefing to the Committee members.

Chairwoman **Michelle Broido** called the meeting to order at 9:03 a.m. She announced that David Thomassen, the Designated Federal Officer (DFO), could not be in attendance on Feb. 18 and that Anjuli Bamzai would be the acting DFO. Steven Larson has resigned from the Committee. Joanna Fowler won a special award in chemistry from the National Academy of Sciences (NAS).

Anna Palmisano was asked to review the state of the Office of Biological and Environmental Research (BER).

For the first time a research scientist, Dr. Steven Chu, is leading the Department of Energy as its Secretary. He was Director of Lawrence Berkeley National Laboratory (LBNL) and helped to launch the Bioenergy Research Center at LBNL. His priorities include biology and biotechnology, climate, and the environment. He is familiar with BER programs.

The President's primary national objective for DOE is to ensure energy to secure America's future by quickly implementing the economic recovery package; restoring

science leadership; reducing greenhouse-gas emissions; saving more oil than the United States currently imports from the Middle East and Venezuela combined within 10 years; and strengthening nonproliferation activities, reducing global stockpiles of nuclear weapons, and maintaining the safety and reliability of the U.S. stockpile.

To achieve these objectives, the Department will focus on transformational science, develop science and engineering talent, and collaborate universally (within DOE, with other agencies, and around the world).

An Under Secretary of Science has not been identified. Patricia Dehmer is acting as Director of Office of Science and continues as Deputy Director of Science Programs.

The Department is currently working on the development of three budgets (FY09, FY10, and FY11) and one for the stimulus package while still operating under a continuing resolution that limits spending. An omnibus spending bill for FY09 is expected shortly. For FY10, the Department is working on priorities for the President's Budget and anticipates submitting a budget to Congress in March or April. For FY11, the budget will begin to be prepared in April. The focus of the American Recovery and Reinvestment Act (ARRA; the stimulus) is on infrastructure and construction rather than operations and multi-year research. DOE will benefit from this. DOE's Office of Science (SC) has $1.6 billion from this bill. The bill is expected to be signed by the President soon. There are many great ideas, but nothing has been finalized, pending Secretary-level and Office of Management and Budget (OMB) approval. Infrastructure improvements that can be paid off in the next 18 months are being looked at. The BER budget profile has not changed recently but stands to benefit from the ARRA.

Sharlene Weatherwax has been recruited as Director of the Biological Systems Science Division. She brings a strong background in both microbiology and plant science to the position. The Office is currently recruiting a plant biologist and a program specialist. It is also finalizing efforts to recruit Intergovernmental Personnel Act staff (IPAs) in plant molecular biology and climate modeling. Patrick Glynn moved from BER to the Office of the Deputy Director for Science as Senior Technical Policy Advisor. The leadership of the Climate and Environmental Sciences Division is still open; Wanda Ferrell is currently acting director. Roger Dahlman has returned from an 8-month detail at the Climate Change Science Program Office. Palmisano thanked the staff of BER for their support, especially Michael Riches and Joanne Corcoran.

BER is embarking on missions with 10-year horizons:

- Developing biofuels as a major secure national energy resource,
- Understanding relationships between climate change and Earth's ecosystems and assessing options for carbon sequestration,
- Predicting the fate and transport of subsurface contaminants, and
- Developing new tools to explore the interface of biological and physical sciences.

BERAC can play a critical role in developing a long-term vision for BER science by looking at a 20-year horizon to position BER for future opportunities and challenges and

learning from the "Basic Research Needs" model of BES, that identified basic research directions required for major technological changes in energy production and use, described a vision for a new era of science, provided inspiration for a series of 10 focused workshops that galvanized the scientific community, and allowed identification of important recurring themes and science grand challenges.

The Biological Systems Science Division conducted (1) a National Synchrotron Light Source II (NSLS-II) Imaging and Spectroscopy Workshop (http://www.science.doe.gov/ober/NSLS_Informal_Report.pdf); (2) a Joint DOE–USDA [U.S. Department of Agriculture] Workshop on Sustainability of Biofuels (for which the report being finalized); (3) the Workshop on New Frontiers of Science in Radiochemistry and Instrumentation for Radionuclide Imaging (http://www.sc.doe.gov/ober/radiochem_2008workshop_report.pdf); and (4) the Workshop on Low Dose Epidemiology. Genomics: GTL had its principal investigator (PI) meeting with more than 500 attendees. Plenary sessions included presentations by the DOE Bioenergy Research Centers, and breakout sessions on biohydrogen; annotation; multiscale computing; Ethical, Legal, and Social Issues (ELSI) and sustainability; and the USDA-DOE Plant Feedstock Genomics for Bioenergy Awardee Workshop 2009.

Reviews have been conducted for the three Bioenergy Research Centers, and a triennial onsite review of the Joint Genome Institute (JGI) was held. JGI will hold a user meeting March 25-27, 2009, in Walnut Creek, Calif., with sessions on improving biomass, its degradation, and biofuels; genome evolution and adaptation; new sequencing technologies and functional genomics; and synthetic biology and workshops on JGI 101, integrated microbial genomes, and eukaryotic annotation.

Broido noted that the Committee of Visitors (COV) referenced the JGI's onsite review and asked if that will be discussed later. Palmisano responded that the final report is still being prepared and will be discussed at the next BERAC meeting. Broido pointed out that there is a 6-month plan, and the knowledge from the review is needed to inform that planning effort.

In the Climate and Environmental Sciences Division, workshops were held on (1) Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) (http://www.arm.gov/publications/programdocs/doe-sc-arm-0707.pdf), (2) Climate Change Prediction Using Extreme Scale Computation to explore the potential applications of extreme-scale computing research to enable discovery in climate change science, and (3) Exploring the Future of Integrated Assessment Research.

A review was held of the Environmental Molecular Sciences Laboratory in August 2008. The results were extremely positive. The review found that the Laboratory is doing world-class science and has strong strategic planning and good implementation, strong leadership and vision, and good user communication but needs to increase user support time.

The Scientific Focus Areas (SFAs), BER's new management approach for funding merit-reviewed research at the national laboratories, encourage integrative, collaborative research programs in support of the DOE mission. SFAs take advantage of unique national laboratory strengths in interdisciplinary, team-oriented, mission-relevant research. They will enhance dialogue between national laboratory science managers and BER program managers. Best management practices will be developed and shared with the national laboratories with follow-up conference calls. It is anticipated that new funds will be openly competed among universities and national laboratories, except in cases of targeted needs. BER continues to encourage national laboratory–university collaborations.

Partnerships are important to BER. Through a partnership with the Office of Advanced Scientific Computing Research (ASCR) it has leveraged the nation's intellectual investment in computational science for scientific discovery in climate change research to study how the Earth's climate will respond to physical, chemical, and biological changes produced by global alterations of the atmosphere, ocean, and land; in Genomics: GTL to develop new methods for modeling complex biological systems, including molecular complexes, metabolic and signaling pathways, individual cells, and interacting organisms and ecosystems; and in environmental remediation sciences to develop more-advanced models for better understanding the movement of subsurface contaminants.

BER also partners with other federal agencies to leverage budgets and coordinate national scientific programs, such as DOE-USDA Genomics for Bioenergy Feedstocks; Strategic Environmental Research and Development Program (SERDP); Protein Data Bank [with the National Science Foundation (NSF) and the National Institutes of Health (NIH)]; Fogarty Center International Collaborative Biodiversity Groups (along with NSF, USDA, and NIH); the National Aeronautics and Space Administration (NASA) Human Research Program (HRP) Space Radiation Research Project; and the Climate Change Science Program. New and ongoing partnerships include those with NSF Geosciences on climate research and with the NIH National Center for Research Resources (NCRR) on structural biology and proteomics. Memoranda of understanding have been signed with NIH and NSF on renewed support for the Protein Data Bank and with the USDA Forest Service to support collaborative activities with the DOE Bioenergy Research Centers. During the next day's session of this meeting, the development of a long-term vision, JGI strategic planning, and interagency partnering will be discussed.

Broido noted that another avenue of interaction is for BERAC members to call the Chair or the Director directly.

Bierly asked how BER's relations were with Fossil Energy (FE) and Energy Efficiency and Renewable Energy (EERE), who are getting a lot of money from the stimulus bill, more than the Office of Science (SC). Palmisano responded that BER has some wonderful partnerships with other offices (e.g., the Office of Biomass of EERE). It is anticipated that BER will work closely with them on stimulus-funded programs. In FE, they lean toward commercialization. BER has a long-standing relationship with Environmental Management (EM).

Tiedje stated that the SFAs should be closely focused and should report frequently. He asked what encouragement was given to the national laboratories to collaborate with universities. Palmisano said that the incentive is science, and there are a lot people on this Committee who have benefited from such collaborative offers. The SFAs are reviewed annually. Unsuccessful funding is recompeted.

Sayler asked if she saw cooperation with FE and EERE as part of a strategic plan. Palmisano responded that that was an important observation. Secretary Chu wants to enhance interactions among offices across the Department. That secretarial buy-in will have a huge influence. More such efforts should occur.

Wildung said that regional centers and environmental remediation and other topics could be fruitful. Palmisano responded that the NAS review of the GTL program advised having similar regional centers in bioremediation and other topics. On the horizon, scientists should be galvanized around such questions.

