BERAC
Hilton Hotel
Gaithersburg, Maryland
September 16-17, 2010

BERAC Members Present

Gary Stacey, Chair
Janet Braam
James Ehleringer
Joanna Fowler
Paul Gilna
Susan Hubbard
Andrzej Joachimiak
L. Ruby Leung
Gerald Mace
Joyce Penner
Gregory Petsko
David Randall
Karin Remington
G. Philip Robertson
Gary Sayler
Herman Shugart
Judy Wall
Warren Washington (Thursday only)
Raymond Wildung
Minghua Zhang

BERAC Members Absent

Robert Dickinson
Stephen Padgette
Margaret Riley
James Tiedje
Mavrik Zavarin

About 60 others were in attendance during the course of the two-day meeting.

Thursday, September 16, 2010
Morning Session

The meeting was called to order at 9:01 a.m. by the chair, **Gary Stacey**. He asked the members to introduce themselves.

Anna Palmisano [Associate Director of Science, Office of Biological and Environmental Research, Office of Science, DOE] to present the status of the Office of Biological and Environmental Research (BER).

BER is driven by discovery and innovation in such areas as Earth systems and climate; by the translation of the information stored in the genome into active microbes, plants, and ecosystems; and by the biology and physics of Earth's subsurface environment. It also serves DOE's mission needs by performing science to support the development of biofuels as a major and sustainable national energy source, determining the potential effects of greenhouse gases on Earth's climate and biosphere and their future impacts, predicting the fate and transport of contaminants in the subsurface environment at DOE sites, and developing new tools to explore the interface of the biological and physical sciences.

BER excels in transdisciplinary science that includes chemical engineering, computational biology, and other disciplines. BER is a systems-based science organization that is extremely data intensive and data diverse. Its user facilities [Atmospheric Radiation Measurement (ARM), Environmental Molecular Sciences Laboratory (EMSL), and Joint Genome Institute (JGI)] are very important to the scientific community. And it creates and nurtures partnerships to advance science through interagency interactions, workshops, and collaborations.

In FY10, the total BER budget was $604.2 million. The FY11 President's request was for $626.9 million. The Senate mark has cut that back to $614.5 million. That mark puts the

Biological Systems Science Division (BSSD) budget down a bit from FY10; but for the Climate and Environmental Sciences Division (CESD), the budget is still up from FY10 despite the Senate cuts. The bottom line is that the BER budget is growing.

BER is looking for a long-term vision through identifying grand challenges in biology, climate, and the environment. It seeks to find out how BER should be positioned to address those challenges, what new and innovative tools are needed, and how the workforce of the future in integrative system science can/should be trained. To that end, the BERAC Grand Challenges Workshop was held, based on the Basic Research Needs (BRN) workshops of the Basic Energy Sciences Advisory Committee (BESAC). The BERAC workshop engaged about 100 scientific leaders in biology, climate, environment, energy, sustainability, computation, and other fields, engendering exciting discussions centered around systems biology, synthetic biology, climate science, and sustainability. It also looked at the cross-cutting areas of computation, scaling, data management, education and training. A presentation on the draft workshop report appears later in this meeting.

A Committee of Visitors (COV) review of the Climate and Environmental Sciences Division was conducted in July 2010. The COV assessed the processes used to solicit, review, recommend, and monitor funding activities; proposals for research; the breadth, depth, and standing of portfolios; and the management and oversight of national user facilities. The findings of the COV appears later in this meeting.

Dr. Gary Geernaert was hired as the Division Director for Climate and Environmental Sciences. Wanda Ferrell and Mike Kuperberg were thanked for filling this position in an acting capacity over the past several years. Two new program managers were hired for climate modeling, Renu Joseph and Dorothy Koch. Jeff Amthor moved to the University of Sydney, so an ecologist is being recruited to fill his position. Other recruitments have been placed on hold pending the outcome of the continuing resolution and budget situation.

The DOE Systems Biology Knowledgebase is establishing a systems biology modeling framework, working with data producers to set standards for data and metadata, quality control and assurance, and automated data handling. It will support software and tools for analysis and visualization, *in silico* experimentation, and tracking and evaluation of tool use. It will also provide community-wide stewardship. American Recovery and Reinvestment Act (ARRA) funds were used for startup activities. Several workshops were held as part of this activity. A series of community workshops were held for supercomputing, plant and animal genomes, genomic science grantees, and JGI users in addition to a synthesis workshop and the funding of pilot research projects. BER is in discussions with the Office of Advanced Scientific Computing Research (ASCR), the iPlant Collaborative, the National Center for Biotechnology Information (NCBI), Google, and Amazon about computational issues.

The three Bioenergy Research Centers are undergoing a year 3 review with reverse-site visits and evaluations by an external review team for the quality of the science produced, management, and progress against stated milestones.

The Climate Roadmap Workshop was held to determine the research challenges that are important for developing a predictive understanding of global climate. More than 50 scientists identified key science challenges and research opportunities for the next 10 years. A report on this workshop appears later in this meeting.

One place BER can make an important impact is in Arctic Climate science. The Arctic is vitally important to global climate. This globally sensitive region has vast reservoirs of carbon and ice. Melting Arctic permafrost will release massive amounts of carbon and melting Arctic ice could have major impacts on ocean circulation. A next-generation ecosystem experiment on Arctic tundra is being designed by Oak Ridge National Laboratory (ORNL). It targets a system that is globally important, climatically sensitive, and understudied. Warming could cause a large net release of carbon dioxide and/or methane to the atmosphere. Warming might also reduce albedo. BER can bring unique scientific expertise to this initiative in the areas of large-scale ecological experiments, ecogenomics and microbial ecology, atmospheric exchange, and radiative forcing.

The two largest BER ARRA projects are for the ARM Climate Research Facility (ACRF), which has received $60 million for capital investments in instrumentation and research infrastructure, and for the EMSL, which has also received $60 million for capital investments in instrumentation. Other ARRA investments include $13.5 million in capital equipment for the Bioenergy Research Centers, $13.1 million for data and networking systems and next-generation DNA sequencing equipment for the JGI, and $3.2 million for workshops and software-development projects for the Knowledgebase.

The Early Career Awards (ECAs) are the largest effort of their kind in DOE history aimed at supporting the next-generation of scientists. David Thomassen is the overall lead for BER. Early career is defined as no more than 10 years past the PhD. There were eight ECAs in FY10. For FY11, pre-applications were due August 13, 2010; proposals were due November 9, 2010; and new awards will be made in the spring of 2011.

The Office of Science (SC) also funded graduate research fellowships in FY 2010, managed by the Office of Workforce Development for Teachers and Scientists (WDTS). There were thousands of applications. 150 awards were made in FY 2010. The FY 2011 application process is pending. Support for the FY 2010 fellows comes, in part, from $12.5 million from the ARRA. Of the more than 3200 applications, 1155 of them were binned as BER-relevant.

In interagency activities, the National Science Foundation (NSF)–DOE–U.S. Department of Agriculture (USDA) Regional Climate Modeling program will develop models to help regional decision makers. The DOE–USDA Plant Feedstock Genomics for Bioenergy is now in its fifth year and is managed by Cathy Ronning; it has had 45 projects, totaling $40.1 million. With Catherine Lewis, David Thomassen has been organizing a DOE–National Institutes of Health (NIH) Workshop on the Interface of Biology and Physics. It is to identify opportunities to advance biology by leveraging advances in physics. It is planned for early spring 2011. It will address two driving questions: What are the big questions in biology that cannot be addressed with existing technology? And what are emerging ideas or technologies in physics that have potential applications in biology? The ARM campaigns have included a joint campaign with the National Aeronautics and Space Administration (NASA) at Southern Great Plains and joint participation in DYNAMO [Dynamics of the Madden–Julian Oscillation] with NSF, NASA, the Navy, and the National Oceanographic and Atmospheric Administration (NOAA) as part of the Cooperative Indian Ocean Experiment on Intraseasonal Variability.

QUESTIONS

Stacey asked if a funding opportunity announcement (FOA) was foreseen in FY11 for universities in the Knowledgebase area. Palmisano replied that Susan Gregurick would speak to that issue later in the meeting.

Sayler asked how BER fared versus other SC offices in the Senate mark. Palmisano answered, about the same.

Wilding congratulated her for the work on the ECAs. He asked how many BER fellowships there were in the Graduate Fellowship Program. Palmisano responded that, in FY10, BER got more than its share. Of the 150 SC fellowships, there were 32 relevant to BER research interests.

Washington asked how the coordination of the U.S. Global Change Research Program was coming along and how computing did in the budget. Palmisano replied that the USGCRP is undergoing expansion to an end-to-end program. DOE is working hard to make sure that basic science remains high on USGCRP’s agenda. The Program just held a strategic planning workshop. In the FY11 budget, $8 million were cut in climate modeling. The next steps in the budget process will allow opportunities for changes in the final budget.

Hubbard asked what the path forward was to bring expertise into planning for the next generation ecosystem experiment. Palmisano answered that at an upcoming workshop in Fairbanks new disciplines will be engaged and that should continue in future planning workshops.

Gilna asked if there were interactions with international activities. Palmisano replied that there were such interactions across the board [e.g., the 16-year cooperation with the Intergovernmental Group on Earth Observations (GEO)].

Judy Wall [Department of Agriculture Biochemistry, University of Missouri] was asked to report on the COV to the Climate and Environmental Sciences Division.

The COV was charged to assess the processes used to manage the Division's research programs and user facilities by reviewing the solicitations, reviews, recommendations, and monitoring of proposals for research funded from FY07 through FY09. During that period, the director of the division retired and was replaced by acting directors. There were also program reorganizations and renamings; primary among those changes was the breaking out of facilities for separate management.

The COV met July 20–22, 2010. Six subcommittees reviewed the four research areas and two facilities (EMSL and ARM) of the division. All material requested was provided, and program managers gave summaries of their programs. The program managers were recognized for being knowledgeable, passionate, and tireless.

No major problems were found. The scientific portfolio was appropriate, the research addressed political concerns and has made substantive contributions, and the national laboratories are now primarily funded through Scientific Focus Areas (SFAs).

