Minutes for the
Basic Energy Sciences Advisory Committee Meeting
August 2-3, 2001
Gaithersburg Marriott Washingtonian Center Gaithersburg, Maryland

BESAC members present:

Collin L. Broholm	Philip Bucksbaum
Jack E. Crow	Mostafa A. El-Sayed, Vice Chair
George Flynn	D. Wayne Goodman
Laura H. Greene	Anthony M. Johnson
Walter Kohn	Marsha I. Lester
Gabrielle Long	Anne M. Mayes
C. William McCurdy, Jr.	C. Bradley Moore
Ward Plummer	John Richards
Geraldine L. Richmond, Chair	Zhi-Xun Shen
Sunil Sinha	Richard E. Smalley
Joachim Stohr	Samuel I. Stupp
Kathleen C. Taylor	Rudolf Tromp

BESAC members absent:

Patricia M. Dove	James A. Dumesic
Daniel Morse	Cherry Murray

Also participating:

Mark Alper, Deputy Head, Materials Sciences Division, Lawrence Berkeley National Laboratory
Samuel Baldwin, Chief Technology Officer, Office of Energy Efficiency and Renewable Energy, DOE
James Decker, Acting Director, Office of Science, DOE
Patricia Dehmer, Director, Office of Basic Energy Sciences, DOE
David Garman, Assistant Secretary, Office of Energy Efficiency and Renewable Energy, DOE
Patrick Gallagher, Office of Science and Technology Policy, EOP
John Galayda, Linac Coherent Light Source Project Manager, Stanford Linear Accelerator Center
Keith Hodgson, Director, Stanford Synchrotron Radiation Laboratory, Stanford University
Michael Holland, Office of Management and Budget
Paul W. Lisowski, Director, LANSCE Division, Los Alamos National Laboratory
Douglas Lowndes, Director, Center for Nanophase Materials Sciences, Oak Ridge National Laboratory
Thom Mason, Associate Laboratory Director for the Spallation Neutron Source, Oak Ridge National Laboratory
Gail Marcus, Principal Deputy Director, Office of Nuclear Energy, Science, and Technology, DOE
Don Parkin, Center for Materials Science, Los Alamos National Laboratory

James B. Roberto, Associate Director, Oak Ridge National Laboratory
Mihail Roco, Senior Advisor, National Science Foundation
Marvin Singer, Senior Advisor and Director of Advanced Research, Office of Fossil Energy, DOE
Iran Thomas, Associate Director, Office of Basic Energy Sciences; Director, Division of Materials Science, Office of Basic Energy Sciences, DOE

Thursday, August 2, 2001

Chair Geraldine Richmond called the meeting to order at 8:30 p.m. She welcomed the members and asked each to introduce himself or herself. After introductions, Richmond introduced **James Decker**, Acting Director of the Office of Science, to address the status of the FY 2002 budget for the Office of Science (SC).

The budget request for SC is flat from last year. Congress added funding for a number of initiatives for which the Department did not request funding. Those actions resulted in an increase in the overall funding request for SC. BES, for example, saw a $36 million increase in the Senate markup of the requested budget. The Office of Biological and Environmental Research (OBER) got an increase of $47 million, mostly for Genome to Life. High Energy Physics got an additional $9 million, mostly for universities. Nuclear Physics had $12.5 million for the Relativistic Heavy-Ion Collider and the Jefferson Laboratory.

On July 26, 2001, the Secretary issued a memorandum on changes to the Department's management structure. The new DOE organization chart showed two under secretaries, one for National Security (John Gordon) and one for Energy, Science, and Environment (Bob Card), and the Chief Financial Officer (CFO) reporting to the Secretary. The Under Secretary for Energy, Science, and Environment has responsibility for the Offices of Science, Energy Efficiency and Renewable Energy (EERE), Nuclear Energy, Science, and Technology (NE), Fossil Energy (FE), Environmental Management (EM), and Civilian Radioactive Waste Management (RW).
Other major changes include:

- The Independent Oversight and Performance Assessment is now responsible for Environment, Safety, and Health (ES&H) oversight.
- The Assistant Secretary for ES&H now reports to Under Secretary Card.
- The Chief Information Officer, a new office, now reports to the Office of the Secretary.
- The Management & Administration function has been combined with the CFO to form Management, Budget, and Evaluation.
- The Offices of Policy and International Affairs have been combined into Assistant Secretary for Policy & International Affairs.
- The Energy Information Administration now reports to the Office of the Secretary. Changes in management style have also been adopted:
- The Deputy Secretary has started a series of Operational Program Reviews. They have a significant emphasis on management. Several of the new leaders are from industry. There will be a big emphasis on metrics to ensure that programs are on schedule, within budget, and deliver intended results. The Office of Energy Efficiency and Renewable Energy

(EERE) is acting as a pilot. These reviews will be held quarterly; with the SC review scheduled for the week of November 12.