Leinen noted that things may change quite quickly in climate-change science and asked if the Climate Change Division could react to such rapid change. Palmisano answered that the Strategic Plan is a dynamic document and it has a framework within which changes can be made quickly. Broido stated that, with the change in national leadership, the plan is already obsolete. In previous changes of administration, the bureaucracy reacted quickly. She was confident that it will do so again. Palmisano said that, with the change in administration, it may be possible to accelerate some programs.

Joachimiak asked how one can keep these programs operating in the future. Palmisano responded that that is what is keeping Michael Riches so busy: structuring the budget.

A break was taken at 10:10 a.m. The meeting was reconvened at 10:25 a.m.

Sharlene Weatherwax was introduced to give an update on the Biological Systems Science Division.

The SFAs include GTL Fundamental Science, GTL Biofuels, Low-Dose Radiochemistry and Instrumentation, and ELSI.

The SFAs have laboratory and BER points of contact; and the DOE programs have points of contact; and these points of contact coordinate activities with weekly reports. Science research plans will be drawn up in May, and a merit review panel of the SFA plans is scheduled for summer 2009.

Several solicitations are in play:

- 09-03 is a joint USDA–DOE plant feedstock genomics solicitation (closed)
- 09-08 is an ongoing integrated radiochemistry research projects of excellence solicitation

- 08-21 is a low-dose-radiation research for integrated programs solicitation for which funding is not yet available (closed)
- 08-20 is a low-dose radiation research for basic biology and modeling solicitation for which funding is not yet available (closed)
- NSF 08-588 is an interagency opportunities in metabolic engineering solicitation for which funding is not yet available (closed)

There was a workshop on biological imaging and spectroscopy for work to be done at the NSLS II, being built at Brookhaven National Laboratory (BNL) for completion in 2015, cosponsored by DOE and NIH. An informal workshop report is available on the web (see above). The goal is to develop new synchrotron technologies for studying systems important to cellular function. Proof-of-principle work has been completed on enzymatic catalysis of cellular functions.

A workshop on low-dose epidemiology was held in December to discuss existing studies of low-dose/dose-rate epidemiology and future needs. It found a critical need to re-examine low-dose human epidemiological studies because many worker studies can be usefully expanded and updated to the present and meta-analysis performed.

The Radiation, Imaging, and Instrumentation Program had a program review.
The Genomics: GTL had its annual PI meeting in Rockville, Maryland, on February 8–11, 2009.
The Carbon Cycling and Biosequestration Workshop report is available (http://genomicsgtl.energy.gov/carboncycle).
The Knowledgebase Workshop Report is available (http://genomicsgtl.energy.gov/compbio/) .
A Workshop on Advanced Characterization and Imaging of Biological Systems is being planned for May 2009.

GTL Science is closely cooperating with SciDAC [Scientific Discovery Through Advanced Computing]. One cooperative project is to predict an organism's phenotype from its genomic sequence and produce new computational tools for redesigning metabolic networks.

All three Bioenergy Research Centers (BRCs) are up and running. The science and management of the centers have been reviewed. The findings were enthusiastic. The hosts stood up and staffed the centers quickly and well. The start-up phase was executed successfully. All centers have demonstrated significant research accomplishments. A high-throughput characterization pipeline has been established at the BioEnergy Research Center (BESC) at Oak Ridge National Laboratory (ORNL) to link genes and genetic markers to develop less-recalcitrant feedstocks. New ionic liquid biochemical pretreatment methods for enzymatic breakdown of biomass has been developed at the Joint BioEnergy Institute at LBNL. And leaf-cutter ants were analyzed for novel deconstruction microbes and enzymes at the Great Lakes Bioenergy Research Center at the University of Wisconsin; hundreds of good degraders were isolated.

The JGI science and operations review was held in December 2008. The findings and recommendations will be issued soon. JGI strategic planning is under way. They have completed the sequencing of the soybean genome and published the sorghum genome.

In the Division, an offer has been extended for an IPA for a biologist position. Interviews are being held for a program specialist. A plant biologist is also being sought. A Division retreat is scheduled for April 15.

Padgette asked if the drop in oil prices and the economic crisis will affect the Division's planning. Weatherwax replied that industry is cutting back on research funding. The Division is working closely with EERE and is looking into possible cost-shared programs.

Stacey asked what was being done to coordinate the BRCs and the core facilities. Weatherwax responded that the centers are partnered with core facilities and are actually doing some of their work there. Two centers are located at laboratories with core facilities and use the facilities there.

Wildung asked how BER and the Office of Basic Energy Sciences (BES) are working together. Weatherwax answered that coordination was being conducted at the program-manager level to make sure that they are complementing each other's research.

Wanda Ferrell was asked to update the Committee on the Climate and Environmental Sciences Division (CESD).

BER's Climate Change Program Strategic Plan is complete (http://www.sc.doe.gov/ober/CCRD/climate%20strategic%20plan.pdf). Atmospheric Science and ARM are developing a joint science plan. In the Program for Ecosystem Research, several sites are being shut down.

Two solicitation updates are outstanding:

- Climate Change Modeling, LAB 09-06, to enhance CESD Earth System Models and
- Environmental Remediation Science Program, Notice DE-PS02-09ER09-07, to support innovative, fundamental research on the transport of subsurface contaminants.

In the future, there will be three new calls on the topics of carbon sequestration, terrestrial carbon processes, and new technologies for next-generation experiments.

The Environmental Remediation Sciences SFA was reviewed last year. One SFA's science plan was found lacking, and that project is being recompeted. Climate program plans were received from six national laboratories. Comments on the plans were sent to those laboratories in late January. Science plans are due in May. A merit review panel is being planned for mid-June.

The ACRF provides long-term observations addressing the critical role of clouds and aerosols and their influence on radiative processes in the atmosphere. This effort addresses the largest uncertainty in climate models. ACRF has 10 sites around the world. It has successfully completed the ARM Mobile Facility (AMF) experiment in China; completed the Indirect and Semi-Direct Aerosol Campaign (ISDAC) at the North Slope of Alaska site; and began a 6-month aerial campaign in January to study thin clouds.

The ARM Science Program improves scientific understanding of the fundamental physics of clouds and the interactions between clouds and radiative feedback processes in the atmosphere to improve climate model predictions. It has improved climate models through convective parameterization, improved parameterizations for mixed phase clouds, and a new cloud microphysics scheme being implemented in CAM3.

The Atmospheric Science Program has four components:

- Laboratory studies of basic processes
- Field campaigns for "real world" observations and to validate model predictions
- Model-based representations of processes (develop, implement, and validate)
- Measurement instrumentation / method development

Some of its accomplishments include: participation in VOCALS [VAMOS (Variability of the American Monsoon Systems) Ocean-Cloud-Atmosphere-Land Study], an international campaign, off the coast of Chile; a new aerosol microphysical module developed and evaluated for the Goddard Institute for Space Studies (GISS) climate model; and the development and characterization of Fast-Stepping/Scanning Thermodenuder for Chemically-Resolved Aerosol Volatility Measurements.

The Terrestrial Carbon Program is designed to understand processes and mechanisms controlling the exchange of CO_2 between the atmosphere and terrestrial ecosystems. It is concluding the Free Air Carbon Dioxide Enrichment (FACE) experiments and planning for the next generation of experiments. It found a novel relationship between nitrogen and albedo.

The Program for Ecosystem Research investigates the potential effects of climate change on terrestrial ecosystems. It has shown that climate change is causing rapid shifts in plant distribution in the California mountains.

The DOE Climate Change Modeling Program determines the range of climate change over the 21st century at high spatial and temporal scales. It has helped resolve the disagreement of observations with theoretical expectations of greater warming in tropical troposphere than at the tropical land and ocean surface. A BER-supported model improves simulation of sea ice and has been integrated in global climate models.

The Integrated Assessment Research Program helps to:

- Understand and model the complex interactions of human and natural systems;
- Explore developmental pathways, emissions, role of energy innovations, and mitigation strategies;

- Provide insights into climate change impacts, adaptations, and effects of combined, multiple stressors; and
- Develop global, national, and regional perspectives within economic and other policy-relevant frameworks.

The Program has provided insights in three reports: (1) spatial distribution of population and emissions to 2100, (2) climate feedbacks to energy demand in China, and (3) consequences of carbon–nitrogen interactions on feedbacks between climate and the terrestrial carbon cycle.

The Environmental Remediation Sciences Program is advancing fundamental understanding of coupled physical, chemical, and biological processes controlling contaminant mobility in the environment and addressing DOE's intractable environmental remediation, long-term stewardship and nuclear waste disposal issues. The Program has successfully developed (1) new genome-based tools to improve description of uranium bioreduction in the environment and (2) science-based bioremediation strategies for reducing chromium concentration in the groundwater at the Hanford Site.

The Environmental Molecular Sciences Laboratory (EMSL) has integrated experimental and supercomputing capabilities that enable users to study molecular-level processes underpinning energy and environmental challenges. More than 60 leading-edge capabilities and expert staff are made available to University, DOE Lab and Industry scientists. EMSL focuses on

- Biological interactions and dynamics,
- Biogeochemistry/geochemistry and subsurface science, and
- Science of interfacial phenomena.

It has discovered (1) a rare, linear chromosome in cyanobacteria; (2) two new isomers of 9-atom boron clusters; and (3) ozonolysis of unsaturated organics on salt crystals that may aid in understanding the role of these aerosols in dry environments.