The insufficient staffing and funding found by the prior COV are a continuing and critical concern. The transitioning of the national laboratories to SFAs is creating a dual evaluation and reporting system for the program managers. The COV recommends that more staff be made available for workshop and review planning as well as for reviewer database maintenance. The peer review process is working well. The use of pre-proposals saves time and effort. Reviews are thorough and timely. Reviewers are appropriate and without apparent biases. Program managers often communicate personally with principal investigators (PIs) to resolve reviewer questions. However, feedback on unsuccessful proposals is often not substantive. The COV recommends that more informative statements be included in declination letters to guide appropriate future responses by PIs.

The COV recommends improvements in the electronic grant recordkeeping at DOE. More effort is encouraged for the publication of DOE contributions to make the public aware of the high quality of work supported. As research programs evolve, program name changes can become confusing; care should be taken to delineate the relationships between newer and older programs.

The SFA funding model raises concerns regarding nimble responses to research priority changes, efficient use of resources, and decisions regarding the distribution of resources. The COV recommends that a plan for recompeting SFAs be developed and implemented as soon as conveniently possible.

In Atmospheric System Research, the COV recommends improved solicitations and better use of the pre-proposal process, panel reviews of proposals, and quantitative metrics of output publications to improve monitoring and to indicate future research directions. As the transition to SFA funding is initiated, the COV supports the design of an ongoing review schedule that assures long-term excellence.

In Climate Modeling Programs, the COV was impressed with the review process, the breadth and quality of the programs, and the international impact of the findings. Gender balance was good in the awards made with the exception that all national laboratory PIs were men, reflecting the demographics of senior scientists there. The COV lauds the program managers' organization of a PI meeting that is proposed to become an annual event. These programs work with ASCR to provide the most advanced computational capabilities for the next Intergovernmental Panel on Climate Change (IPCC) assessment, and the Program for Climate Model Diagnosis and Intercomparison (PCMDI) and the Earth System Grid now provide data for the international community. There are too few program managers for this large a program, and a mentoring program for new program managers is recommended.

In Subsurface Biogeochemical Research (formerly the Environmental Research Science Program and a separate division), the COV found the review of solicitations to be very well handled, resulting in the selection of high-quality research projects. Declination letters were not particularly informative. It is recommended that sufficient information be included in decision letters for PI decision making about future submissions. SFA solicitations in this area were models for implementation; there was a lot of planning of the science focus planning, expert panel reviews, and annual reports required. Three-year reviews with a rolling schedule have been developed. The plan for continuation beyond 6 years was not clear. The COV recommends that plans for year 6 and beyond be articulated and communicated. Additional reviews might take advantage of virtual-presence technology. The program also includes the Science Discovery through Advanced Computing (SciDAC) and the Integrated Field Research Challenge (IFRC). The management of SciDAC has been good, and partnership with ASCR has been effective. The IFRC sites were well reviewed when funded. All are highly productive and serve to integrate scientist's efforts. The COV recommends development of a comprehensive data-management plan for the IFRCs. Recompeting should be considered.

Terrestrial Ecosystem Science/Terrestrial Carbon Sequestration resulted from the consolidation of the terrestrial carbon processes and the ecosystem function and response programs. Climate Mitigation transitioned to Terrestrial Carbon Sequestration. The program has had many accomplishments, such as a suite of free-air CO_2 enrichment (FACE) experiments, the CO_2–ozone interaction experiment, the precipitation manipulation experiments, temperature manipulation experiments, the establishment of long-term flux measuring sites, the Ameriflux network, and an important understanding of belowground and decomposition research. The reorganization was considered worthwhile and appropriate. The COV applauds efforts to discontinue renewals with little critical evaluation and supports adoption of competitive processes that are transparent, rigorous, and encourage excellence. The COV suggests that solicitations should target model needs or deficiencies as a selection criterion for proposal funding. A workshop was recommended to determine how ecosystem models can be better interfaced into climate models [this has since happened]. This program manages Ameriflux, which is no longer monitored with standard research proposals. The COV was concerned that Ameriflux support would compete with that available for research efforts and recommends careful consideration of the long-term commitment to Ameriflux and its goals and suggests site reviews be considered.

The first facility assessed was the ARM Climate Research Facility. It has fixed, mobile, and aerial sites. The program has been quite successful, resulting in 235 published papers during the reviewed period. Funding has been separated from the research program of ARM. The COV would suggest a face-to-face panel or teleconference for the technical merit review. With the removal of ARM oversight, the COV has some concern that the Facility will suffer from the lack of scientific feedback and interactions with user PIs. The COV praises the Facility for its proactive management in developing the "best estimate" cloud/aerosol data sets and encourages this approach in other areas.

The other facility reviewed was EMSL. This facility has been removed from the Environmental Remediation Sciences Program (ESRP; now Subsurface Biogeochemical Research) oversight. User proposals are reviewed in-house at EMSL, and reviews were not available. Proposals are of four types: science theme, general, partner, and rapid-turnaround. Page limit guidelines for preparation of proposals did not appear to be rigidly enforced. Reviews have both internal and external components and enumerated criteria. In FY09, 80 of 122 proposals were approved. The COV recommends that length guidelines be adhered to for fairness to PIs.

Additional effort to engage the private sector as users is recommended. DOE/BER reviews the user facilities on a 3-year cycle. EMSL was reviewed in 2008, and five issues were identified that required formal action. A plan of action was established, and corrections have been made. The COV praises the quick and thorough response of both EMSL and DOE to the recommendations of the 2008 science and operations review.

QUESTIONS

Stacey said that two recommendations struck him: the need for additional program managers and the issue of getting good critiques back to proposal submitters. He asked if there had been any thought put into that latter issue. Palmisano responded that the feedback is often done on the telephone and not captured for the review. Wall affirmed that there were some documentations of phone calls. That takes time; that is why program managers need additional help. Stacey stated that those phone calls are always initiated by the PI and do not count.

Leung asked two questions: What follow-up actions will come from the COV recommendations? Was there a specific recommendation on how often SFA recompetitions should be made? Palmisano said that the follow-up is specified by SC procedures: the division director will review the recommendations with the staff and respond on the web to each recommendation. Wall stated that the competing of the SFAs was not on the COV's radar. The SFAs are still in transition. The COV recommends that, sometime in the future, plans be laid out for re-competing the SFAs.

Penner asked what improvements have been made in the electronic grant-application process. Wall commented that the COV had paper.

Joachimiak said that he was surprised that there was no long-term support for supercomputer usage. Palmisano said that BER collaborates with ASCR in a lot of ways, through Innovative and Novel Computational Impact on Theory and Experiment (INCITE) and SciDAC, for example. BER has a SciDAC program at the EMSL. Joachimiak asked how a new idea from outside the SFAs can get into the program. Palmisano said that the SFA model empowers the national laboratories to expand into new areas (but with a set budget). Thomassen added that money is always a challenge. The SFA program is still in its early phases. This model places new responsibilities on the national laboratories to stay ahead of the curve.

Ehrlinger asked what the concern was about Ameriflux. Wall replied that they are not getting feedback from the scientific community. The question is not integration of data or coordination of activities. The National Ecological Observatory Network (NEON) was seen to collaborate with ARM and Ameriflux, and the interactions were excellent. Palmisano added that BER coordinates closely with NEON and Ameriflux.

Robertson asked if the COV reviewed how the pre-proposal process has been conducted. Wall replied that the process is carried out in-house and is limited to screening out proposals that do not fit the program. Palmisano added that BER tries to err on the side of being inclusive.

Fowler stated that BER research results need to be highlighted and the public and Congress need to be made aware of how compelling that research is. Palmisano pointed out that a talk on this subject appears later in this meeting.

Zhang noted that the COV did not review the process of selecting users of facilities. Wall said that no concern about this topic was expressed.

Shugart said that the lack of reportage on pre-proposals should be addressed. Feedback on the quality of review should be sought. All agreed. The COV recommended that there should be some face-to-face interviews with reviewers.

Sayler asked what the COV response was to the subsurface program changes. Wall said that the integration of the program into other programs broadened the base of information. Sayler asked if the changes made the programs' research become less basic. Wall stated that there is a huge amount of information being generated; being available to more people will make it more valuable; reviews are always needed to ensure that the needs of the community are being met.

A break was declared at 10:49 a.m.

The meeting was called back into session at 1:02 a.m.

Gary Sayler [Director, Center for Environmental Biotechnology, The University of Tennessee] was asked to discuss environmental biosensing with bacterial bioluminescence.

One approach to seeing how microorganisms' genes are expressed and their associated physiological behavior, such as interaction with their environment, is the use of reporter genes that emit light (lux genes). This topic has evolved during the past 20 years.

An organism can be attached to a transducer through an immobilizing interface. The reporter gene is turned on by an analyte through a promoter and emits 490-nm bioluminescence. Organisms that degrade toluene, turning on the lux genes and bioluminescing, have been developed. The light emitted indicates the activity of the degrading organism. A series of positively regulated lux CDABE transcriptional fusions have been developed for whole-cell biosensors of organic pollutants, and mechanistic tools for inter-species extrapolation in the environmental and biomedical sciences are being looked at.

Bioluminescent (lux) bioreporters are used because they provide an autonomous response, are repeatable and re-usable, provide a near-real-time response, have an easily measured output (light), and consist of a living system capable of self repair. In other words, they are robust. One can look at these processes as they occur in situ. They provide a real-time analytical approach for the detection and measurement of bioavailable contaminants in the environment and waste treatment systems. They allow online and in situ process monitoring and control strategies for bioremediation and waste treatment. And they offer alternative endpoints for clean-up technologies. This technique has been applied to all sorts of environments: radioactive waste sites, water pollution, etc.

These systems are cyclic and can be continuously recycled. Oxygen and adenosine triphosphate (ATP) are needed. However, it is not the toxicity of the cell that is being looked at but the cell's participation in a process.

The organisms developed came from highly contaminated sites and can be put back into those sites to report on the degradation process in real time. There is a startup time (e.g., 30 minutes) for the bioluminescence to begin because the concentrations of intermediates have to be built up.