- The Secretary has directed the start of Quarterly Leadership meetings. The Deputy Secretary is likely to chair these meetings, which will review objectives and performance measures, share best practices, and review cross-cutting issues. Participants will include department principals, staff offices, field office managers, and power market administrators. A proposed schedule has been published, with the first one in October.

Ongoing efforts include reviewing the relation of science and security within the Department. After the Wen Ho Lee event, a lot of security activities have been put in place. Because of the complexity of the situation (including the presence of foreign nationals and foreign travel), a committee was put in place to review security issues. In October 2000, Secretary Richardson commissioned the Center for Strategic and International Studies (CSIS) to study ways for strengthening the science and security functions of the Department of Energy. John Hamre, CSIS President and former Deputy Secretary of Defense, formed a Commission and is leading the study. General Gordon and departmental staff provided continuity across the change of administrations. Hamre briefed Secretary Richardson in January 2001, which led to:

- a review of the impacts of existing security and counterintelligence orders on the scientific and security environment at the labs and production facilities,
- a suspension of all draft security or counter-intelligence policies and procedures,
- a review of the use of the term "sensitive but unclassified" information within the DOE complex, and
- support for the review of polygraphs by the National Academy of Sciences.

A final report is due in April 2002, but preliminary results and findings will be forwarded in mid-September.

Richmond reviewed the schedule and activities of the BESAC subcommittees. Advisory-committee chairs met in Washington, D.C., in May. The panel visited with key congressional members and staffers and testified before the Committee on Energy in June. In July, Richmond spoke at a luncheon briefing on physical science's response to energy needs. On August 1st, she met with Bob Card, Under Secretary for Energy, Science, and Environment, for 40 minutes to discuss BESAC's initiatives (e.g., nanoscience, etc.). They discussed the important areas to be put in the forefront for funding. He has been invited to the November or February BESAC meeting. He is very future-oriented and interested in investing in science.

Kohn asked what "future" means to him. Richmond responded, looking farther into the future and establishing a base and encouraging the enterprise that will produce a rewarding long-term future. Decker commented that Secretary Abraham is also a strong supporter of science. Mayes asked if he was interested in some specific technology. Decker replied, no; he is interested in how we can get a better payoff from basic research. The Department's leaders are not interested in just short-term research.

Richmond then introduced **Patricia Dehmer**, Associate Director of Science for Basic Energy Science, for an overview of BES. Dehmer introduced a number of new faces in Washington. The President intends to nominate John H. Marburger, III, as Director of the Office of Science and Technology. He is currently the Director of the U.S. Department of Energy's Brookhaven National Laboratory and President of Brookhaven Science Associates. As Laboratory Director since March 1998, he has overseen an era of exciting scientific advances at Brookhaven. Prior to joining Brookhaven, Dr. Marburger led a distinguished career in both science and education. From 1980 to 1994, he served as President of Stony Brook University. In the fall of 1994, he returned to the Stony Brook faculty, teaching and conducting research in optical science. Three years later, he became President of Brookhaven Science Associates, a partnership founded by Stony Brook University and Battelle, which was awarded the contract to manage and operate Brookhaven National Laboratory for the U.S. Department of Energy.

The new Deputy Secretary of Energy is Francis Blake, the former Senior Vice President of Corporate Business Development at General Electric, where he served since 1991. Before joining GE, he was a Partner with Swidler, Berlin, Shereff, Friedman, LLP, in Washington, D.C., and served as General Counsel at the Environmental Protection Agency from 1985 to 1988. He served as Deputy Counsel to Vice President George Bush from 1981 to 1983.

The new Under Secretary of Energy is Robert Card, the past President and Chief Executive Officer of Kaiser-Hill Company in Colorado, and was previously Executive Vice President of CH2M Hill, Inc.