Workshops include the ACRF Workshop, Integrated Assessment Research Program Workshop, and International Workshop on Climate Change Prediction Using Extreme-Scale Computation.

Roger Dahlman has completed the detail to Climate Change Science Program Office, and an offer has been extended to a candidate for an IPA in the Climate Modeling Program.

Jeffrey Amthor was asked to update the Committee on the BER Climate-Change Research Strategic Plan.

The Plan is posted at the BER website (see above). It is based on BER's Climate Change Research mission statement: Advance the forefront of climate change research to provide the nation with the scientific knowledge it needs about the effects of greenhouse gas emissions on Earth's climate and biosphere to support effective energy and environmental decision making.

The Plan builds on a wide range of previous reports, especially the Report of the BERAC ARM Facility Review Panel, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, U.S. Climate Change Science Program's Synthesis and Assessment Products, and the National Research Council reports related to climate change research.

The energy–climate link is the foundation of the Plan. The strong link between climate change and greenhouse gas emissions resulting from fossil fuel use makes improving the scientific understanding of ongoing climate change a priority for DOE because the Department (1) is responsible for developing and sustaining a national energy system that is secure and environmentally sound; (2) provides critical R&D to deliver future energy systems and infrastructure, that might be affected by the future climate; and (3) has the unique research capabilities and facilities, as well as the scientific leadership, needed to tackle complex climate change science issues. It has a distinguished history of climate change research. BER has been a leading member of the multiagency U.S. Global Change Research Program since that program's creation two decades ago.

Today, BER is an international leader in climate-relevant atmospheric process research and modeling, including clouds, aerosols, and the terrestrial carbon cycle; state-of-the-science climate change modeling; experimental research on the effects of climate change (and associated changes in atmospheric composition) on ecosystems; and integrated analysis of climate change from the causes through to the impacts, including impacts on energy production and use.

The Plan focuses on two high-priority general questions: When, where, and by how much will climate be affected by increasing greenhouse gas concentrations in the atmosphere? And what are the likely consequences of climate change for ecosystems, the energy system, and other important human and natural systems? In answering these questions, BER-supported climate change research is generating the scientific knowledgebase needed to

- Inform the public discussion about the science of climate change;
- Support scientific considerations of energy policy options related to climate change; and
- Provide the scientific foundations and tools that can be used by the nation to plan for, adapt to, and mitigate climate change.

The overall plan is directed toward a general outcome. In the coming decade, BER Climate Change Research will play a leading role in providing the nation's decision makers (including the public) with the scientific information they need to understand, plan for, and potentially adapt to and mitigate the environmental and economic consequences of climate change. It is expected that the scientific knowledge that is needed to evaluate alternative energy strategies and supply the insights needed to plan new energy technologies and infrastructures necessary to meet society's demands for reliable energy in a changing climate.

The Plan has five interconnected strategic focus areas: climate change process research, climate change modeling, climate change ecological effects research, carbon sequestration research, and education. Within each of these there is

- A focus-area-specific mission statement
- A terse evaluation of the current situation, including a list of specific high-priority science questions
- An outline of BER resources available to answer the science questions
- A list of up to 5 specific near-term goals (1 to 3 years)
- A list of up to 5 specific mid-term goals (4 to 6 years)
- A list of up to 4 specific long-term goals (7 to 10 years)
- The desired outcome for science and society within this focus area

The Plan has several science questions, including: What are the climatically relevant chemical and physical properties of aerosols that control their effects on the atmosphere's radiation balance, and how can they be best represented in climate models? And it has a large number of near-term goals, such as: Begin intensive characterization of the 3-D structure of clouds through an expanded horizontal measuring capability of the ARM Facility.

The take-home message is that climate change is of considerable significance to the nation and the world. People everywhere need information about climate change based on objective, leading-edge science. BER is prepared to make rapid advances in providing science-based answers to many of the high-priority science questions about climate change, and the Strategic Plan provides a path toward answering those questions sooner rather than later.

Broido pointed out that Palmisano had noted that the Secretary is interested in transformative, not incremental, progress. The plan should be oriented toward the transformative. She asked if the science questions had changed. Amthor replied, no, they have not. This plan is not incremental at all. The field is moving to a new scale in modeling and is addressing new issues. Broido asked if he could give an example. Amthor pointed out that, in the ARM Program, the researchers are poised to go from 1-D to 3-D right now.

Leinen asked how the Strategic Plan could (1) allow people to understand nonlinear changes, (2) identify the climate-change consequences of various energy strategies and the new class of problems that they call up, and (3) quickly adapt a generic approach to a specific problem. Amthor confessed that the Division is not doing a lot of those things; instead, it is trying to develop this plan given a very limited budget. It is looking at calls that respond to workshop recommendations. It is looking at modeling being helpful to those deploying windmills. Bamzai added that the National Climate Service will need the best scientific underpinnings.

Joachimiak said that GTL is looking at different applications. The research can help model the cropping systems, and data assets should be coordinated with these social

systems. Amthor agreed and noted that the Division was not funding any more two-point experimental studies. Everything has to reflect multiple levels.

Sharlene Weatherwax was asked to respond to the COV Report on the Life and Medical Sciences Division.

The COV was charged to assess the processes that the Division used to solicit proposals, recommend funding actions, manage the research program, and respond to the 2005 COV report. The COV's report (http://www.sc.doe.gov/ober/berac/LMSD_2008_COV_report.pdf) and the Division's response (http://www.sc.doe.gov/ober/berac/LMSD_COV_Response_2008.pdf) have been posted on the web . General observations by the COV included that BER is increasing staffing, travel funds, and efficiency. No new program advisory committees were established because of time and costs. Many programs have their own advisory committees. The Division will continue to organize workshops, participate in workshops of other agencies, and participate in scientific meetings.

The recommendations regarding levels of funding are out of the scope of the COV.

In the GTL, there is improved documentation, continuation of the current strategy, and improved documentation in the FY09 with the SFA process.

In the BRCs, the Division's strong oversight mechanisms are being continued, and each center has its own science advisory committee. Communication continues to be improved, and centers' sequencing requests are being coordinated.

In the Computational Biology Program, the focus continues to be on the GTL Program's priority needs: knowledgebase development, bioinformatics, and communication with the GTL research community. The Division continues to work actively with ASCR, as appropriate.

Stacey asked how DOE coordinates with the iPlant Collaborative [a distributed, cyberinfrastructure-centered, international community of plant and computing researchers]. Weatherwax responded that iPlant was invited to attend the Division's workshop and give a plenary address. The Division has no direct input into iPlant's selection of grand challenges.

In Structural Biology, the NSLS II workshop was cosponsored with NIH. BER and NIH will assess the status of the U.S. Pixel Array Detector Project. BER will initiate multi-agency discussion for developing life-science capabilities at the Spallation Neutron Source (SNS) and coordinating with ORNL to define the priorities for new biology experimental stations at the SNS. BER will support the full range of BER activities at these facilities.

Petsko asked if any thought had been specifically given to structural biology. Weatherwax replied, yes; but it will be broader than GTL. Palmisano added that the

Office is working closely with many agencies because the appetite for structure is widespread. As much will be done as the budget allows.

In terms of the Radiochemistry and Instrument Program, BER held a community workshop to focus its research. Beginning in FY09, the program is reconfigured to reflect DOE's energy and environmental missions.

The Artificial Retina Program will be ended in FY 2010 because the proof of concept will have been accomplished. The private sector now has it in clinical trials. Broido said that a recent report from the NAS highlights the Artificial Retina Program in its description of advanced technologies.

In carbon sequestration, the joint USDA-DOE Plant Feedstock Genomics for Bioenergy program is placing a greater program emphasis on using genomics to understand bioenergy crop response to nutrient and water use, two key impacts expected from climate-change predictions.

In Low-Dose Radiation Research, solicitations have already asked for high-risk/high-payoff research applications, but funding is not yet available.

In ELSI, BER will continue to hold workshops and to explore potential ELSI topics but will not establish an advisory committee.

In the JGI, BER will improve merit review, introduce more transparency, consider the transformative nature of the research, review more active management of JGI, and put greater emphasis on informatics.

Riley pointed out that the COV recommended increased staffing levels and advisory committees because the Division was not getting the needed input and patterns of communication for cutting-edge research. It may be a pain in the neck to establish advisory committees, but the Division needs them to develop great strengths. Palmisano said that she was surprised how the staff had been depleted. Building it up (even with IPAs) is her highest priority. Those positions need to be filled in a strategic manner, and the Office is constantly looking for new slots. Given the stewardship of one half billion dollars, the Office needs to build up its staff to be good stewards.

Stacey noted that workshops reflect the participants. The environmental remediation workshops rarely include agriculturalists. Focus groups can identify such lacks in expertise and improve the output at a lower cost. Weatherwax said that the Division would welcome such small-group discussions, but it has to be careful not to violate Federal Advisory Committee Act (FACA) rules. With more travel to scientific meetings, program managers can do more networking and engage in more dialogues. They need to be freed up from administrative duties.

Riley asked if communication between the JGI and the BRCs could be brought up during the report on the JGI review. Weatherwax said that Rubin would probably respond to that question in his presentation during the following day's session.

A break for lunch was declared at 12:33 p.m.

Wednesday, February 18, 2009
Afternoon Session

The meeting was called back into session at 2 p.m.

Martin Keller was asked to report on the BioEnergy Science Center (BESC) at ORNL.