A prescreening technology has been developed with this process to check new chemicals for toxicity, saving money by avoiding the cost of the development of potential new chemical products that would not be environmentally acceptable.

The lysimeter facility at ORNL was used to do replicated field studies on contaminated soil. Fiber optics were used to detect light signals throughout this mesocosm to demonstrate activity and decontamination of the soil. Photomultiplier-tube probes were also used to watch the organisms function in the soil. After 13 years, the organisms are no longer found in the lysimeters and are likely to have transferred to the soil community.

Groundwater contamination at Columbus Air Force Base was assayed for $500 in one day rather for $50,000 in six months.

There was a failure of the fiber optics because the light produced was not bright enough. The answer to this problem was the development of bioluminescence bioreporting integrated circuits (BBICs), low-power sensor systems with signal-processing circuitry, an opaque porous barrier, photodetectors, and encapsulated bioluminescent bioreporters. A prototype has been produced that can be used in sol-gel glasses.

New directions have also been taken in eukaryotic cells, interfacing a nanotube/fiber with biological organisms, allowing all-animal sensors. This effort started with yeast cells. Transcription factors are introduced into the nucleus. The genes have to be optimized to the method employed by the species to read the genes. Sensors were developed for estrogenic compounds. The lux genes and estrogenic-compound sensitivities exist in different plasmids. This system is used in wastewater-treatment systems.

It was desired to use a mouse model that used a human cell line. A similar strategy with two plasmids for lux expression was again used. One trick was to introduce an enzyme (luciferase) that operated at the temperature of the human body. All genes have now been subjected to codon optimization, separating them with internal ribosome entry site (IRES) elements, and dividing the expression between two plasmids. One can see a remarkable rise in light production. There is also near-zero background light interfering with the signal. Initial work has demonstrated the ability to trace lux expression throughout a living animal. The number of cells needed to be detected is being reduced to several thousands. This system is not plagued with autoluminescence, as is the green fluorescent protein (GFP) of the firefly system.

It is now desirable to put this under the control of genes, and the work has gone into human breast cancer studies, elucidating the estrogen receptor signaling pathway. A number of clones are being produced with increasingly optimized plasmids.

As these systems are built, they can be used for receptor-binding assay, receptor transactivation, uterotrophic assay, Hershberger assays, structure-activity relationship–quantitative structure-activity relationship, and receptor-reporter assays. Further research will deal with mixtures and interaction, automation to decrease the processing time, online real-time monitoring, and eukaryotic lux expression in vertebrate and mammalian cells.

Biofilm electrode chips with gold and carbon nanofiber-electrode arrays are now being developed to detect biological or chemical agents. NSF is interested in them for real-time bioreporter sensors and therapeutic-effector loops for monitoring physiological fluctuations. One application would be to use an in vivo system to detect an insult and then release, say, an antibiotic to neutralize the insult. A mouse model has been developed for vascular endothelial inflammatory response to pulmonary arterial hypertension, a mouse model that is predisposed to colon rectal cancer, systems for blood glucose monitoring and control, and a zebrafish sensor for endocrine disrupter chemicals in surface waters. Major collaborators are ORNL, Jet Propulsion Laboratory, Kennedy Space Center, and the Electrical Engineering Department of The University of Tennessee.

QUESTIONS

Wall asked how stable the plasmids were. Sayler replied, very stable with just a few copies.

Hubbard asked what Sayler was thinking about in the subsurface application. Sayler answered that, at the Columbus Air Force Base, the organisms were not put in the soil, so one could not look at movement. These organisms make a lot of polymers that hold them in place. One can go down to one cell.

Wildung asked how the search for gene transfer was going to be approached. Sayler said that they had gone into the lysimeter and done nucleic acid extractions. The flux of genes has gone into the soil community. Their resident locations will now be looked for in the metagenome via 454 sequencing.

The meeting was adjourned for lunch at 12 p.m.

Thursday, September 16, 2010
Afternoon session

The meeting was called to order at 1:32 p.m. Petsko moved to approve the COV report, and Joachimiak seconded. The motion passed with one abstention.

Gary Geernaert [Director, Climate and Environmental Sciences Division, Office of Biological and Environmental Research, Office of Science, DOE] was asked to provide an update on the Climate and Environmental Sciences Division (CESD).

As the new Division Director, he wants to make the Division science centric (producing science that matters, is mission relevant, and DOE unique) and be an efficient steward of taxpayer investment, cooperating with other parts of SC and the federal government, exploiting dual-use opportunities. Data are critical to science and must be made available. One must also make sure the science is adopted. His management/leadership priorities are to adopt a shared vision on multidisciplinary problems, maintain the prominence of the staff, look at the “one culture” paradigm (adopting similar ways to do business), and build strong multi-program teams with buy-in from stakeholders.

DOE culture is unique. CESD and BER people should be emphasized and built upon in collaborations with other agencies, making the Division’s efforts fruitful to the USGCRP and the Office of Management and Budget. He is looking forward to laboratory visits and reviews to meet people and to ensure that the Division is working on behalf of the BER scientific community.

Atmospheric system research is improving aerosols in Global Climate Models. There are two problems: (1) primary aerosol emissions and how they are transported up and (2) the transformations of the aerosols to secondary aerosols. A major question is how much resolution is necessary for predictive capability.

The climate research facility’s Small Particles in Cirrus (SPARTICUS) is looking at the in situ size and number of ice crystals in cirrus clouds, conducting direct comparisons on the extinction that is remotely sensed and directly measured in cirrus. The question here is how well measurements from aircraft reflect real ice in clouds. The need is to correct the factor-of-5 difference in current data. One problem is that ice gets shattered as it is sampled.

ARM has made investments in fixed facilities and one mobile facility. A second mobile facility will begin its inaugural deployment at Storm Peak, Colorado in FY11.

In terrestrial ecosystem science, DOE data in the carbon program evaluated the importance of species, succession, and climate on forest composition and biomass accumulation. There are also insect and microbe effects on climate change. One cannot just look at air, ocean, and soil. Insects and subsurface dynamics have to be included, a complex task. In subsurface biogeochemical research, humic particulates from wetland sediments were examined for evidence of microbial reduction. Multidisciplinary approaches will be built to probe microbial dynamics.

EMSL opportunities will be tapped into. Aerosols have brown and white components. EMSL is examining processes governing brown carbon formation using desorption electrospray ionization mass spectrometry (DESI-MS).

In regional and global climate modeling, a coupled land-atmosphere model that includes groundwater table dynamics for climate simulations was developed. This study suggests that climate change, land-use change, and groundwater withdrawal can affect regional precipitation through domino changes in groundwater table depth to provide feedback to the atmosphere.

Each year, climate modelers summarize the state of the art in models and sub models. The Intergovernmental Panel on Climate Change (IPCC) simulation is needed next year. This summer, there were workshops on the advances in the modeling to be used.

Integrated assessment is an important extension to the modeling enterprise, projecting changes in temperature and precipitation that are expected in the next two decades. More exceedances in extreme events are expected in the coming decades.

In summary, a shared vision is being developed with the science community, CESD staff, and BERAC. A broad, amplified program excellence will be built. Multidisciplinarity is a big deal; one must put one’s money where one’s mouth is. Partnering across SC, DOE, and other agencies is important.

QUESTIONS

Shugart asked if the spirit of internationalism carried over from climate to ecological sciences. Geernaert replied that one is never in isolation from other nations and organizations. That said, BER is interested in field sites within the United States (for control over siting and relevance of results).

Robertson observed that there are resource problems in bringing new facets to a field of research and asked what the partnership possibilities were. Geernaert responded that, under fiscal pressures, the Division has to be smart in leveraging. Relations with other programs were sought where interactions were possible. There are a lot of partners in Arctic research (NOAA, the Navy, etc.). The Division will constantly look for new partners.

Mace observed that the new $60 million of instruments will need operational and maintenance support and asked where that money will come from. Geernaert answered that ARM is the backbone of the science that comes out of the program.

Petsko asked where the “culture” comes from. Geernaert replied that SC is the most fundamental part of DOE because it has a culture of discovery. He had not witnessed much stress on the culture on the yearning to advance.

Wildung noted that there are some obvious places where there could be interfaces among research areas and asked if any thought had been given to restructuring. Geernaert responded, no; he was happy the way things were. Interdisciplinism will need to be dealt with in the future, but that need not mean restructuring.

Sharlene Weatherwax [Director, Biological Systems Science Division, Office of Biological and Environmental Research, Office of Science, DOE] was asked for an update on the Biological Systems Science Division.

Every penny for FY10 has been spent. There is a current solicitation on Genomic Science and Technology for Energy and Environment. Future solicitations might include one on Joint USDA–DOE Plant Feedstock Genomics for Bioenergy and one on the Systems Biology Knowledgebase.

A BER Workshop on CAFAE, the Critical Assessment of Functional Annotation Experiment, was held in May. There was broad participation, and a report has been published. Its goal was to explore the feasibility of emulating a critical assessment of computational structural prediction (CASP) competition to improve annotation of genes and genomes. It recommended further discussion for organizing a competition to stimulate improved annotations. Requirements include clear goals and metrics for accomplishment and a governance committee and mechanism that have the respect and confidence of the participating research communities. It was also recommended that awarding a prize for defined specific goals be considered to engage people’s interest.

The Division has also established the Central DOE Institutional Review Board (IRB) as part of its responsibility for the protection of human research subjects at the Department. In 2001, DOE established its Central Beryllium IRB to review all DOE-funded and -conducted human-subjects research related to the diagnosis, treatment, and prognosis of chronic beryllium disease (CBD) in beryllium-exposed workers. In 2010, the scope of that IRB was expanded to include non-beryllium-related multisite health studies of the DOE workforce. The Central DOE IRB (CDOEIRB) held its first meeting in spring 2010. The expansion has been well received by the DOE site IRBs, who also have large representation on the CDOEIRB, and by PIs. The expansion resulted in streamlined approval process for PIs who now do not have to submit protocols for multisite studies to multiple DOE site IRBs for review. The Institutional Official is Anna Palmisano, and the Chair is Jim Morris.