The organization chart for BES was used to show how BESAC was related to the organization, which has two large divisions (the Materials Sciences and Engineering Division and the Chemical Sciences, Geosciences, and Biosciences Division). The Materials Sciences and Engineering Division has two teams: (1) Condensed-Matter Physics and Materials Chemistry and (2) Metal, Ceramic, and Engineering Sciences. The Chemical Sciences, Geosciences, and Biosciences Division has three teams: (1) Fundamental Interactions, (2) Molecular Processing and Geosciences, and (3) Energy Bioscience. Fewer than 50 DOE employees run all these offices; 11 new program managers were hired this past year, and BES is still looking for two more good people.

A pie chart of the BES funding request showed that about 40% goes to research and about 38% to construction. With those funds, BES operates eight world-class x-ray and neutron-scattering facilities. A significant portion of the budget goes to BES's 16 user facilities. The impact this program has had over the years is reflected in the seven Nobel Prizes awarded to its researchers during the past 15 years:

Henry Taube	Chemistry	1983
Yuan Tseh Lee	Chemistry	1986
Donald J. Cram	Chemistry	1987
Clifford G. Shull	Physics	1994
Frank Sherwood Rowland	Chemistry	1995
Richard E. Smalley and Robert Curl	Chemistry	1996

Paul D. Boyer Chemistry 1997

The BES FY 2002 budget request after congressional action was reviewed. It stands at $1.04 billion after the Senate markup, which includes:

- $3,000,000 to initiate project engineering and design for three nanoscale science research centers (a reduction of $1,000,000 from the budget request; House version)
- $3,000,000 for university research in nanoscale science and engineering
- $10,000,000 for EPSCoR (Experimental Program to Stimulate Competitive Research), an increase of $2,315,000 over the budget request (House version)
- $12,000,000 for the Department's Experimental Program to Stimulate Competitive Research and $4,000,000 for programmatic activities at the National Center of Excellence in Photonics and Microsystems (Senate version)
- additional funds to support facility operations user support, completion of the Nanoscience Research Center project engineering and design, and additional work in computational sciences in materials and chemistry
- $4,000,000 for project engineering design work for three of five planned user centers for nanoscale science, engineering, and technology research (Senate version).
- BES went into the budget hearings with a flat budget, which means a 5% decrease in buying power.

In the BES Nanoscale Science, Engineering, and Technology (NSET) Program for FY 2001, universities were awarded $16.1 million from 745 preapplications being received; 313 being encouraged; and 417 formal applications being received. As a result, 39 grants (about 25% of the encouraged preproposals) totaling $7.8 million were funded from the Chemical Sciences, Geosciences, and Biosciences Division, and 35 grants totaling $8.3 million were funded from the Materials Sciences and Engineering Division. Awards were made to about half of the meritorious proposals. In that same program, DOE Laboratories were awarded $10.4 million. Submissions were restricted to four proposals per laboratory; 46 proposals were received; and 12 awards were funded (again, a 25% success rate), with all but one receiving partial funding.

The second part of the nanoscale strategy is to establish Nanoscale Science Research Centers (NSRCs) that will:

- Provide state-of-the-art nanofabrication and characterization facilities to in-house and visiting researchers and
- Support research for fundamental understanding and control of materials at the nanoscale.

Five proposals were submitted of which three were approved for conceptual-design preparation [the Molecular Foundry at Lawrence Berkeley National Laboratory (LBNL), the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory (ORNL), and the Center for Integrated Nanotechnologies at Sandia National Laboratories and Los Alamos National Laboratory (SNL/ LANL)]. Design funds are being requested for FY 2002, and construction could start in 2003.

Another major topic of BESAC discussion was the Linac Coherent Light Source (LCLS). An additional workshop after the Feb. 2001 BESAC meeting convinced BES to go forward with this project. The LCLS will have a time-averaged brightness 2 to 4 orders of magnitude greater than third-generation sources; a peak brightness 10 orders of magnitude greater than third-generation sources; 230-fs pulses initially; shorter to be developed; and transversely coherent radiation.