The BESC is a multi-institutional DOE-funded center dedicated to understanding and modifying plant biomass recalcitrance. Access to the sugars in lignocellulosic biomass is the current critical barrier. Savings in processing cost for the conversion of biomass into available sugars are much greater than those for conversion of sugars into biofuel. Biomass modification will streamline baseline, multistep cellulosic ethanol production and lower costs.

A two-pronged approach focuses on switchgrass and poplar. The first strategy applied is to identify, understand, and manipulate the plant-cell-wall genes responsible for recalcitrance. The second is to measure, understand, and model biomass recalcitrance. The third is to identify, understand, and manipulate "biological catalysts" to overcome recalcitrance.

In the first strategy, many of the cell-wall biosynthetic genes are not yet identified. Currently, only 5 to 10% of the *Arabidopsis* wall biosynthetic enzymes are known out of more than 2000 such enzymes; only ~20 genes have been identified out of more than 200 wall polysaccharide transferases for *Arabidopsis*; and only 40 to 60 % of the 20 to 30 lignin biosynthetic genes have been identified. Multiple types of proteins affect cell-wall synthesis, but it is not known which of these affect recalcitrance

Petsko asked how the 2000-enzyme value was arrived at. Keller answered that it was estimated from the number of steps needed to synthesize the wall.

Two methods are used to identify recalcitrance genes: The targeted cell-wall synthesis method includes testing known putative recalcitrance genes in via *Populus* and switchgrass transgenics. Basic research is needed to identify unknown genes and to decipher how they affect recalcitrance. The discovery-based natural-variation method includes identifying natural variation in recalcitrance, identifying the gene responsible, testing via *Populus* and switchgrass transgenics (TP), and activation tagging. To determine what genes control cell wall synthesis, one looks at native plants and conducts high-throughput screening (HTS) for sugar accessibility, producing a database.

A gene transformation pipeline has been established and is running 70 *Populus* genes per set, 4 switchgrass for stable transformation per set, and 30 switchgrass by viral-induced gene silencing (VIGS) per set. Three sets totaling more than 300 genes are in the pipeline after three rounds of review. For *Populus*, 200 genes per year can be transformed, and 1000 genes per year can be activation tagged. For switchgrass, 20 genes can be transformed in the first year and 40 to 60 in the second; 200 genes per year can be spliced. It takes about a year to select and characterize one putative recalcitrance gene.

A Plant Biomass Recalcitrance Gene KnowledgeBase (KB) has been established with reference genomes, BESC curation, gene discovery tools, pathway building, and links to BESC data. This knowledgebase contains "everything" about a plant gene.

In the second strategy, a high-throughput characterization pipeline has been established for the recalcitrance phenotype. Screening of thousands of samples is leading to a detailed structural analysis of specific samples.

Each biomass type has to be tested individually for its digestibility. This task is being done at the rate of 20 biomasses/day. Composition data from analytic pyrolysis (molecular beam mass spectrometry) for high-throughput (HTP) screening of transgenic populations is rapid and reliable and gives values for glucan, xylan, lignin, and details on monomers. The idea was to develop an HTP pretreatment for thousands of small samples, going straight to the sugar analysis. A 96-well-plate Pretreatment and Co-hydrolysis Performance was developed that yields the same total sugar release as conventional reactors and washed solids hydrolysis.

Recalcitrance is ultimately determined by enzyme access to carbohydrates and sugar release. First-tier assays (>1000 samples/week) evaluate baseline susceptibility of pretreated biomass as well as enzymes from natural diversity. Second-tier assays (~200 samples/day) subject hits from the primary screen to multidimensional assays using engineered enzyme cocktails for precise assessment of cell-wall changes. That is what is seen in the lignin content vs. sugar released data. Hot-water pretreatments at 160 and 180ºC led to 95% sugar release, meaning that there are trees out there that are amenable to treatment.

The next step is to conduct a pretreatment/saccharification analysis of poplar diversity. Laboratory information management system reports are used for science and for material transfer agreements. Detailed analyses of specific samples inform cell-wall chemistry and structure. Solid-state nuclear magnetic resonance (NMR) spectroscopy is used to characterize whole cryo-milled cell-wall residue, the results of which are then compared to those from liquid NMR spectroscopy.

Preliminary conclusions from a detailed analysis of alfalfa mutants show that a crosslinking between polymers is critical, altered localization does occur in mutants, crystallinity was not a major factor, and multiple techniques on the same samples add insights in the hands of experts.

In the third strategy, novel environments are explored, working with rumen endosymbionts, caecum endosymbionts, coleopteran larvae, biotraps, shipworms, and fungi. About 10^7 clones were screened for activity, and 29 unique enzymes were discovered.

Integrating expression, proteomics, single-nucleotide polymorphisms (SNPs), and metabolites on cellular systems in a bioenergy-related microbes knowledgebase allows one to compare everything known about these genes. Developing tools to allow people to do this faster is important.

BESC has developed a new website (http://bioenergycenter.org/). In addition it has made more than 138 presentations at meetings, published 29 papers, given 11 workshops, disclosed 10 inventions, made more than 70 presentations to stakeholders, and given more than 65 media interviews.

Some of the lessons that have been learned are: A coherent vision, goal, and theme are critical to create a team, mission and excitement. Have your arguments early and honest and based on strong scientific judgment and respect developed with input from the whole team. After a vision is defined, let the science lead. Make sure success is defined through clear milestones and deliverables. Management needs to strongly encourage collaborations by intentional scientific plans, by "natural" means, and by directive. A strong, integrated operations team is essential for start-up. Leveraging unique strengths among universities, national laboratories, and industries creates synergy. A center can be highly integrated without being collocated. Allowing scientists to participate from home institutions enables the assembly of a team with a much higher proportion of the most accomplished experts. Capital costs are lowered by using existing infrastructure/equipment available at partner facilities. Travel costs are higher than for other organizations because of the need for periodic center meetings and workshops. Establishing and maintaining trust between partners is imperative. Organizational discipline is critical to success. Communication is essential.

Tiedje asked how one evaluates a treatment's effects when there are so many confounding variables. Keller said that one gathers the data and works backwards. The natural variability is more than 50%. Just because they are not attacked by insects or disease in a small plot does not mean they will not be on a large scale. The data need to be spread out so the variation can be seen across a tree, a zone, and a plot.

John Houghton was asked to report on the Workshop on Bioenergy Sustainability.

Recalcitrance is a dominant factor in the cost of biofuels and has implications for the amount of biomass needed and, thereby, the sustainability of biomass production and harvesting.

As part of the Energy Independence and Security Act of 2007 (EISA), the Renewable Fuel Standard (RFS) mandates that 36 billion gallons of biofuels are to be produced annually by 2022, of which at least 16 billion gallons are expected to be produced from

cellulosic feedstocks. In addition to provisions for biofuel production, EISA recognizes the importance of biofuel sustainability by mandating a life-cycle analysis for biofuels every two years and the development of sustainability criteria and indicators.

In a traditional framework for understanding biofuel systems, disturbance gives way to a cropping system that produces ecosystem services that have implications for the human social system.

"Sustainable biofuels" constitutes the economic production of biofuels today in ways that consider current and future environmental and social needs. The three key aspects of sustainability are

1. Environmental aspects require consideration of biogeochemical and biodiversity responses at multiple scales.
2. Economic aspects require assessing demand for biofuels and ensuring that cellulosic biofuels are cost-competitive with other fuel sources and profitable for feedstock producers and refineries.
3. Social sustainability aspects require consideration of food security, energy security, and rural community interests, among others.

To fully understand each key element, it is necessary to know how they interact.

BER develops biofuels as a major secure sustainable national energy resource; seeks to understand the potential effects of greenhouse gas emissions on Earth's climate and biosphere and their implications for our energy future; predicts the fate and transport of contaminants in the subsurface environment at DOE sites; and develops new tools to explore the interface of biological and physical sciences.

A workshop was held to address salient sustainability issues, survey the present state of knowledge, point out gaps in understanding where more research is needed, and produce a report that summarizes these items. It was jointly sponsored by DOE/BER and USDA Resource, Education, and Economics (REE). The report is expected to be released in March. The workshop identified important environmental, economic, and social aspects of sustainable biomass production.

It urged the investigation of improved models of carbon, nitrogen, and water cycles to predict feedstock productivity and environmental outcomes by examining long-term data to predict changes in soil, microbial, nutrient cycling of biofuel ecosystems to long-term environmental change, using varied rainfall, temperature, and other factors where possible; linking biophysical models to land use, economic, other socioecological models; and identifying response thresholds to residue removal and fertilizer inputs.

It also urged the use of advanced genomics to characterize microbial communities within biofuel plant–soil systems.

More is needed to be known about carbon cycling and sequestration, methane, and nitrous oxide fluxes for candidate biofuel cropping systems; and field-deployable

instrumentation for quantifying in situ nitrous oxide and methane fluxes need to be developed.

Water supply and quality are important. Research needs to determine water fluxes in mixed agricultural systems, including investigating water use for marginal lands; initiate modeling studies to compare current climate conditions with projected future climate change; understand the effects of crop selection and cultivation on streamflow and groundwater to better manage the water cycle; investigate new approaches to agricultural and silvicultural land-use design and management practices that reduce runoff of sediments, nutrients, pesticides, or other inputs; and establish watershed-scale field studies examining hydrology and water-quality effects of conversion from agricultural crops and other land uses to different bioenergy crops and cultivation options.