New approaches have been developed for visualizing biofuel catalytic reactions. Neutron crystallography has been used to understand the movement of hydrogen atoms as the enzyme D-xylose isomerase (XI) converts glucose to fructose. Experiments show how hydrogen atoms are moved in the isomerization process, including which amino acid residues are protonated in each step. The results provide a foundation for engineering improvements in the performance of the enzyme with potential applications to biofuel production.

A flux analysis has revealed a new metabolic role for carbon dioxide and nitrogen fixation. The question was why photo-heterotrophic bacteria need to fix CO_2 while consuming organic acids as a carbon source. Transcriptomics was used to examine the flow of carbon and electrons during the growth of *R. palustris* on acetate. One of the interesting findings was that biosynthesis consumes only 50% of the reduced cofactor; extra electrons are directed to fix CO_2, recharge cofactors, and balance the redox potential. During N_2 fixation, electron flow is partially redirected towards hydrogen production. This research illustrates how cells can use core metabolic processes to perform multiple functions.

At Lawrence Berkeley National Laboratory, a broader role of metals in microbial processes was studied to understand the true extent of metal-containing microbial proteins on a genome-wide scale using a new combination of techniques that separated proteins from bugs and analyzed the distribution of metals in those proteins. An unexpectedly high number of metal-containing proteins were identified with a broad diversity of metals. These results point to a revised and broader role for metals in microbial processes and the validation of a new discovery tool for biology.

A question that has puzzled biologists for decades is why all cells do not respond to radiation in the same way. Experiments were conducted to study cellular inter-individual variation in DNA damage repair after exposure to low-dose radiation. These experiments found a significantly slower focus formation in seven normal strains similar to most of the mutant strains. Genetic variants in DNA damage signaling and repair genes in apparently normal individuals may contribute to different susceptibility to cancer induced by radiation exposures. These findings point to the fact that there is a lot more complexity to the repair process.

In an experiment on flexible, high-performance electronics for radiotracer imaging, the goal was to design electronics that can be used for a wide variety of radiotracer imaging cameras. Open-source software and firmware were developed to allow multiple research groups to pool resources and speed development. This is useful for DOE mission needs and the radiation imaging instrumentation community.

A joint program in SciDAC sought to identify all possible metabolic microbial pathways and to optimize these pathways to achieve a target level of product. Optimization blocks the “side roads” and looks at what happens to the traffic on the beltway. This allows one to translate predictive metabolic pathways into quantifiable levels of products and to quickly identify novel pathways and intermediates that can be explored using experimental metabolic bioengineering techniques.

The switchgrass genome structure is being revealed to enable genetic improvement of the crop. Switchgrass is tetraploid with two male and two female parents. Complete male and female parental linkage maps of two tetraploid switchgrass genotypes are being constructed and compared to sorghum, foxtail, and millet. This approach is expected to enable the development of marker-assisted selection strategies to improve switchgrass and other potential bioenergy grass species.

The third-year review of the DOE bioenergy research centers will entail reverse site progress reviews in late September 2010. A single external review team will evaluate the science and management and the progress made against stated milestones of all three centers.

At the Great Lakes Bioenergy Research Center, the gene responsible for the synthesis of low-viscosity seed oil has been identified to enable discovery and engineering of novel oils in plants. *Euonymus alatus* (burning bush) seed oil is 30% less viscous than conventional vegetable oils because of an unusual triacylglycerol (TAG) content. The JGI was used to isolate the rare gene encoding the enzyme required for acTAG. A*rabidopsis* was transformed with this gene-produced acTAG. The identification of this gene suggests the potential of engineering plant oils with specific desired properties for biofuels.

The JGI is determining what genes are responsible for the synthesis of long-chain alkanes in *Micrococcus luteus* for biofuels. Three genes were identified that resulted in the synthesis of long-chain alkanes when introduced into a fatty-acid-overproducing strain of *Escherichia coli*.

The BioEnergy Science Center at ORNL is using high spatial-resolution chemical imaging of lignin to supply potential explanations for improvements in saccharification. In a wild-type cell, one can have a lot of lignin buildup. Wild-type and reduced-lignin alfalfa were imaged to show that lignin modification occurs preferentially in cell corners, perhaps providing larger pathways for the movement of enzymes.

The Joint Genome Institute had its Community Sequencing Program review in August, and responses are imminent. They have held their fifth annual user meeting, a workshop on finishing in the future, and the 10th cyanobacterial workshop. The March peer review of the JGI was positive. The reviewers found that JGI is highly committed to improve operations and efficiency, but it needs to identify critical workflow bottlenecks, establish key performance indicators, and implement workflow and tracking processes. In addition, it needs to augment senior information-technology-operations management expertise. The JGI response was to hire a chief information officer and associate director, to acquire a laboratory information management system designed for sequencers, and to develop improved standard operating procedures. These actions should lead to greater efficiency for the user community. JGI is seeking genomic clues into multicellularity by probing its genetic basis. There is sizable overlap of different genomes, so they are sequencing the genome of the multicellular alga *Volvoc carteri* to compare it to the sequence of a single-celled alga *Chlamydomonas*.

BSSD is going to hold PI meetings for the Interagency Modeling and Analysis Group, Radiochemistry and Instrumentation Research, and Genomic Sciences. It will also hold workshops on switchgrass and low-dose strategic planning.

QUESTIONS

Petsko noted that, in modeling pathways, an implanted gene was shared 700 million base pairs upstream by *Escherichia coli*. He suggested that more time might be spent on modeling. Weatherwax responded that one can build a lot of models, but they have to be experimentally validated. The Division is trying to do experiments in a way that a lot of people with different viewpoints can access and use the data.

Gilna stated that proposals coming into the JGI have outpaced capacity despite the fact that capacity has now grown tremendously. He asked if there were a change in the dynamics of market demand. Weatherwax replied that there is a lot of interest and there are a lot of submissions. Some interest is in sequencing, and some in analysis. The division is working with submitters to understand the difference and to forecast demand and capacity. Daniel Drell (BSSD, BER, DOE) added that, in the current cycle, JGI specifically asked for the more complex projects.

Joachimiak noted that there had been no mention of metagenomics and asked what the major challenges in that field were. Weatherwax replied that the Knowledge Base will deal with metagenomics (or metanomics).

Wall noted that there is a huge pressure on JGI and asked if that was coming at the expense of closing sequences. Weatherwax answered that, to a certain extent, the answer to that question is yes. New machines will broaden the bandwidth.

Joachimiak asked if BER were funding research on oil-producing organisms. Weatherwax responded that she did not believe that any of the BRCs were targeting oil-producing organisms, although some national laboratory resources are being used by companies to do that. BER contributed to the fundamental science that underpins those efforts.

A break was declared at 3:06 p.m. The meeting was called back into session at 3:31 p.m.

Palmisano introduced **William Brinkman** [Director, Office of Science, DOE] to give an overview of activities in the DOE Office of Science (SC).

He thanked the Committee members for their dedication and hard work. What BER is doing will play an important role in energy conservation and climate. The budget is a continuous struggle. There will be a continuing resolution starting October 1.

SC has six research offices [Basic Energy Sciences (BES), BER, ASCR, Nuclear Physics (NP), High Energy Physics (HEP), and Fusion Energy Sciences (FES)] and WDTS. SC's priorities are in scientific computing and climate science. Its requested budget for FY11 is $5.1 billion, a 6.1% increase. The 2011 budget has now come out of the congressional committees. SC took a heavy hit in the House markup (minus $221.5 million); the Senate took $109 million away from the request. BES took a heavy hit, a loss of $95.9 million in the Senate markup. BER took a –2% hit; both the House and Senate took out about $8 million. All of this is being appealed now. There were $18.3 million in unfunded directed earmarks in the House markup and $40.8 million in the Senate markup. Congress moved nuclear medicine from nuclear energy (NE) to NP. An effort will be made to try to have the cuts restored.

The SC Graduate Fellowship Program is very important. $10 million will be needed in FY11 to fund about 170 additional fellows. There were more than 3000 applications for 150 fellowships this year. About $16 million will be available in FY11 to fund about 60 additional Early Career Awards at universities and DOE national laboratories. These budget changes reflect the reversion to a more normal budget after the Recovery Act (ARRA) infusion.

SC now has proposed two hubs. The ultimate goal for the Fuels from Sunlight Hub is to imitate photosynthesis with a factor-of-10 increase in productivity. The winning team was California Institute of Technology and Lawrence Berkeley National Laboratory (LBNL); it will be led by Nate Lewis and will partner with six other institutions. The Department is pushing for a Battery and Energy Storage Hub that will deal with the problems produced by intermittent energy sources (wind, solar, etc.). It is in the Senate version of the FY11 budget but not in the House version.

SC has the number one (ORNL.), number nine [Argonne National Laboratory (ANL)], and number 17 [National Energy Research Supercomputing Center (NERSC)] computers in the world. They are pushing the nation's modeling and simulation capabilities. ASCR has an Exascale Initiative that will allow even greater capabilities in modeling and simulation of clouds, heat turbulence in the atmosphere and oceans, and climate. The major components of the Exascale Initiative include platform R&D on power, integration, and risk mitigation; critical technologies; software and environments; co-design and integration with vendors; and platforms that ensure component integration and usefulness. The long-lead-time R&D is required on applied mathematics and computer science.

The Linac Coherent Light Source (LCLS) at SLAC produces an amplified X-ray beam. It worked the first day it was turned on, and has already produced several science results, such as refracting nanocrystals in water. The Bioenergy Research Centers will make a big difference in the energy picture.

The International Thermonuclear Experimental Reactor (ITER) in the past year has developed a real schedule, estimated a realistic cost (that translates to a billion dollar annual contribution from the United States), and installed a new director. It has been established as an independent international legal entity with about 400 personnel from all of the member nations. The United States has a 9% share in this enterprise; the European Union has a 49% share of it. Roughly 80% of the U.S. contribution will be in-kind components manufactured largely by U.S. industry. In addition, the United States will contribute 13% of the cost for operation, deactivation, and decommissioning. The U.S. share of construction was estimated to be $1.45 billion to $2.2 billion. ITER is located in Cadarache, France, and the site has been prepared.