She then turned to the BES Vision Statement. The mission of BES is fundamental research to provide the bases for new, improved, environmentally conscientious energy technologies and energy-saving processes. It seeks to assemble the right portfolio to address tomorrow's energy challenges with university and national laboratory performers that will produce excellent research, providing international leadership in nanoscale research and beyond. It wants to build NSRCs that will be 21st-century nanofabrication capabilities and a model for research activities/facility operations at the laboratories. It wants its facilities to be international leaders in science, advanced instrumentation, new machine concepts, and in providing outstanding user operations. It wants its program management to recruit and retain top program managers; ask for the right advice; and plan, execute, benchmark, and vet the programs. BES will do this despite budgets that do not always match the pace of scientific inflation.

Looking back at recent BESAC activities, it is illustrated that the Committee has two or three major panels operating at any given time. Each of the panels in the past has made tough recommendations to BES; in most cases, BES has done what was recommended. Examples include:

- *Neutron Source Upgrades and Specifications for the SNS* (1996)
- *DOE Synchrotron Radiation Sources and Science* (1997), which set the tone for all subsequent BESAC activities
- *Novel, Coherent Light Sources* (1999)

BES is now conducting reviews using BESAC criteria. For the next several years, BESAC should continue this thrust, which was started in 1979.

James Decker has formulated a new charge to BESAC:

> "BESAC has been engaged in activities relating to nanoscale science, including the formation of Nanoscale Science Research Centers, and has clearly articulated that scientific understanding at the nanoscale is required for the development of larger functional systems that use nanoscale building blocks. The report of the workshop on Complex Systems outlined an exciting science agenda that integrates the disciplines of physics, chemistry, materials science, and biology to build on the foundations that now have been put in place by the National Nanotechnology Initiative. I would like you to help refine that research agenda. In the world "beyond nano," it will be necessary to use atoms, molecules, and nanoscale materials as the building blocks for larger supramolecules and hierarchical assemblies. As was described in

> *Complex Systems - Science for the 21st Century*, the promise is nanometer-scale (and larger) chemical factories, molecular pumps, and sensors. This has the potential to provide new routes to high-performance materials such as adhesives and composites, highly specific membrane and filtration systems, low-friction bearings, wear-resistant materials, high-strength lightweight materials, photosynthetic materials with built-in energy storage devices, and much more. The magnitude of the challenge is perhaps more daunting than any faced before by these disciplines. I would greatly appreciate BESAC's help in defining these challenges." He asked BESAC to help put together a workshop to look at this topic.
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> "What are the 21st century fundamental scientific challenges that BES must consider in addressing the DOE missions in energy efficiency, renewable energy resources, improved use of fossil fuels, safe and publicly acceptable nuclear energy, future energy sources, science-based stockpile stewardship, and reduced environmental impacts of energy production and use? To that end, I would like BESAC to oversee a small number of workshops (perhaps 2 or 3) that articulate the 21st century discovery potential in DOE mission areas."

The Office has been comparing BES research activities with other DOE program offices. BES activities often support technological activities carried out by other offices, and BES is thinking about what will be needed in the future.

Future BESAC activities include:

- conducting a Committee of Visitors for Chemistry Programs;
- holding a BESAC Full Committee Meeting on November 14-15, 2001;
- conducting BESAC Workshops on (1) Nanoscale Science and Beyond and (2) Research Opportunities for Energy; and
- holding a BESAC Full Committee Meeting on February 25-26, 2002.

The basic facts about BESAC were reviewed for the new members: It was established September 4, 1986. It operates in accordance with the Federal Advisory Committee Act and all applicable amendments, federal regulations, and executive orders. It reports to the Director of the Office of Science, who provides charges to the committee annually or as needed. It is a large Advisory Committee and meets 2 to 4 times per year. The Federal Advisory Committee Act was established to provide the only mechanism by which federal officials may obtain consensus advice, and it requires advisory committees to be fairly balanced. Most of the work of BESAC is done through subcommittees. Membership on BESAC means that you give up certain rights. As a committee member, you are entitled to contact Congress as long as the issue is related to you personally or your primary employment and you are asked by Congress to do so. It is lawful to meet with Members of Congress on subjects as described above while referencing federal documents resulting from advisory committee activities. It is unlawful to organize, or be part of an organized group, to orchestrate a group assault on Congress, using taxpayer dollars. Meaning you cannot arrange BESAC or BES meetings to coordinate and orchestrate a group assault for basic science and research. But, as a Federal Advisory Committee member, you do not surrender your right under the First Amendment to petition the Government for a redress of grievances. Members are required to recuse themselves from participating in any meeting, study, recommendation, or other Committee activity that could have a direct and predictable effect on the companies, organizations, or agencies with which they are associated or in which they have a financial interest.