In terms of biodiversity and ecosystem services, research needs to determine the services provided by biofuel feedstocks as a function of feedstock, regional characteristics, and cultivation practice; build improved models of the projected impacts of bioenergy crops on biodiversity and ecosystem services in agricultural landscapes; study impact of invasive, exotic, or transgenic biofuel crops on ecosystem services; and investigate the connections between biodiversity and resilience, and identify perturbations of concern.

More is needed to be known about large scales than about regional scales.

In the economic section, research needs to develop a regionally detailed supply curve for cellulosic ethanol; provide scenarios of patterns of crop selection for other analysts; assess noncropland availability for biomass crop production; develop consistent life-cycle analysis tools; and assess the impact of cellulosic ethanol on land-use changes, which are major.

And in terms of social aspects, research is needed to analyze and better understand stakeholder values and views regarding biofuel development. These issues include

- Potential economic and job impacts;
- Options for models of ownership, such as cooperatives, and allocation of risk for participation in biofuels development;
- Ecosystem services and biodiversity; and
- Infrastructure changes, such as transportation.

Research is also needed to improve economic, environmental, and land-use models to more explicitly portray social concerns.

Washington noted that the workshop was held in October and that biofuel plants are now closing down across the country. He asked if the economic models could have predicted that. Houghton replied that the Division was interested in lignocellulosic alcohol, not the corn ethanol that is produced in the United States. The Energy Information Administration (EIA) models could and did predict the decrease in corn ethanol.

Petsko asked if the development of plants that made more accessible sugars was considered at the workshop. Houghton replied, no.

Penner noted that it is difficult to scale up to the regional level for CO_2 flux and asked how one could do that. Houghton answered that the workshop participants were told that one cannot scale from the field to the region now and that more work needs to go into that problem. It is particularly important for biofuels.

Wildung said that he did not see any reference to fundamental research being needed.

Houghton replied that there were lots of systems-biology and other fundamental-research issues brought up at the workshop. The report will summarize some of these topics. Tiedje added that there was a lot of fundamental research discussed. Those details just did not make it to a high-level description.

Stacey asked if there was any focus on biochemical conversion. Houghton replied, yes, but the workshop did not consider thermochemical conversion.

Prem Srivastava was asked to report on the Workshop on Radiation and Instrumentation for Radionuclide Imaging.

A workshop was held November 4-5, 2008, to ascertain how radiochemistry and radionuclide-detection instrumentation could be used to benefit diverse aspects of basic research in microbial and plant metabolism relevant to biofuel production and bioremediation and be transferable for use in nuclear-medicine research and applications by NIH and industry. Invitations went to workers in biological sciences, environmental sciences, nuclear medicine sciences, radiochemistry, instrumentation, and imaging applications. The workshop brought together 43 scientists from plant, microbial, and environmental biology with chemists, physicists, and engineers from the nuclear-medicine research community. Participants were from academia, NIH, and DOE national laboratories. It had a general session on

- Brain imaging from genes to behavior
- Imaging instrumentation
- Radiotracers for imaging applications
- Transport of radionuclides in biological systems
- Microbial bioremediation/biomineralization
- Fluorescent probes for visualizing living plant cells and plant-associated microbes
- Photosynthetic biofuels: tracing metabolic pathways

and breakout working groups on challenges and opportunities in

- Radiotracer chemistry
- Radionuclide and hybrid instrumentation development
- Radioisotope methodologies for probing plants, microbes, and the environment
- Identification of new technologies for plants and environmental biology

Some generic questions were posed to the breakout groups, and they identified some new research opportunities:

- More generally applicable and reliable methodologies to expand the range of radiotracers for broader use
- Radiotracer approaches for labeling of macromolecules and nanoparticles at high specific activity for PET/SPECT (positron-emission spectroscopy/ single photon emission computed tomography) or multimodality imaging
- Generator systems or compact and portable devices for onsite radiotracer chemistry
- Improvements in radionuclide imaging instruments for spatial resolution, efficiency, volume, and geometry requirements relevant to plants
- Dual-modality imaging devices to address problems of resolution, object size, sensitivity, time scale, and operation in a wide range of environments

Working groups 1 and 2 were also presented with group-specific questions about the current state of science needs. They identified these research opportunities:

- Development of chemical reactions to overcome synthetic constraints of working with radioisotopes at high specific activity
- Physical chemistry models to predict reactivity at the tracer mass scale
- Construction of nanoparticle platforms
- Automation technologies for radiotracer synthesis
- Scanner geometries for geometries and fields of view ranging from 100 μm spatial resolution to m^3 volumes
- Higher resolution-PET detector systems
- Dual-modality imaging
- Imaging devices capable of operating in diverse environments

Working groups 3 and 4 also identified topic-specific research opportunities:

- Radiochemistry and instrument methodologies for biology and environmental research
- A low-energy accelerator having a reduced power demand, low neutron flux, and small footprint
- Detector systems with high spatial resolution and high sensitivity that directly measure charged ions
- Radiotracer techniques to study carbon flow dynamics with PET (C-11) in combination with ^{14}C mass spectroscopy and hyperpolarized ^{13}C NMR spectroscopy

The workshop report provides an analysis of the current state of radiotracer chemistry, radioanalytical methodology, and imaging instrumentation and then presents a series of new opportunities for DOE developments in areas that could provide major benefits to fundamental research in alternative energy production and in the environmental sciences. It was recognized, however, that this effort was only a beginning. With a clearer recognition of the capabilities that basic radiochemistry and radionuclide imaging instrumentation technologies can provide to biologists and environmental scientists and a better understanding of the problems being tackled in plant biology by the chemists, physicists, and engineers, this merger of talent has great potential for advancing current

DOE missions. Because of the multidisciplinary nature of this work, a new workforce trained by new academic programs is needed.

Wildung asked if the workshop identified a need for isotopes of different properties to image key processes. Srivastava said that there was another workshop on the availability and production of research and medical isotopes. Riley added that there was about a half-hour discussion of that topic in one of the breakout groups, but the expertise needed to address the topic in depth was not present.

A break was declared at 4:05 p.m. The meeting was called back into session at 4:20 p.m.

Warren Washington was asked to report on the Scientific Grand Challenge Workshop on Climate Science and the role of extreme-scale computing.

A workshop was held on Challenges in Climate Change Science and the Role of Computing at the Extreme Scale. The workshop goals were to review and identify the critical scientific challenges; prioritize the challenges in terms of annual to decadal and beyond timelines; identify the challenges where computing at the extreme scales is critical for climate change science success within the next two decades; engage international scientific leaders in discussing opportunities to shape the nature of extreme scale scientific computing; provide the high-performance computing community with an opportunity to understand the potential future needs of the climate change research community; and look for breakthroughs. Of the 95 participants, 11% were international guests.

The workshop had breakout panels on

- Model development and integrated assessment
- Algorithms and computational environment
- Data, visualization, and productivity
- Decadal predictability and prediction

and was guided by the prior reports: *Identifying Outstanding Grand Challenges in Climate Change Research: Guiding DOE's Strategic Planning*; *Report on Computational and Information Technology Rate Limiters to the Advancement of Climate Change Science*; and the report of the 2008 World Modeling Summit for Climate Prediction.

Priority Research Directions (PRDs) were established for each of the breakout sessions. PRDs for model development and integrated assessment (whose models take into consideration economics, land-use change, emissions, natural processes like forest fires, etc.) included

- Determining critical cloud controls on climate
- Determining the importance of motions and particle-scale processes that are still unresolved
- Developing and applying global cloud-resolving models
- Describing the importance processes governing ice sheet melt

- More accurately representing important vertical mixing in the ocean
- Determining how mixing eddies and surface forcing combine to affect the stability and variability of the meridional overturning circulation

PRDs for algorithms and computational environment included

- Developing numerical algorithms to *efficiently* use upcoming petascale and exascale architectures with thousands and millions of CPUs
- Forming an international consortium for parallel input/output, metadata, analysis, and modeling tools for regional and decadal multimodel ensembles
- Developing multicore and deep-memory languages to support parallel software infrastructure
- Training scientists in the use of high-performance computers

PRDs for decadal predictability and prediction include

- Identifying sources and mechanisms for potential decadal predictability
- Developing strategies for tapping into this predictability and ultimately realizing predictions that have societal benefit

PRDs for data visualization and computing productivity include

- Developing new, robust techniques for dealing with the input/output, storage, processing, and wide-area transport demands of exascale data
- Integrating diverse and complex data
- Dedicating resources to the development of standards, conventions, and policies, and contribute to related committees

Substantial computing resources are required for decadal climate prediction. Huge amounts of data are being put into the system. A very complex system is being modeled, increasing the computational intensity. And multiple runs are being made, producing huge amounts of data to store and move around.

PRDs for data visualization and computing productivity include

- Developing new, robust techniques for dealing with the input/output, storage, processing, and wide-area transport demands of exascale data
- Integrating diverse and complex data
- Dedicating resources to the development of standards, conventions, and policies, and contribute to related committees

Crosscutting issues that were identified include

- Educating the next generation of climate scientists in extreme computing and training current scientists in the use of high-performance computers. Computer architectures have become increasingly complex, so it is important to have machines that are easier to use.
- Improving ability to predict changes in land cover, vegetation types, oceanic biology, and atmospheric and oceanic chemistry. We need to know how carbon,

methane, and nitrogen cycles interact with climate change and how local and regional water, ice, and clouds change with global warming.
- Developing scalable algorithms that can use upcoming petascale and exascale architectures efficiently. New, robust techniques must be developed to enhance the input/output, storage, processing, visualization, and wide-area transport demands of exascale data sets.