The Inertial Fusion Energy project at the National Ignition Facility is nearing ignition. They use a deuterium pellet in a gold cage.

HEP has three frontiers: intensity, energy, and astrophysics. In particle physics, SC is supporting work at the Large Hadron Collider (LHC) and at the Long-Baseline Neutrino Experiment (LBNE). There is a big push to keep the Tevatron running; it looks like it can do a lot. The Tevatron was to have been shut down in 2011, but areas of exclusion for the Higgs boson have been constantly expanded, leading to valuable prospective insights from its continued operation for another 2 or 3 years.

In accelerator technology, the questions are:

- Can accelerators be built with about 50 MW of power in the beam?
- Can associated targets be constructed?
- Can accelerators be built to burn the actinides that dominate nuclear-waste-storage issues?

It is now believed that these machines can be built.

Steps are being taken to strengthen the Small Business Innovative Research (SBIR) program, which amounts to $150 million to $200 million per year in the DOE budget, Those steps include increasing the size of grants and its being moved up to report to the Deputy Director of SC. The Office is being enhanced to deal with SBIR better.

The major gaps in climate models are the representation of clouds, direct and indirect effects of aerosols, and interactions of the carbon cycle. BER is making contributions in all three topics.

QUESTIONS

Stacey stated that the Committee supported keeping radiobiology in BER, the federal home of systems biology.

Petsko pointed out that $10 million buys 150 graduate fellowships and that nothing else has a bigger bang for the buck. He asked why 500 fellowships were not instituted. Brinkman agreed and suggested that Petsko write to his congressman.

Wildung noted that Brinkman had not covered DOE legacy waste. Brinkman replied that that is not part of SC; the Office of Environmental Management (EM) is a separate organization. The topic needs more fundamental science clout. There is a lot of waste around the country. Wildung stated that the way to deal with it is with a strong fundamental research program, which exists in BER.

Gary Stacey [BERAC Chair; Department of Microbiology and Molecular Immunology, University of Missouri] described the Workshop on Grand Challenges for Biological and Environmental Research: A Long-Term Vision. This is a BERAC activity, and the report of this workshop must be what BERAC wants.

By taking a long-term approach, the workshop eliminated self-centered discussions. In a series of conference calls, the steering committee decided to focus on four white papers: systems biology, systems integration framework for informational and synthetic biology, climate change, and system sustainability for energy options. White papers were written ahead of time and distributed to the participants. They formed the foundation of the draft report.

The workshop was held March 3–4, 2010, with breakout groups on the four main topics. It also had interdisciplinary breakout groups on understanding systems across temporal and spatial scales; meeting workforce and education needs; data integration and knowledgebase development; and novel tools, techniques, and probes. All of these discussions were integrated into the report.

There is some (good) repetition in the report on the cross-cutting themes of complexity, scales from the molecular to the ecosystem, multidisciplinary research, computing and mathematics, education, and human impacts of climate and terrestrial ecology. The report was divided into the five areas of

- Biological systems, which represents the approaches and tools needed to address biological complexity
- Computational bioscience
- Climate research
- Energy sustainability
- Education and workforce training

The grand challenges in biological sciences are systems and synthetic biology for enabling predictive biology, measuring and analyzing biological systems, and exploring ecosystem biogeochemistry and carbon cycling to achieve DOE missions in energy production, carbon biosequestration, and environmental remediation. The complexity of a single cell is so great, the first task should be to catalog all the parts of a cell and how it forms. New, more relevant model organisms need to be established for understanding ecological processes. It is very clear that biological systems need additional measurement and analysis. Only 10% of microarrays have the time of day noted, which is needed to study circadian rhythms. More reproducible sampling and standardization are needed.

Gary Sayler [BERAC member; Director, Center for Environmental Biotechnology, The University of Tennessee] reported that, in exploring ecosystem biogeochemistry and carbon cycling, the workshop was trying to pull together synthetic biology and ecosystem function. A huge leap forward is needed. The same thing is needed for soil microbial communities and other systems. These systems all interact. The workshop agreed that progress needs to be made in this regard so systems can be manipulated in 20 years. A possible goal might be to increase carbon binding in biomass by 50% in the future.

The grand challenges in computational bioscience include

- A new publishing paradigm needs to be created.
- The data-management paradigm calls for the exascale computer mentioned by Brinkman. The amount of data is increasing exponentially, but the number of people that can analyze those data is leveling off.
- A new computing paradigm needs to be developed.
- Experimental protocols need to be standardized, and methods to increase interoperability need to be devised. There is not enough information in publications today to allow replication.
- Data quality needs to be improved.

David Randall [BERAC member; Department of Atmospheric Science, Colorado State University] presented the grand challenges in climate research, of which there are six focuses:

1. A climate model with additional processes and a longer timescale and higher resolution is needed for Earth-system modeling.
2. Cloud and aerosol processes need to be better understood to improve parameterizations for microphysics, radiative transfer, and turbulence processes.
3. Ocean and terrestrial processes require ecosystem-observing systems to monitor biogeochemical cycles and the ocean and terrestrial biospheres, including subsurface soils (e.g., permafrost).
4. Biological processes (including interactions and feedbacks) need to be better understood.
5. Human interactions (e.g., anthropogenic climate forcings) on century timescales are getting beyond today’s models.
6. Observing systems and facilities like the ARM Program are needed for dealing with all the topics above.

Stacey continued with the grand challenges in energy sustainability, which include land use. The system is very interactive and coupled. Sustainability is better defined by the problem than by the science. It has a large influence from human behaviors. Social sciences are needed.

In discussing the grand challenges in education and workforce training, the point was made that there is a lot of information available that this community should learn about. The community should transition to an experimental method of learning and install education experts at the national laboratories to fulfill the DOE education mission.

DISCUSSION

Now the report will be taken by BER (if approved by BERAC) and used to guide planning and activities. He thanked the steering committee, workshop attendees, contributing authors, BER staff, Betty Mansfield and her staff at ORNL, DOE funders, and SC for initiating the process.

Sayler asked whether BERAC will have a chance to react to the draft report. Stacey said that Committee had the next 60 minutes for additional input. Palmisano thanked everyone for the input; it will influence the direction of BER for years. The report is full of information and very readable.

Penner noted that there are two short chapters, and therefore there are some balance issues to resolve. Chapter 5 could be rolled into the climate chapter, where there are also computational aspects. Stacey pointed out that there is a section on the workforce in the climate chapter although there is a separate chapter on that topic.

Hubbard said that there seemed to be a lot more granularity in the recommendations in the biological systems section. Stacey said that each group took a different approach on how they did the recommendations.

Fowler pointed out that there were two talks by Brinkman and Koonin at the workshop that were very pointed. She suggested that it would be good to have those talks at the beginning so the public would understand the size of the problem. Stacey suggested that there could be a letter from them at the beginning. Palmisano said that it should be a BERAC report, but one could go back and look at the transcripts from their talks.

Ehrlinger said that he did not see any mention of the urgency to get on with these issues. That part is missing. It just looks like a shopping list. Stacey agreed that the urgency should be set out at the beginning of the report and then the focus should shift to the science. The workshop was not asked for a roadmap or plan but grand challenges. Follow-on workshops will fill out a roadmap. Palmisano said that there will be a lot of ideas given the 20-year horizon. Decisions will have to be made about what priorities should be dealt with first. Wildung pointed out that, by holding workshops, one *is* setting priorities. Palmisano replied that the Office does not want a ranked list, but urgent issues could be flagged.

Sayler stated that some of the plenary papers gave a sense of the urgency. A synopsis of those papers could be used as a preamble. Robertson added that those plenaries could be pulled out in boxes. The balance issues should be dealt with. The recommendations of the first section could be grouped. The sustainability section acknowledges the importance of human factors but stops there. The report should recommend that BER have social sciences in its portfolio; NSF does.

Stacey agreed that categorization of the recommendations in the biological systems chapter was a good idea.

Hubbard noted that, in the cross-cutting themes, a couple seemed to be approaches and suggested that they be moved to a different section and to use complexity as a unifying theme.

Shugart noted that Chapter 4 talks about a variety of issues and that things get softer when one gets to oceanic and terrestrial processes. That imprecision should be addressed. One needs to know not only *how* it works but also *how much* of it is in play. Stronger points could be made here. Randall pointed out that what was there was what was heard from the participants. Carbon feedbacks are very worrisome. He would appreciate some additional text. Saylor added that this was the direction that was discussed in the workshop. This issue needs to be brought out more and linked to the models. Joachimiak suggested that there could be a theme of complex systems. Stacey said that there was a discussion of evolutionary changes; however, the original used animal models and was dropped out.

Leung pointed out that a lot of modeling problems are caused by the lack of data. More data are needed.

Stacey mused whether the problem with the computational chapter might be the title because it is very generic. He pointed out that the language of the recommendations is very different from that in the other chapters and needs to be fixed. The recommendations need to be lengthened and made more descriptive.

Wildung pointed out that there was no mention of informatics. Stacey pointed out that there is some language about informatics in the biological systems chapter.

Stacey summed up:

1. The computational chapter needs to be looked at again.
2. A preamble needs to address the urgency.
3. Hank needs to put his aspects into the climate section.
4. Evolution needs to be included.

Hubbard added that the recommendations need to be balanced, also. Stacey promised to categorize them to about five points with some subpoints. Robertson said that he believed that social science should be put into the sustainability section. Stacey asked that, if people had marked up copies, those copies be passed in so the changes could be incorporated. He asked if the Committee were comfortable with accepting this report. André replied, yes. Mace said that the preamble should not be alarmist. Zhang pointed out that the Executive Summary refers to grand challenges but the text refers to recommendations. Stacey revised the list of changes to be made:

1. Balance the recommendations, categorizing the biological systems recommendations.
2. Look at the computational chapter again.
3. Strengthen some evolutionary statements.
4. Provide additional input to the climate chapter.
5. Put in a preamble.

Sayler moved, Joachimiak seconded, to accept the report with changes that will be reviewed by the whole Committee.