Dehmer commented that dealing with advisory committees is the most interesting part of her job. The Office is publishing a new poster: Periodical Table of Scientific Discovery. BES will not do journal cover posters anymore; it is time to move on to something else.

Stohr noted that the $36 million for nanoscience was reduced to $26 million and asked what happened. Dehmer said that the $36 million was reduced to $35.1 million by the general reduction [including Small Business Innovative Research (SBIR)]; $26 million was awarded in grants and laboratory actions; $1.5 million was awarded for the conceptual design for the nanoscience centers, $0.5 million was awarded for a nanoscience network between Defense Programs (DP) and SC; about $3 million was awarded to facilities for increased operations; $0.25 million was given to an interagency office in the National Science Foundation (NSF) for the National Nanotechnology Initiative (NNI); and about $3 million was redirected to the engineering program through peer review.

Stupp asked if she saw the structure of BES as being optimal for the exploration of the area of complex systems. Dehmer replied that it might not be; it may need to be changed. Stupp asked what the purpose of the workshop will be. Dehmer said that it will scope out fields of research that should be explored, identify topics of specific workshops, and develop advice on worthwhile science investments.

Moore asked how broad BESAC's charge is. Dehmer said that the charge will be refined when a chair is named.

Kohn commented that the National Energy Policy (NEP) had not come up. It struck him as not having much science in it and found the new charge to BESAC very good because of this lack of science in the NEP. Renewable energy is mentioned in the NEP in a negative way. This office must take a positive view of renewable energy. There is a sharp distinction between energy conservation and efficiency. The NEP stresses efficiency; the United States must also stress conservation. Dehmer pointed out that the NEP was tied to certain issues of concern at the time it was developed.

Flynn asked how much of the $35 million put into nanoscience was new money. Dehmer replied, all of it.

Stohr stated that the Committee could use more background material and that the table that shows which BES programs relate to the bigger DOE picture is the type of information that the

Committee could use more of and asked if a future BESAC meeting could be devoted to this topic. Dehmer replied affirmatively.

Plummer noted her comment that more of the university proposals could have merited funding and asked if more universities would have been funded if the national laboratories were competed evenly with the universities? Dehmer said no; the distribution of funding would probably have been about the same. The one thing that stands out was the overwhelming response from universities.

Richmond asked for suggestions of names for subcommittee members.

Smalley said that he was thrilled with the number of times the word “energy” had come up and agreed with Kohn about the need for renewable sources, especially solar conversion.

Mayes asked for more information about how BES will carry out the facility reviews. Dehmer said that BES wanted to do the facility reviews along with the program reviews. BES was very impressed with the way that BESAC did this and with the results that came from those reviews. BES intends to revisit the facilities that BESAC has reviewed, to follow up on the BESAC recommendations, and to assess those facilities once again as BESAC had.

El Sayed asked if any reports on nanoscience and technology are available from any other agencies. Dehmer said there had been a number of workshops, mostly interagency ones, not solely NSF ones. Many of those workshops have the Interagency Working Group (IWG) as the umbrella, and their reports are available on the Web.

Richmond asked members to think about these new charges and noted that a discussion could be held later in this meeting. A break was called at 10:17 am. The meeting was called back into session at 10:47 am to hear **Thom Mason** describe the current status and future prospects of the SNS. The SNS is an accelerator-based neutron source with a superconducting linac being designed at LANL with a ring being developed by Brookhaven National Laboratory (BNL), and a target being designed at ORNL. It will be collocated with the Joint Institute for Neutron Science (funded by the State of Tennessee) and the Nanoscale Science Research Center.

The SNS will begin operation in 2006. The power will be an order of magnitude higher than that of the ISIS, currently the world’s leading pulsed spallation neutron source. Its peak thermal neutron flux will be 50 to 100 times that of ILL (Institute Laue Langevin). The SNS will be the world’s leading facility for neutron scattering. It will be a short drive from the High-Flux Isotope Reactor (HFIR), a reactor source with a flux comparable to the ILL.