The final version of the report should be completed in March 2009.

Sayler asked if the models can identify a means of reversing global warming. Washington replied that there is great concern that the CO_2 residence time is about 100 years. What is really being talked about is irreversible warming. What is of concern is that nations are not bringing down the levels of emissions. This trend may be an issue addressed by the Obama administration. A paper is coming out in the next few weeks that shows what happens if emissions are cut; the concentration of CO_2 in the atmosphere can be stabilized at 450 ppm. The stemming of emissions should be started very soon.

Wanda Ferrell was asked to review the ARM Climate Research User Facility workshop.

The mission of the ACRF is to provide high-quality, long-term, continuous measurements needed to determine the effects of atmospheric water vapor, clouds and cloud properties, and aerosols on the radiation balance of the atmosphere across a range of climatic regimes. The ACRF consists of fixed and mobile sites (one open this year and one more next year) and aerial measurements. The user-facility designation requires that proposals for facility use are peer reviewed, a Science Board reviews all major resource requests for site use, and OMB tracks operation metrics on a quarterly basis.

BER's Climate Change Program Strategic Plan is complete. ACRF planning is under way. A workshop of key scientists was held in October to determine what the outstanding science questions are for the next ten years; what specific locations are appropriate to address science questions; how long an observational period will be required at each location; and what measurements, instruments, and data products are needed to address science questions. It concluded that data are continuously collected at sites with high temporal resolution. This makes ACRF observations ideal for studying the diurnal cycle, an important mode of climate variability that is not well sampled by most satellite sensors. The ACRF is best suited to study processes at the local or cloud scale. The combination of spatial and temporal scales makes ACRF observations uniquely suited for studying local cloud processes, many aspects remain among the most poorly represented processes in climate models. The target issues were to:
- Focus on the diurnal cycle, a time scale that ACRF is uniquely qualified to address;
- Improve measurements of cloud properties and enable measurements during precipitation;
- Determine the impact of aerosols on cloud properties;

- Obtain measurements of trade cumulus, a key cloud type for climate processes; and
- Increase emphasis on surface-process measurements.

Two of these target issues would require observations in a new location, the remaining three could be carried out at the existing ACRF locales. In general, for the science issues put forward at the workshop, the majority could be addressed at the existing sites.

In addition, the workshop identified new instruments needed for better temporal sampling of upper tropospheric water vapor, measurements of nighttime aerosol, and nighttime sky imaging. Improved measurements of cloud properties and significantly improved ability to measure cloud properties during precipitation are needed. For aerosols, instruments are needed to determine detailed composition of the aerosol. Currently, a scanning W-band ARM cloud radar to detect all radiatively significant clouds in a radius of 5 to 10 km and a scanning dual-frequency radar are being built. In the dual-frequency unit, the second frequency extends the range of the system into drizzle and shallow precipitation and allows the retrieval of liquid water content and particle size using the differential reflectivity that is proportional to cloud liquid water content.

The next steps include developing spending plans for new instruments and measurements and adding new capabilities as the budget allows.

Sayler asked what the better model parameterizations would transform. Ferrell replied that the better models will produce better results. One has water, ice, and aerosols in the clouds. Sayler asked what a perfect model of a cloud would do. Washington replied that more and more sites have been added, which gives a window on how clouds work, which allows one to better understand what is happening in a cloud. Randall added that, as one improves parameters, the errors in heating rates get smaller, but there is still a long way to go.

Broido announced that the Committee had received an e-mail comment from “Jean Public,” asking that the message be made part of the public record of the meeting. It is appended to these minutes along with Thomassen’s response, which thanked the commentator and gave information on the membership and activities of the Committee.

The floor was opened for public comment. There being none, the meeting was adjourned for the day at 5:15 p.m.

Thursday, February 19, 2009
Morning Session

The meeting was called to order at 8:30 a.m.

Eddy Rubin was asked to give an overview of the 5-Year Strategic Planning process for the Joint Genome Institute (JGI). The Institute has been in existence for 10 years. Its primary mission, sequencing the human genome, was completed in 2004. It now has three areas of focus: plants, microbes, and metagenomes because of their importance to the DOE mission. It has produced a lot of science activity, with 50 papers in *Science* and *Nature*. The JGI strategic vision is to contribute genomics of scale to accelerate the response to energy and environmental challenges.

A large technological change is happening. During the first 20 years of this field, Sanger sequences were produced at a peak of 10 million base pairs per week. This year, with three new technologies, 10 billion base pairs per week are produced. There will be further change, increasing output to 100 billion base pairs per week. This is why it is difficult to develop a 20-year plan.

JGI has external advisors in the form of its Policy Board and Scientific Advisory Committee. It held a 3-day retreat for users, university scientists, the BRCs, and big-science representatives. It highlighted that JGI's unique capabilities are in carrying out genomics of focus, scale, and complexity. Another important task is to help users solve hard problems, increasing DOE's scientific productivity. The retreat participants broke into four working groups for the 5-year JGI roadmap:

- Plants
- Microbes/metagenomics
- User programs
- Informatics

JGI is the world's largest producer of plant genomes. It currently has the genomes available for a limited number of plants. The genomes are minimally annotated, and the function of the genes is not understood. A National Research Council (NRC) report said that "JGI's contribution to plant genomics is unique and fundamental ... it is critical that JGI continue to serve a broad remit for sequencing and resequencing of plant genomes."

Early on, it was clear what had to be done first. Today, it is not so clear. The plan is to not only complete the assembly and annotation of >10 new plant genomes but also create the associated expression and genotyping resources needed to advance the understanding of plant growth and development. A long-term goal is to create a set of genome-based resources and tools that will enable the breeding and/or engineering of plants within the DOE mission. A programmatic approach is needed to select the most important plants to advance DOE science. The goal is to have a systems-level understanding of plants enabling us to harness them for bioenergy production and to respond to environmental challenges.

JGI is also the largest producer (one-third) of the world's microbial genomes.
It has many diverse one-off microbial and metagenomic projects; the Community Sequencing Program (CSP) and the BRCs are the major sources of individual microbial and metagenomic projects. But three-quarters of the sequenced genomes come from just three phyla. There is an uneven distribution of genomes. To understand what is being

seen, a broader scope of microbes needs to be looked at, and a phylogenic approach needs to be taken, which is the Genomic Encyclopaedia of Bacterial and Archaea (GEBA), a pilot project sequencing and analysis of 100 microbial genomes chosen based on phylogenetic relationships.

Many of the organisms that JGI deals with are available only in the wild. A reference genome is needed.

JGI needs to do more large-scale projects (making available ~1000 GEBA Genomes from all major branches in the tree of life in the next 5 years), employing high-throughput methods for sample acquisition, preparation, and analysis, including culture-independent methods, single-cell genomics, new analyses and ways to query data approaches, and transcriptome and proteomic studies increasingly integrated with all DNA sequencing.

JGI's in-house capabilities have been pushing the field forward. Another NRC report recommended the establishment of a small number of large-scale projects that would unite scientists of multiple disciplines around the study of a particular habitat. JGI provides all sorts of capabilities that normal laboratories do not have. As a result, it is going to initiate user calls for large-scale (terabase) grand-challenge metagenomic projects that cannot be done anywhere else. Eventually, single-cell genomics will be fused into assembled genomes. So, in addition to its existing user program, JGI will engage the community and panels of experts in developing plans for the scale-up of GEBA and other GEBA-like projects, a fungal version of GEBA, and large-scale metagenomic projects (grand challenge projects).

Outcomes that will be enabled by the proposed goals will include contributing to the significant replacement of petroleum with biofuels, developing bioremediation approaches to clean up diverse contaminants and pollutants, and developing theoretical strategies for manipulating the global carbon and nitrogen cycles.

JGI has 1300 users. 70% of its sequencing goes to large user programs, 20% to the BRCs, and 10% to directed science. The user program in the future will continue the current practices, expand pre- and post-sequencing capabilities, and develop grand challenge programs.

The grand-challenge projects will address metagenomics going deep and/or going broad, producing a terrestrial version of the Global Ocean Survey and investigating biomass-degrading environments; interfacing with other OBER Science Programs; and cross-cutting themes, such as plant/microbe interactions.

An informatics working group is staying ahead of the rising data flow and providing basal annotation services targeted to the plant, microbial, and metagenomic data produced by the JGI. In the future, JGI is going to become more integrated with the informatics of the rest of the world. It is going to elevate the importance given to informatics at JGI. Analysis of these data sets is going to get harder, and this is where JGI

is going to help external researchers most. People will come to JGI with problems, and JGI will help them solve those problems. It is all about analysis, not the machines.

Fowler asked if the Institute had any plans to look at epigenetics. Rubin replied that the Institute has not had people coming to it with such problems, but that trend is starting.

Joachimiak noted that the data are highly dispersed; bringing the data together is the biggest problem. He asked how one discovers things from the data. Rubin replied that this is an exciting challenge. DOE is well positioned to address it. It involves the development of algorithms. The field is in the process of making that transition. It is a computationally tractable problem.

Reilly said that, during the review of the JGI, she realized that the people who do it are exploring a number of routes for addressing the problem, and they need inspired leadership.