Thomassen observed that the Committee had three options: it could float a conditional acceptance pending revision of the report as discussed, wait until the next meeting to accept the report, or have a FACA [Federal Advisory Committee Act] teleconference after this meeting but before the next meeting. Stacey said that he believed that the changes were largely editorial and that the motion on the floor could be voted on. Robertson pointed out that none of the recommendations would be changed. Mace was concerned about the tone of the preamble. Stacey promised that the report will not go out with a preamble that the Committee does not see and have a voice on. Ehleringer pointed out that there is always an opportunity for additional changes.

Stacey reiterated that the motion was to accept the grand challenges report with the understanding that revisions will be made and submitted to the full Committee for review and additional changes, if necessary. The vote was unanimously in favor of the motion.

Stacey announced that there are two new charges to the committee. Minghua Zhang (BERAC member) has agreed to chair the review of the ARM Climate Research Facility (ACRF). Daniel Bush (Colorado State University) will chair the COV of the Biological Systems Science Division (BSSD) program.

He opened the floor for additional business of the Committee. There was none.

He opened the floor to public comment. There being none, the meeting was adjourned for the day at 5:20 PM.

Friday, September 17
Morning Session

The meeting was called back into session at 8:29 AM by the chair, Stacey, who asked for corrections to the Grand Challenges Report to be turned in.

Palmisano introduced **Steven Koonin** [Under Secretary for Science, DOE] to give an overview from the perspective of the Under Secretary of Energy for Science.

DOE has four missions: to sustain basic research for the discovery potential and to support the Department's missions, to catalyze the transformation of the national and global energy system, to enhance nuclear security, and to contribute to U.S. competitiveness and jobs in both the long-term and the near term. Science is the heart of DOE, and fundamental research is the heart of science.

In basic research, the United States has been a global leader for 50 years, but now the rest of the world is investing a lot of money in science. It is unclear if the United States is still the leader in many fields. It must be determined in what fields United States is the leader, in what fields it is content to run with the pack, and what fields it wants to leave to others. DOE needs to balance resources in basic research between fields that are close to versus distant from applications. Agencies must talk to the public and to Congress more effectively. Climate science must be improved; it has gone from an academic exercise 30 years ago to prominence today. How to deal with all these issues are major questions to be addressed. The level of computer science research is a commensurate with its level of importance.

The drivers of energy transformation are energy security and reducing greenhouse-gas emissions. To enhance energy security, the target is to reduce crude-oil use by 3.5 million barrels per day. To check greenhouse-gas emissions, a 17% reduction in emissions is sought by 2020 and an 83% reduction by 2050. These are massive changes. Changes in energy supply occur at decadal scales; it takes a long time to make changes in energy use. The fastest the nation has ever changed was at the rate of 1% per year. One question is how to hook up science and technology with society and industry; the government does not operate the major energy enterprises in the country, and the goal of the private sector is to make money, not changes. Another question is what the best research structures are. Coupling basic and applied research is being addressed with the energy hubs and the Advanced Research Projects Agency–Energy (ARPA-E) initiative. The policy must be gotten right because a reliable and enduring policy must be in place before industry will move.

Nuclear security is half the energy enterprise, a big change from decades ago. It is not well understood outside the Department. DOE must maintain a technical base, it must keep its staff engaged even though it is not testing weapons anymore, it will begin a sustained-burn campaign in a couple of weeks at the National Ignition Facility, and it needs to exploit the simulation capabilities developed for simulating physical nuclear testing. SC has developed modeling and simulation this past decade and has the world's fastest computer. Simulation can also help shorten the time to market.

In U.S. competitiveness, a deep understanding of the issues must be grasped. The rest of the world is growing and developing faster than the United States is. The long-term trends in domestic output and employment are not in the nation's favor. Scientists and science and technology must determine the right strategy and what roles they are to play in it; innovation is key to competitiveness.

In FY09, federal spending was largely for Social Security, Medicare, Medicaid and the State Children's Health Insurance Program, unemployment and welfare, interest on the national debt, and the Department of Defense (DoD). DOE is in the discretionary portion of the budget. This is unfortunate because the federal deficit is shaping the budget discussions. SC is in the nondefense discretionary part of the budget. There has been a phase shift in the federal deficit projections that will cause difficult financial discussions in the coming years.

He thanked the Committee for its hard work and continued dedication to advising the government.

QUESTIONS

Sayler asked if there were a science role in dealing with resilience issues. Koonin replied, yes; in a nuclear incident, DOE would work closely with the Federal Emergency Management Agency (FEMA). Simulations and models are used to make projections of disasters.

Petsko asked about the role of peer review in setting priorities. Koonin said that peer review is right for certain fields, certainly for a field like yeast genomics. It becomes much harder when one is trying to allocate research dollars between high-energy physics and basic biology. A deliberative effort is needed at that level rather than the microbalancing of traditional peer review. The question then arises, at what level would one want to undertake a deliberative priority setting?

Stacey asked if anything could be said about strategic planning. Koonin replied that the Secretary has asked for a strategic plan for the Department. A draft is being reviewed. It will be ready for public review soon. It is a bottom-up exercise.

Sayler asked if the Department came under pressure to do more in the petroleum sector since the BP disaster. Koonin said that he was constrained by ethics in discussing such issues since joining the Department. DOE had a role in capping the well. The Department may have a role in basic research related to petroleum extraction in the future.

Michael Kuperberg [Program Manager, Climate and Environmental Sciences Division, Office of Biological and Environmental Research, Office of Science, DOE] was asked to describe the activities of the Climate Research Roadmapping Workshop.

DOE must understand the effects of greenhouse-gas emissions on Earth's climate and the biosphere and provide foundational science to support critical energy and environmental decision making. BER has expertise in and tools for atmospheric-system research, environmental-system science, climate and Earth-system modeling, and the ARM Climate Research Facility.

BER addresses key uncertainties in climate models, investigating how clouds, aerosols, and the carbon cycle interact with the Earth-system, regional, and global models and with integrated assessment. The question posed to the workshop was how can process research and climate models be better integrated.

The Climate Research Roadmapping Workshop's objectives were to create a forum for discussion of scientific opportunities and knowledge gaps; to provide input in the framework of the near, mid-term, and long-term goals for the next 10 years; and to identify new approaches for integration of climate science and encourage a wide range of ideas. These objectives were approached by putting together a steering committee and developing white papers and blogs to spark discussion and promote debate. The focus was on areas of unique DOE strengths and atmospheric and terrestrial modeling. It also focused on latitudinal challenges (high, mid, and low latitudes) in modeling. Jerry Melillo made a keynote presentation to more than 50 participants of diverse scientific and institutional backgrounds.

Following the workshop, BER staff compiled material from discussion papers, presentations, and extensive notes into the workshop report. Hard copies will be available soon, and a digital version will be posted on the BER website at (http://www.sc.doe.gov/ober/ClimateRoadmapWorkshop_2010.pdf).

BER identified seven overarching findings from the workshop:

1. BER's strengths and integrated, model-inspired science should be built upon to understand complex systems (look at where the models are, where they are going, and what they need).

2. Foster a balanced program of discovery and use-inspired research.
3. Develop and support targeted scientific research campaigns (in the most general way) focusing on practical challenges that may or may not require mathematical modeling.
4. Understand and quantify uncertainty in climate projections (not just *how much* uncertainty, but also *why* uncertainty).
5. Understand the sign of the carbon feedbacks (from all forms of carbon) and how it changes over time; process research needs to be coupled with model development and evaluation.
6. Understand the role of natural and anthropogenic disturbances in Earth systems and incorporate information into model projections; disturbance can be the driving factor in the balance of Earth systems; disturbance needs to be incorporated appropriately into models.
7. Understand and incorporate the complete water cycle into regional, climate, Earth-system, and integrated-assessment models (the water cycle has not been studied in its entirety); water is the integrating factor with respect to Earth's complex systems; precipitation, soil moisture, and surface and subsurface water movement are critical to Earth systems; a holistic view needs to be taken of the complete water cycle.

Next steps include:

- The climate report will be posted digitally and published in hard copy.
- The report on the Climate Research Roadmap Workshop provides vital input from the scientific community on key knowledge gaps, important scientific opportunities, and new science-integration ideas.
- The Climate and Environmental Sciences Division will use the findings from the Roadmap Workshop to update its 10-year strategic plan from 2008.

DISCUSSION

Shugart said that he was pleased to see the feedback case made. He asked what the short-term feedbacks were and whether they make long-term feedbacks moot. Many global-scale carbon-budgeting models overlook mortality, which should be reflected in these models. Kuperberg replied that the workshop discussed who needs to be doing what modeling and what links need to be made to R&D.

Wall pointed out that nitrogen oxide is never mentioned and asked if it were not a problem. Kuperberg answered that nitrogen cycling has to go into these models. They need to focus on carbon, but now are shifting to terrestrial ecosystems where nitrogen cycling must be considered.

Braam asked how one will know what is to be included in targeted research campaigns. Kuperberg responded that workshops and report writing will result in very interactive community-based understanding and decision making. A lot of effort will be invested in understanding how these systems work, effort that will be guided by community input.

Gilna asked where this work dovetailed with the Department's strategic plan. Palmisano replied that the Department's strategic plan is a high-level document that has a section on climate to which BER will contribute.

Mace stated that global models need global measurements and asked what role BER will play with other agencies in gathering those data. Kuperberg replied that was not a topic of the workshop. The American data provide a part of the global datasets needed. There is a lot of collaboration, but there is certainly a way to go. Palmisano pointed out that there is BER cooperation with NASA on global observations. Other federal agencies have played key roles in collaboration with BER, also.

Ehrlinger asked if there were any consideration of research in the Arctic regions. Kuperberg replied that BER was working closely with NSF on that and had a meeting with them in a matter of hours. BER is actively engaged in the issue.

Penner noted that most R&D had focused on narrow topics and asked where the recommendations for targeted applications came from. Kuperberg said that they came from all sides. There are gaps in knowledge that the groups reminded the Office to pursue with use-directed research.

Zhang asked if these recommendations were consistent with the current program. Kuperberg replied, yes, except for the holistic water-cycle recommendation linking all the pieces.