The FY 2002 request was $291 million. Now in its peak funding year, the project enjoys solid congressional support. The overall project design is 61% complete. Overall, the project itself is 30% complete (through June 01) and on budget and schedule. The total cost will be $1.4 billion. The initial safety documentation is now in place both for the accelerator, instruments, and target. There is good progress on all of the technical components: front end, superconducting linac, ring, target, and instruments. It has had excellent ES&H performance.

There have been some organization changes since the February BESAC meeting. A new contractor has taken over at ORNL. The organization of the project itself has not changed significantly, but now the SNS Project Director reports to the Director of ORNL as an Associate Laboratory Director.

Preliminary design on four of the first five project funded instruments is 50 to 80% complete. The first RF- (radiofrequency-) accelerated beam was achieved on the first attempt at LBNL; the machine will be installed in Oak Ridge in about a year. Superconducting-cavity-gradient R&D is getting the same linac energy at a lower cost. Contracts for the Front End Building and Linac Tunnel (the most complex tunnel structure because of RF penetrations) concrete installation have been awarded. Significant sums ($194 million as of June 2001) have been awarded in procurements of technical systems, and the project is staying within the cost envelope.

Construction is well underway. The Target Building deep foundation installation has been completed. More than 1.4 million cubic yards have been excavated during site preparation. Bedrock is 80 to 130 feet down; steel-pipe piles ensure stability for instruments.

The semiannual Lehman review produced a May 2001 baseline:

- Energy has been fixed at 1 GeV with a higher gradient and fewer superconducting cavities.
- The Central Office Complex has been designed to support facility operations and user programs.
- The instrumentation budget has been increased to $60 million to support an increased number of instruments.

Interactions with the scientific community include getting user input into the SNS instrument suite through the Scientific Advisory Committee, Experimental Facilities Advisory Committee, and a large number of user meetings and workshops. Technical, scientific, and logistical support will be provided for users carrying out experiments The SNS will have a peer-reviewed proposal system. The instrument suite will allow 1000 to 2000 users per year from academia, government, and industry, both domestic and abroad. A flexible instrument strategy will support both general user access and dedicated access for expert instrument teams that contribute to construction and operation of instruments. 5000 hours per year of user operations will be provided with high reliability (>90% with >95% as the ultimate goal).

A process has been developed and is being followed for instrument selection and inclusion in the project baseline. A group has been assembled and has formed the Instrument Advisory Team. It will write a letter of intent, which then leads to review by the Experimental Facilities Advisory Committee (EFAC). EFAC also reviews the conceptual-design study and recommends the preliminary engineering design. The preliminary engineering design leads to the inclusion of an instrument in the project baseline through scientific review of the design, engineering design review, and a Project Change Request.

The Instrument Advisory Team (IAT) instruments will be designed, built, and operated by the SNS for the general user community. Access will be through a peer-reviewed proposal system based on scientific merit; it will be open to all with no quotas, no tickets, and no special provision for IAT members. The SNS construction project includes an initial suite of at least five best-in-class instruments; 24 instruments can be eventually accommodated. The Guidelines for General User Access have been drafted and circulated for comment to advisory committees and the Users Group executive; comments are being incorporated in the final version. The HFIR user program will follow the same model. (The HFIR restart is expected in late October with the cold source in operation by late 2002.)

In addition to access to IAT instruments on an experiment-by-experiment basis, there will be research programs that can benefit from more dedicated access to instruments on a long-term basis. There may also be requirements for instrumentation tailored to the specific research needs of institutions or consortia of institutions that possess the capability to design and build neutron-scattering equipment. The SNS will provide for this through Instrument Development Teams (IDTs) that will use the same staged approach as the IAT process. Up to 60% of the beam time will be available to the IDT for its own research; the actual beam-time allocation will scale with the fraction of construction and operating funding provided by the IDT. Guidelines for IDTs have been drafted and circulated for comment to the advisory committees and the User Group executive; comments are being incorporated in the final version.

The current instrument concepts include ten instruments that have been approved:

- high-resolution backscattering spectrometer
- magnetism reflectometer
- liquids reflectometer
- engineering materials diffractometer
- extended Q-range small-angle diffractometer
- 6-m chopper spectrometer
- third-generation powder diffractometer
- inelastic spectrometer with 10- to 100-microvolt resolution
- disordered-materials diffractometer
- high-pressure diffractometer

Other instruments in the pipeline include a 2.5-m chopper spectrometer, a high-speed single-crystal diffractometer, spin echo, and fundamental neutron physics.