Stacey said that the real challenges are combining different types of data. The JGI needs to be positioned to be as unique tomorrow as it was in its first year. Rubin replied that it was hoped that the grand challenge questions will drive that innovation.

Petsko said that the ability to recognize a function from sequence is poor. Rubin answered that about 70% of the *Escherichia coli* annotations are wrong. Writing sequence is one path. Analysis and annotation is another. The JGI is looking to improve its capabilities in the latter.

Timothy Killeen was asked to give an update on NSF's Geosciences Program and its strategic partnership with DOE.

The NSF Geosciences Directorate (GEO) has a small management staff and a $745 million budget. It funds 1243 PIs around the nation, 709 co-PIs, 265 postdocs, 1109 graduate students, and 647 undergraduate students. Some 3800 competitive proposals were received last year with a funding rate of 27%. The NSF will increase the funding rate with stimulus dollars. NSF supports about 60% of the research in the geosciences. About 55% of GEO's funding goes to discovery, and about 40% goes to infrastructure, including world-class computational and experimental capabilities.

It is looking at the biosphere below the seafloor, looking at 100 millions of years of sediment.

Earthscope is an integrated system of systems to look inside the Earth, producing a 3-D representation of plate tectonics. One of its first findings is a new way that the earth releases stress: episodic tremor and slip. This finding will alter how volcanoes and earthquakes are understood. It opens up the question whether the Mississippi Delta, for example, can be geoengineered.

The carbon cycle and the economy are also being looked at. Where the carbon is needs to be known.

There are also uncertainties in projected patterns of precipitation change in key regions.

GEO is looking at human influence on the monsoon through the atmospheric brown cloud. Modeling indicates the possibility of failures of the monsoon in the future.

GEO supports a multi-year global carbon cycle experiment, HIAPER (High-Performance Instrumented Airborne Platform for Environmental Research) Pole-to-Pole Observations (HIPPO), to produce pole-to-pole observations of the carbon cycle and greenhouse gases in all seasons.

The budget outlook for GEO includes still being on a continuing resolution through at least March 6, 2009. NSF gets $3 billion from the recovery bill, doubling the amount of work with the same number of staff members. It still has the goal of doubling over 10 years.

Two new facilities in the FY09 budget are the Alaska region research vessel (to be delivered in 2013) to monitor climate change in the Arctic and the ocean observatories investment to launch an era of science discovery across and within the ocean basins using widely accessible, scalable, interactive telepresence (currently being reviewed). GEO will study methane hydrates on the seafloor. They represent more than 50% of the Earth's carbon reserves.

The agency sees and faces a challenge in science literacy in producing a flow of students into the earth sciences. At the middle school, high school, and undergraduate levels, curricula need to be expanded, and science education needs to be reformed. GEO is developing a roadmap for reform of the nation's Earth-system science education.

The Directorate's strategic plan calls for enabling a sustainable future through understanding our changing and complex planet. The challenge is understanding and predicting the Earth system, reducing vulnerability in sustaining life, and connecting geoscience to society. About 4000 geoscientists are graduated each year; this rate does not replace the losses from the workforce from retirement.

The key research challenges are climate change, mitigation, and adaptation; scale reduction (to regional and decadal); resources and hazards; societal drivers for modeling products; risk and decision making; and designed, engineered options. GEO's key partners are other directorates at NSF, NIH, DOE, the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA). Key new technologies are high-performance computing, deep theory, high-resolution observing networks, virtual organizations, experimental testing, and new sensors and ideas.

A possible framework for GEO includes a theme of "Change and Complexity in Earth Systems" and the priorities of the geosciences and us (workforce, public, teachers, learners, and websites); climate change; dynamic Earth (weather, geo-space, geo-dynamics, oceans, and ecosystem change); and Earth–society interactions and feedbacks (natural resources, hazards, and ecosystem services).

GEO is planning some strategic investments in advanced observing networks and platforms with new sensors, data systems, and assimilative modeling; decadal, regional Earth-system modeling and prediction; scaling bio-geo processes by crossing spatial, temporal, and biological organization scales; interactions with social sciences on valuation, risk, and decision making; a petascale collaboratory for geosciences; and Earth-system science-literacy initiatives. Planning is proceeding through partnerships, portfolio analyses, workshops, community building, and fostering interdisciplinary science.

Three Dear-Colleague letters to identify potential funding partners were issued in February on multiscale modeling; emerging topics in biogeochemical cycles; and environment, society, and economy.

Broido stated that there is clearly an interest in partnering and asked if the Directorate had thought about better ways to structure partnerships than just partitioning the science. Palmisano said that BER was participating in high-level discussions among DOE, NSF, NOAA, and NASA to do just that. Killeen added that NSF was identifying the strengths of each agency, the proposals coming to each agency, the interests of each, and the facilities of each. Integrated goals are being developed, and more than one grand challenge is being found per agency. NSF is committed to seek cooperation and partnerships.

Sayler noted that EPA seems to be left out of the mix. Also, an integrated cyberinfrastructure may help attain educational objectives. Killeen responded that the stimulus emphasis on broadband will be used for that purpose, but one also has to inspire the students in the classroom.

Bierly noted that a prior push for science, technology, engineering, and mathematics (STEM) education did not include geoscience. Killeen agreed. The nation needs mathematics, chemistry, and physics, but it also needs geoscience, economics, and social sciences.

Randall observed that an Intergovernmental Panel on Climate Change (IPCC) assessment is getting under way, but the size of the climate-modeling community may be too small to support it. He asked how participation in climate modeling can be increased. Killeen replied that that is a real problem. The needs for supporting the IPCC have been quantified.

Washington asked what mechanisms might come out of the Obama administration for coordinating interagency science. Killeen responded that the President's Council of

Advisors on Science and Technology (PCAST) will play a major role. The administration has queried NSF about its priorities and interests.

Leinen wanted to emphasize that DOE and NSF are in a unique position to contribute to climate management because their leaderships understand the problem. She urged NSF to think as big as possible about the possibilities of what the country will need in the next 25 to 50 years. Killeen said that the community also needs to be bold.

Ehleringer said that he was glad to hear about the inclusion of the social sciences and asked if this implied a greater role for the study of urban ecosystems. Killeen said that there is a strong interest in that topic at NSF, and there are indications that programs will be emerging shortly.

A break was declared at 10:06 a.m. The Committee was called back into session at 10:20 a.m.

Anna Palmisano shared her vision for developing a long-term plan for BER.

BER advances world-class biological and environmental research programs and scientific user facilities to support DOE's mission needs in energy, climate, and the environment. Its mission priorities are to

- Develop biofuels as a major, secure, national energy resource,
- Understand the relationships between climate change and Earth's ecosystems and assess options for carbon sequestration,
- Predict the fate and transport of subsurface contaminants, and
- Develop new tools to explore the interface of biological and physical sciences.

The ultimate goal is high-impact science: specifically, achieving a predictive understanding of complex biological, climate and environmental systems in support of DOE's mission needs. The question is how to position BER for the challenges and opportunities of 20 years and out.

One can learn from the "Basic Research Needs" model led by Pat Dehmer in BES. The resulting BESAC workshop reports

- identified basic research directions required for major technological changes in energy production and use,
- described a vision for a new era of science,
- provided inspiration for a series of 10 focused workshops that galvanized the scientific community, and
- allowed identification of important recurring themes and science grand challenges.

The reports identified basic research directions required for major technological changes in the largest industries in the world and highlighted the remarkable scientific journey that took place during the past few decades. 1500 scientists were engaged in this effort through workshops. 37 research directions were set forth in 9 program areas (fossil

energy; renewable and solar energy; bioenergy; nuclear fission energy; fusion energy; distributed energy, fuel cells, and hydrogen; residential, commercial, and industrial energy consumption; transportation energy consumption; and cross-cutting research and education) and major workshops were held in each of those areas. Several recurrent, cross-cutting themes were found and identified.

Is BERAC willing to take on a similar challenge? If so, what is the best process for organizing the critical, agenda-setting workshop?

Broido noted that several members have discussed this possibility of conducting a series of workshops and formed a working group to plan an agenda-setting workshop.

Petsko said that setting long-term goals is good, and this is a good time to do it. DOE is psychologically constrained by its small life-sciences budget in relation to the NIH's budget. But DOE is able to accomplish disproportionately more than its budget would indicate. The most desirable goal is to turn basic science into practical applications. We need to go from biological information to engineering tools.

Stacey added that another constraint is what DOE does rather than what other agencies do. What the workshop should look at is what should be done to change society.

Petsko reminisced that his father always said that only the dead are without fear, and you should never let fear make your decisions for you.

Broido commented that the ideal workshop would consider: (1) What does society need? (2) Where is society going to be in 20 years? (3) What is the role of DOE in taking society to that point? (4) What can BER contribute to that role? Topics that could be considered include sustainability, less dispersed cities, and energy requirements. Science needs to be pushed to allow society to achieve these end points. BERAC gets to be visionary, and BER gets to do the work.

Sayler noted that economics drives a lot of the choices made by society and individuals. Coal is cheap and is likely to be the fuel of choice despite environmental consequences. A dose of reality is needed on how the economic drivers will shape the future.

Tiedje suggested that BER can look at the diversity of microbes and at the existing microbial world. It is hard to understand the carbon cycle without understanding the nitrogen and phosphorus cycles, also. The Committee needs to think more broadly.