Robertson asked if the group expressed any concerns about investments in long-term investments or collocating the Intensive Operation Periods (IOPs) with other networks. Kuperberg responded, no. A paper on "how long is long enough" for long-term experiments is coming out soon in the journal literature. One has to have timescales that make sense for the process.

David Randall introduced **Ted Schuur** [Department of Biology, University of Florida] to make a presentation on permafrost carbon and climate feedbacks in a warmer world.

The climate in the 21st century is going to be very different from that of preceding centuries. Warming at high latitudes will be greater than the global average increase in temperature.

There is a feedback between climate and terrestrial ecosystems, mainly through the carbon cycle. Global flows of carbon are dominated by plants and soil. Areas subject to vulnerability because of the carbon cycle in the 21st century include high-latitude peatlands, tundra peatlands, and vegetation as affected by land-use change and fire.

Some model-ensemble runs have looked at land influence on the carbon cycle in the future (the net land uptake of carbon per year). They agree that the terrestrial system is a carbon sink. However, they diverge after 2010. Many carbon pools and sinks are not represented well in these models.

One feedback loop is temperature rise from carbon dioxide that propagates into the permafrost that is then subject to microbial decomposition, releasing more carbon. The rates of emission and the carbon pools' size are uncertain. Permafrost zones have been identified. Ecosystem factors play a large role in carbon release. Permafrost has an active layer and can have ice wedges and permafrost soil interfaced with the active layer. The soil column has an organic soil layer and then a mineral soil layer.

Twice as much carbon is frozen in the permafrost (1672 Pg) than is now in the atmosphere (777+ Pg). During permafrost thaw, there are several thresholds at the freezing point, a biological threshold and a physical threshold. When the ice wedges thaw, the ground can collapse, and the thawing of the permafrost can occur much faster.

It is normally expected that the permafrost thaw will result in the active layer thickening. The circumpolar active layer network measures the depth of the active layer around the Arctic Circle. The plans have been modeled and the model results showed the disappearance of the top 3 m of the permafrost in the next century for 85 to 90% of the near-surface permafrost.

Under the influence of increased temperature, the ground subsides. No models reflect this phenomenon, and there are no data being gathered about it. 50% of Alaskan permafrost displays this phenomenon. This is a rapidly growing occurrence. In Alaska, this thermokarst subsidence is expected to increase from 0.6% to 4.4% of the continuous zone and from 26% to 33% of the discontinuous zone during the next five decades. This thermokarst subsidence often results in thermokarst lakes. In Siberia, there was a 12% increase in lake area in the continuous zone and a 13% decrease in the discontinuous zone (water seeps into the ground) between 1973 and 1998.

Ecosystems are responding in their plant growth, also, producing a greening of the Arctic (to boreal forest) that offsets the release of carbon from peat. It is not known how the respiration potential will evolve; methane may be the dominant emission, or it may be carbon dioxide. A lot of work has been done on this question. Research in the discontinuous zone shows early indicators. All of the permafrost is degrading in the Eight-Mile Lake study area. The more thawing there is, the more respiration there is, producing "old carbon" loss to the atmosphere.

During the past 15 years of thawing, greening is a bigger actor than the carbon loss from the peat. At the same time, the permafrost carbon is being degraded. But currently, the negative feedback is smaller than the positive feedback.

With winter-warming experiments, the permafrost is thawed down to 50 cm, producing a degradation of the surface permafrost. Under summer conditions, there is no effective warming. Under winter conditions, there is a positive effect. Integrated over the year, there is a negative effect. The expected effects are seen: warmth affects the carbon cycle.

A major question is: What is likely to be the relative importance of methane versus carbon dioxide release for future climate forcing? The global warming potential is 25 to 1 (methane to carbon dioxide). A single laboratory experiment showed that the relative climate forcing of the two gases is the same for aerobic systems. The literature as a whole shows methane is an important player, contributing about half of the methane released to the atmosphere in the past century. The surface permafrost will lose about 1 Pg of carbon per year.

In conclusion, permafrost carbon pools are large and quite sensitive to changes in temperature. Rapid (decadal scale) destabilization of these pools is possible, given threshold dynamics. And the future annual contribution to the atmosphere could be similar in size to that of land-use change but is currently poorly constrained.

QUESTIONS

Stacey asked whether, the last time there was global warming, it was accompanied by a rise in carbon dioxide in the atmosphere. Schuur said that his understanding was that there had been an increase in atmospheric carbon dioxide during the past five interglaciations but that there was a lag between the rise in carbon dioxide and the warming. Solar forcing played a role in the past, but the current temperature rise is not being initiated by solar input this time. It is different.

Shugart said that, in the Little Ice Age, there was a 60 ppm increase in carbon dioxide per degree increase after a 50-year lag, which is consistent with the current observations. Schuur noted that only isolated observations are being made at the current time.

Mace asked if one can find evidence that the soils were degraded during the Little Ice Age. Schuur replied affirmatively. One can find ice wedges that are not there in Europe; and when one looks at their carbon content, one finds that their carbon has already degraded.

Leung asked what timescale differences there were. Schuur replied that the timescales are important. The plants respond more quickly than does the peat-decomposition process. They cannot be decoupled. But plants are constrained by how fast they can grow, whereas there is no such constraint to peat thawing. Greening is not going to offset permafrost carbon release in the first decades.

Ehrlinger asked at what point the nutrient level influences carbon uptake. Schuur answered that that issue is complicated by export of nutrients to lakes, rivers, and oceans. The system is leakier than first expected. This is a weak link in the modeling.

Robertson noted that there is an albedo effect in play here, also, and asked how that affected the modeling results. Schuur said that the albedo is affected not only by snow presence but also by land cover. Shrubs and trees decrease the albedo in a magnitude that is equal to the carbon effects, balancing out the carbon influence. It is difficult to figure out the net balance because of local ecosystem effects (i.e., land vegetative cover).

Robertson asked if there were any indication that nitrous oxide will affect the processes. Schuur replied that nitrification is very low, but not all the sources might be being looked at.

A break was declared at 10:15 AM. The meeting was called back to order at 10:31 AM, and

Arun Majumdar [Director. Advanced Research Projects Agency–Energy, DOE] was asked to describe the ARPA-E initiative. As an aside, he noted that research by his daughter had shown that there is a methogenesis gene in permafrost microbes as part of a summer project at the JGI.

ARPA-E was launched with \$400 million of funding in response to the recommendations of the *Gathering Storm* report of the National Academy of Sciences (NAS) and it was modeled after the Defense Advanced Research Projects Agency (DARPA). DARPA was launched in 1958 in response to Sputnik, when the United States felt it was losing its technology lead. The United States is undergoing a Sputnik moment right now in energy security, greenhouse gas emissions, and U.S. technological leadership. The United States has less than 1% of the lithium ion battery production in the world; Japan has 46%

The Earth has a huge population whose energy use is very low now but is growing rapidly. The average CO_2 production per capita for the world is 5 tons per year; the U.S. production is 20 tons per year. In China, they are trying to take a low-intensity energy trajectory.

ARPA-E was authorized in 2007 as part of the America Competes Act. Its first budget was included in the American Recovery and Reinvestment Act of 2009 (ARRA). In its first round of funding, 3700 papers were received, 312 full applications were encouraged, full applications were panel reviewed, and 37 projects were funded (averaging \$4 million for 2 to 3 years). How many good ideas are out there was an eye opener. The contracting process of DOE was changed to process awards in 3.5 months. Putting the contracting offices, scientists, and lawyers in the same space sped up the startup process for getting projects funded and operating.

ARPA-E is looking for high impact on ARPA-E mission areas; disruptive, innovative technical approaches; strong impact of ARPA-E funding relative to the private sector; and best-in-class people and teams.

A few ideas from the first round of funding:

- Artificial cellulose breakdown is expensive, so Agrivida is taking known genes and putting them in the plant in a blocked status to be triggered upon harvest to produce biofuels. The plant produces all the enzymes and chews itself up from the inside out.
- A breakthrough high-efficiency mixer/ejector wind turbine from FloDesign Wind Turbine Corp., increases efficiency from 60% to the point that it beats the “best limit” by 50%, lowering turbine costs by 40%.
- Grid-level electricity storage from the Massachusetts Institute of Technology is scalable from megawatts to gigawatts, using molten aluminum at \$50 per kilowatt-hour.

The second round of awards is considering three technologies. The first technology is batteries for electrical energy storage for transportation. Lithium-ion batteries have a high cost and a low energy density. Targets set include a cell-level energy density of 400 W-h/kg and a cost of \$250/kWh. Metal–air batteries and Li–S batteries may reach these targets but are hard to exploit. The second technology is innovative materials and processes for advanced carbon-capture technologies. The hope is to lower the cost of capturing CO_2 from the current \$70 or \$100 per ton to less that \$30 per ton. Enzymes may be usable to accomplish this reduction. The third technology is electrofuels to produce “gasoline” from CO_2 and hydrogen with off-peak electricity at higher efficiencies than photosynthesis.

The third round of funding is considering transformational approaches to energy storage that enable grid-scale deployment at very low cost (about \$100/kWh); cutting building cooling energy consumption (heating and cooling are 45% of building energy use, and buildings make up 75% of energy use) and greenhouse-gas emissions by 25 to 40%; advancements in power-electronics materials coupled with advanced circuit architectures and scalable manufacturing processes are being looked at to result in low-cost, higher-performance power electronics across many applications. (All of the transformers in the United States come from China, now.) If one modulates a 60-Hz signal to 10 MHz, one can manage the power easily and inexpensively.

The ARPA-E organization is lean, nimble, collaborative, and flat. It reports directly to the Secretary and coordinates closely with SC and the applied-technology offices. Its objectives are to break down stovepipes, encourage debate and partnership between technology pushers and pullers, and provide thoughtful leadership to create new programs. It has the Panel of Senior

Technical Advisors (PASTA), a coordinating council of leaders from across DOE. It also has program, commercialization, operations, and strategic-outreach teams.

The ARPA-E Fellows Program has been created to bring best and brightest scientists, engineers, and technical entrepreneurs into ARPA-E for 1 to 2 years and create a think tank to get the next generation of researchers involved in energy.

In 10 years, it is hoped to see some home runs: increased domestic and global sales and U.S. market share; avoided greenhouse-gas emissions; reduced oil imports; the creation of a new technology/business or new industry ecosystem; jobs; and a besting of current projections and trajectories. In 3 to 5 years, it is hoped to see follow-on investment post ARPA-E awards, an increase in the enterprise value of companies, companies being created, an initiation of new technology-business ecosystems (i.e., supply chains), accelerated market entry of new products and product sales, patents filed and licensed, papers published in top journals, and world-record-setting performances.

The ARPA-E Energy Innovation Summit was held in early March to bring together scientist/engineers from academia, national laboratories, and industry; investors; small/large industry senior management; policy groups; and Congress to discuss: How do we foster and identify game changers? Is it random or is there a system? How do we go from lab to market with disruptive energy technologies that challenge business as usual? How do we scale innovations in the United States? How do we accelerate the pace? How do we balance global competitiveness and partnerships? How do we ensure national security through energy technologies? And how can DOE play a role in energy innovation? There were more than 1700 attendees from 49 states and 15 foreign countries. Twelve national laboratories and dozens of universities participated. Financial deals were worked out on the floor. Next year's summit is now being planned.

Wildung asked if there were any joint activities between ARPA-E and SC. Majumdar replied, yes. PASTA has representatives like Anna Palmisano on it. Wildung asked if there were any examples of SC research contributions to the ARPA-E program. Majumdar said, yes. There were people from BES and ASCR at a workshop on cooling. Palmisano added that the largest interaction is in biological systems science.

Susan Gregurick [Program Manager, Computational Biology and Bioinformatics, Office of Biological and Environmental Research, Office of Science, DOE] was asked to describe the implementation strategy of the DOE Systems Biology Knowledgebase.

The DOE Systems Biology Knowledgebase is a community effort to develop a cyberinfrastructure to integrate, search, and visualize, in an open environment, experimental data, associated information (metadata), corresponding models, and analysis tools. It would enable researchers to (1) ask questions about experiments and data, (2) construct new experiments or new models and simulations, and (3) collaborate with colleagues effectively. Unlike other database efforts, the DOE Systems Biology Knowledgebase is focused along DOE Science Objectives in Microbial, Plant and Community sciences.

It is guided by some underlying principles: (1) open-access data and information exchange and (2) open development of open-source software and tools. In many ways, the Knowledgebase leverages genomic sciences much as it serves genomic sciences from JGI sequencing to metabolic modeling to plant feedstocks for bioenergy to foundational research to carbon-cycling processes. There is a tremendous wealth of data and information in the Genomic Sciences Program. The Knowledgebase is an opportunity to integrate these data and information both within individual activities as well as to integrate together different activities. In biology, one has to tie the data to the states of the biological processes in which those data were gathered.

In March 2009, the DOE Systems Biology Knowledgebase for a New Era in Biology Workshop report was issued. This was a mission needs workshop establishing community need for a Knowledgebase. In July 2009, Recovery Act funds were provided to a Knowledgebase R&D project to support the research and development of an implementation strategy for the Systems

Biology Knowledgebase. It was decided to use the stakeholders in a series of workshops for Supercomputing, Plant and Animal Genome, DOE Genomic Science grantees, and JGI users to discern long-range goals. A synthesis workshop helped to integrate the results of these stakeholder workshops. Pilot projects and infrastructures are being supported to develop bioinformatics software and capabilities for the ASCR Magellan cloud architecture and Kandinsky, a cloud cluster test bed for storing and analyzing experimental data, were funded.

During the design process for the Knowledgebase, scientists were asked to

1. Define a long-term measure for science in their area
2. Define six to eight key objectives that could be met in the near, mid and longer term
3. Prioritize these objectives from high to moderate to low
4. Develop a detailed implementation strategy for the high-priority objectives

Biological scientists worked with computer, data-management, and partner scientists to develop a correspondingly detailed computer architecture implementation strategy. In microbial sciences, the scientific objectives are to rapidly reconstruct metabolic and regulatory pathways for 100 to 1000 microbes with comparative reconstructions at 90% accuracy for growth and phenotypic characteristics by integrating data with genomic function to allow reconstruction, prediction, and manipulation of metabolic networks as well as to determine a gene expression regulatory network. In plant sciences, the objectives are to integrate experimental data with key plant genomes, including real-time field data and to associate experimental data with plant phenotype and predict the relationship between phenotype to genotype to environment by integrating experimental data with plant genomic sequences to allow the compilation of regulatory ’omics data. In microbial community sciences, the objectives are to integrate experimental ’omics data with reference metagenomics sample sequences and to develop capabilities for metabolic reconstructions and modeling in natural microbial communities to understand microbial diversity and poorly characterized genes to enable modeling of metabolic processes within a microbial community and to predict isolated or community growth.

The implementation plan calls for constructing a repository for experimental microbial data, developing workflows, initiating analysis and a program repository, extending data integration for plant phenotypes, developing a reference metagenomic data sets repository, and extending phylogenetic analysis methods for metagenomes in the first and second years. In the third and fourth years, it calls for developing on-the-fly data analysis capabilities data, developing comparative data and analysis methods, developing methods for growth simulations, extending data integration for metabolic and regulatory modeling of plants, and developing new methods for metabolic modeling of microbial communities.

The Knowledgebase has four critical partnerships: the Joint Genome Institute (for high throughput sequencing), Advanced Scientific Computing Research (for leveraging their computing facilities and data-management expertise), National Center for Biotechnology Information, and NSF-funded iPlant Collaborative (iPlant). The interests of this community are integrated into all the Knowledgebase activities.

The Knowledgebase architecture is being designed to host and integrate diverse biological data sets, provide both high-performance and community computational resources, and support a large user community with tools and services.

There is a need to stand up a computational platform and to provide operational support and maintenance to establish and support data and workflow services and core Knowledgebase services. The user environment will include links to community analysis programs. There is a Funding Opportunity Announcement (FOA) outstanding for enabling methods and pilots.

The Knowledgebase architecture includes user access through a Knowledgebase Core Front End, creating a virtual environment that allows users to work on different problems seamlessly. The cloud resources support data storage and analysis at many locations, independent of users. To do this, such resources as the ASCR Magellan, Hewlett-Packard’s High Performance Computing (HPC), NERSC, and Amazon EC2 and S3 need to be leveraged.

The program has funded several pilot projects with ARRA funding to develop analysis tools and infrastructure tools. The FOA on computational biology and bioinformatics methods to enable a Systems Biology Knowledgebase provides $15 million over 3 years and funds 11 projects. It started September 15, 2010. The projects address annotation, ’omic data integration, integrated pathway reconstructions, and whole-cellular simulations.

There is a lot of effort on computational bioinformatics, systems biology experiments, an applications programming interface, and data. No matter whom a researcher is funded by, he or she can plug his or her applications into the Knowledgebase.

QUESTIONS

Remington liked the outline of the scientific objectives and asked if there were opportunities for interaction among the different components. Gregurick replied, absolutely. The Executive Summary points out some examples of how such interactions can be done very seamlessly. Remington asked about plants interacting with microbes. Gregurick again replied, yes. Those microbial and community tools can be leveraged. Remington asked about the user interface and usability. Gregurick replied that it has not been determined what the user would see, but the community has been asked what it would expect to see.

Joachimiak asked who the leader was. Gregurick responded that Bob Cunningham has been the leader, but there is no infrastructure. There is an advisory board.

Stacey surmised that there will be a server somewhere that everyone will link into and cloud resources that can be tapped into. Gregurick confirmed that.

Wilgung noted that there is potential for new science development and that several of the grand challenges relate to such an objective. He asked if the project had looked at these grand challenges and seen how the Knowledgebase could contribute to them. Gregurick said that they had studied the grand challenges report and had not seen much lacking in it.

Robertson pointed out that, for the partnership to be good, interoperability must be built in at the start. The standardization effort in measurements and dictionaries is major. The project should talk to other major players in the world. Gregurick replied that the project had discussed these issues with many of them, and they will contribute to the standardization effort.

Mace stated that this type of initiative is precisely what is needed for climate science. There are terabytes of data streaming in from NASA that people do not look at because it is too voluminous.

David Thomassen [Chief Scientist, Office of Biological and Environmental Research, Office of Science, DOE] was asked to address BER communications.

The Knowledgebase is an example of where BER has taken a lead in a new field with importance not only for biology but also for other sciences.

BER has a communication team with a major involvement from Betty Mansfield’s team at ORNL. Communication is needed in science because it increases awareness of BER programs and changing programmatic research needs and provides a consistent and common message. A science-communication expert once said that there is often a disconnect between what a scientist wants to tell people about science and what the public is actually interested in hearing about.

BER has multiple audiences: Congress, the Office of Science and Technology Policy, the broader media, advisory committees, and researchers. The Office does a lot of forms of communication: workshops, programmatic information, reports, websites, and meeting exhibits and presentations. Programmatic communication is conducted through brochures, research news highlights, exhibits, an internal image gallery, posters, and a PowerPoint slide library.

Workshop reports cover a broad range of scientific topics. Programmatic brochures provide descriptions, detail operations, and provide contact information. Mansfield’s group went to 12 meetings and set up an exhibit on the Genomic Science Program. Websites have put together a great diversity of information. The Human Genome Project website is still getting almost

11,000,000 hits a month even though that program has been completed, illustrating the point that people seek out information on things they are interested in.

Direct mail responses; distribution of materials by and on behalf of JGI, EMSL, and the BRCs; information packets for seminar speakers and workshop leaders; and media releases are also produced. ARM has developed a blog to monitor campaign progress. DOE's website employs social media, and a DOE team is working on similar use by the different offices.

These are all things that BER is doing. There is a need to get out information at the Department level.

QUESTIONS

Hubbard asked if BER were allowed to contact the media directly. Thomassen replied, no. The media have to talk to the Press Office first.

Stacey opened the floor for new business. There was none. He asked the Committee members to forward to him any suggestions for science presentations at future Committee meetings.

Palmisano thanked Stacey for his work on the Grand Challenges Workshop.

The floor was opened for public comment. There being none, the meeting was adjourned at 12:15 PM.