Riley asked if one could figure out what the genomes are encoding; that is the problem. Society needs to train microbial physiologists.

Sayler pointed out that the relationship of fungal growth is very opportunistic for BER.

Broido observed that those points are important; however, one should not plan the long-term horizon by extending the current efforts. One needs to look at the future and then

back up to what needs to be done in order to get there and then identify the transformative research needed.

Padgette noted that there is a ton of science that could represent what BER could do to shape the country's future.

Leinen said that, in terms of the desired future of the nation in the nexus of energy and climate, this group's intellectual talent allows it to fashion the future. If it is not gotten right, the future will be a less-pleasant place.

Washington said that, because BERAC meets only twice a year, should it have additional meetings or conference calls? Broido replied that BER's world changes constantly. There are a number of ways BERAC can contribute guidance. It can have public teleconferences. Subcommittees can make informal recommendations with subsequent formal acceptance of those recommendations by the full Committee at the next scheduled meeting. Members can communicate directly to the Director or through the chair or Designated Federal Officer.

Palmisano stated that she is always eager to hear BERAC's ideas. The workshops that were held this past year were very helpful in developing the budget.
Stacey said that the consensus seems to be that BERAC would like to take on the strategic planning process. The next question is, what procedures will be used to carry it out?

Broido said that a preliminary exploratory workshop would probably be very helpful in seeing how the ideas organize themselves. If it states how we want the future to be and/or what the future may be, then the next step would be to discern the role of the Department in pursuing that future. There are science visionaries who are approachable and could help the Committee in defining the future.

Wildung stated that two such discussions would not constrain the problem well. What might drive the future resource use, economy, and levels of quality of life may be driven largely by population growth.

Padgette offered that the Committee should lay out a planning process. Then the Committee could focus on strategies.

Broido said that she thought she heard Wildung suggest pulling together data on population, resources, etc. at the mission workshop and visualizing the energy future with talks defining 20-year energy use, social structures, etc. that would form a baseline for discussions of energy. Leinen wanted to add genomic, environmental, and biological systems as related to energy. Introductory talks should include visionary presentations on those topics.

Broido commented that the NAS report needs to be complemented. It contains a lot of this information being talked about. Joachimiak said the Committee needs to have a

workshop and present a vision of the future and map appropriate findings onto the DOE mission and to prioritize the areas by their impact on the final outcome. Broido asked if anyone on the Committee had contacts with the authors of the NAS report. Joachimiak said that he knew some of the authors. Palmisano noted the need to focus on the life sciences. Broido was concerned that the NAS report points to the integration of the life and physical sciences. Wildung said that he had read the report, and it only comments on environmental effects that affect agriculture. There are other aspects that affect the life sciences. It is important that those sciences (like geosciences and atmospheric sciences) be brought together.

Broido asked where the Committee should go from here. It wants a workshop to set parameters that may occur in the future. How does one achieve that? The Committee members might go home and think about speakers, topics, and data needed and then share those thoughts with the workshop working group, which will collate and synthesize that information and start working with BERAC and the BER staff. The Committee needs to be concrete about the questions these speakers address.

Stacey said that thought-provoking speakers should be provided and that the discussions in breakout groups should be grounded on the interests of BER. Joachimiak agreed that this was the way to do it.

Sayler suggested that Stacey put together something from what has been said here.

Broido suggested that the working group could have some discussions about the suggestions forwarded to them by the Committee members by March 15. Stacey said that he would set up a conference call with the working group to define the process and to set a timetable. Broido thanked him.

Thomassen said that the office will support this effort with the needed staff. Padgette asked if the owner is BER. Broido said that the owner of Step 1 is BERAC.

Stacey asked if the goal of the first workshop is to determine the schedule and topics of the subsequent workshops. Broido replied that BERAC is taking on two workshops: a planning one and one that postulates a future and how DOE/BER can affect that future.

Public comment.

Douglas Ray said that he had attended all of the BESAC workshops and chaired one of them. Each workshop had a white paper that was circulated two weeks ahead of the workshop to bring all the attendees up to the same speed. A sub-subcommittee drafted those white papers and cleared them through the cochairs before distributing them to the workshop participants.

There being no additional comments, the meeting was adjourned at 11:31 a.m.

Respectfully submitted,

Frederick M. O'Hara, Jr.
Recording Secretary
March 16, 2009

Addendum attached

Addendum
Public Comment

From: jean public [mailto:jeanpublic@yahoo.com]
Sent: Wednesday, February 04, 2009 9:28 AM
To: Thomassen, David; JERSEY@NYTIMES.COM
Subject: DEPT OF ENERGY HAS BEEN MAKING BAD BAD DECISIONS FOR 8 YEARS NOW

WHO SITS ON THIS COMMITTEE AND WHY ARE THEY WORKING AGAINST AMERICAN INTERESTS OF HAVING LOW COST, GREEN ENERGY? I THINK WE NEED NEW MEMBERS - HAVE NEW MEMBERS BEEN APPOINTED. CERTAINLY THE BUSH MEMBERS DID AMERICA NO GOOD AT ALL. CAN YOU PLEASE ADVISE. THIS COMMENT IS FOR THE PUBLIC RECORD.
B SACHAU 15 ELM ST FLORHAM PARK NJ 07932 [Federal Register: February 4, 2009 (Volume 74, Number 22)]
[Notices]
[Page 6017-6018]
>From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr04fe09-26]

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DEPARTMENT OF ENERGY
Biological and Environmental Research Advisory Committee
AGENCY: Department of Energy; Office of Science.
ACTION: Notice of open meeting.

SUMMARY: This notice announces a meeting of the Biological and Environmental Research Advisory Committee. Federal Advisory Committee Act (Pub. L. 92-463, 86 Stat. 770) requires that public notice of these meetings be announced in the Federal Register.

DATES: Wednesday, February 18, 2009, 8:30 a.m. to 5:30 p.m. and Thursday, February 19, 2009, 8:30 a.m. to 12:30 p.m., E.S.T.

ADDRESSES: Bethesda North Marriott Hotel & Conference Center, 5701 Marinelli Road, North Bethesda, MD 20852.

FOR FURTHER INFORMATION CONTACT: Dr. David Thomassen (301-903-9817; david.thomassen@science.doe.gov) Designated Federal Officer, Biological and Environmental Research Advisory Committee, U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research, SC-23/

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Germantown Building, 1000 Independence Avenue, SW., Washington, DC 20585-1290. The most current information concerning this meeting can be found on the Web site: http://www.science.doe.gov/ober/berac/announce.html.

SUPPLEMENTARY INFORMATION:

Purpose of the Meeting: To provide advice on a continuing basis to the Director, Office of Science of the Department of Energy, on the many complex scientific and technical issues that arise in the development and implementation of the Biological and Environmental Research Program.

Tentative Agenda

Report from the Office of Science.
Report from the Office of Biological and Environmental Research.
Presentation of Workshop Reports.
News from the Biological Systems Science and Climate and Environmental Sciences Divisions.
Update on Joint Genome Institute Strategic Planning.
Report on the BER Climate Sciences Strategic Plan.
BER Response to Life and Medical Sciences Division Committee of Visitors Report.
BERAC Discussion of Strategy for Developing a 20-Year Planning Horizon for Biological and Environmental Research.
New Business.
Public Comment.

Public Participation: The day and a half meeting is open to the public. If you would like to file a written statement with the Committee, you may do so either before or after the meeting. If you would like to make oral statements regarding any of the items on the agenda, you should contact David Thomassen at the address or telephone number listed above. You must make your request for an oral statement at least five business days before the meeting. Reasonable provision will be made to include the scheduled oral statements on the agenda. The Chairperson of the Committee will conduct the meeting to facilitate the orderly conduct of business. Public comment will follow the 10-minute rule.

Minutes: The minutes of this meeting will be available for public review and copying within 45 days at the BERAC Web site: http://www.science.doe.gov/ober/berac/Minutes.html.

Issued in Washington, DC, on January 29, 2009.
Rachel M. Samuel,
Deputy Committee Management Officer.
[FR Doc. E9-2354 Filed 2-3-09; 8:45 am]
BILLING CODE 6450-01-P

Reply

From: Thomassen, David
Sent: Thursday, February 05, 2009 7:42 AM
To: 'jeanpublic@yahoo.com'
Cc: Corcoran, Joanne
Subject: RE: DEPT OF ENERGY HAS BEEN MAKING BAD BAD DECISIONS FOR 8 YEARS NOW

Thank you for your comment. We will certainly include your comment in the public record of the meeting. Are you planning on attending the meeting or are you just submitting the written comment?

The attached website includes the names of the scientists who sit on the committee - http://www.science.doe.gov/ober/berac/members.html. Our office, with the critical insights of and review by this committee, funds and support basic scientific research aimed at

* Developing biofuels as a major, secure, and sustainable national energy resource.
* Understanding the potential effects of greenhouse gas emissions on Earth's climate and biosphere, and their implications for our energy future.
* Predicting the fate and transport of contaminants in the subsurface environment at DOE sites.
* Developing new tools to explore the interface of the biological and physical sciences.

We support the basic scientific research that our nation needs to develop "low cost, green energy." Our program is not the one that turns that new knowledge into new energy industries. For more about our bioenergy research programs please see http://genomicsgtl.energy.gov/.

Thank you for your interest in our research program and for your support of green energy.

Sincerely,

David Thomassen, Ph.D.
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