In addition, IDTs are planned for a 10- to 400-microvolt multichopper spectrometer and a 6-m Fermi chopper spectrometer. Letters of intent are being processed for fundamental neutron physics (to be funded by DOE or NSF Nuclear Physics), spin echo (to be funded by Germany), the eV spectrometer (funding to be determined), and a hybrid spectrometer (funding to be determined). In addition, a letter of intent has been submitted to the Canada Foundation for Innovation for partial (~50%) support of two instruments (Chopper and VULCAN). Additional concepts are being developed by the project as a result of previous recommendations. There are near-term prospects for about 10 instruments in early operations.

Mayes asked how instrument time would be allocated among funding entities. Mason said that the operating and capital costs are about equal, so we use a simple algebraic formula. The instrument and beam time will be shared; the most instrument time anyone can get is 60% of the percentage of funding put forth for the instrument.

Crow asked what the status was of the second target station that was proposed to NSF. Mason said that the long wavelength target station has been tabled, but there are continuing discussions with NSF to develop a framework by which they can enhance the capabilities of the SNS.

Sinha noted that the progress is encouraging and asked if it was true that cuts in buildings had been discussed. Mason replied that some capabilities were deferred.

Broholm proposed a motion to commend the project management for keeping the project on time and under budget. Crow seconded. It passed unanimously.

Richmond introduced **Paul Lisowski**, Los Alamos Neutron Science Center (LANSCE) Division Director, to report on program at the LANSCE. For the new members, he reviewed the history of LANSCE. LANSCE is a unique multidisciplinary science facility. Its 800-MeV proton linac now operates only with H . The facility is operated by DP, but a large amount of time and effort is devoted to BES. Its Proton Radiography Facility is not a true user facility; only a limited amount of beam time is available for LANL, Lawrence Livermore National Laboratory (LLNL), and SNL; it will be available in the future for imaging (e.g., real-time imaging of fluid flow in an operating engine). Other facilities attached to the LANSCE include Weapons Neutron Research (WNR), Isotope Production Facility (IPF) that is under construction, and the Manual Lujan, Jr., Neutron Scattering Center.

The overall LANL goal is to deliver neutrons and protons safely and reliably for all LANSCE users. The top seven objectives are:

- Appoint a new LANSCE management team;
- Engage other scientific user facilities to benchmark and improve LANSCE performance;
- Develop and implement an effective governance model involving the National Nuclear Security Administration (NNSA), SC, NE, LANL, and the user communities;
- Ensure appropriate support and oversight, informed by independent review of a bottom-up cost estimate;
- Pause BES development of new Lujan instruments to focus on operation of the user program;
- Increase the Laboratory-Directed Research and Development (LDRD) investment in Lujan science program by the LANL; and
- Maintain strong communication with the LANSCE User Group (LUG).

The new management team has been put in place; Alan Hurd has been appointed the Director of the Lujan Center. The benchmarking of scientific user facilities is well underway; visits to National Institute of Standards and Technology (NIST) and Argonne National Laboratory (ANL) have been completed, and planning is underway for fall trips to ISIS and other European sites. A governance model has been developed and is being implemented that incorporates the ideas and expertise of the LUG and many at DOE, NNSA, and other facilities. The LUG held its initial meeting in April 2001, and a memorandum of agreement (MOA) is ready for signature; the next meeting is planned for September 2001, at which time the MOA will be signed. The LANSCE user facility bottom-up cost estimate review is under way. The BES spectrometer development has been paused, and its funding has been reprogrammed. LANSCE science planning includes (1) a neutron-scattering plan based on user input completed by Alan Hurd and others; (2) a LANSCE planning workshop involving the broader user community at the next LUG meeting, August 12 -14, 2001; and (3) the integration of the strategic plan into the NNSA/DP 5-year planning process. Additional LDRD investments in Lujan science have been secured for FY 2001; an additional $1 million will go to increase the science this year. The stewardship problem is an important issue; DOE has helped resolve conflicts in this area. A memorandum from the Deputy Secretary of Energy to General Gordon dated Dec. 21, 2000, assigns “Defense Programs as the Organizational entity with corporate responsibility and accountability for strategic integration of all three program offices using LANSCE. This approach applies both to the short-term objective of facilitating IPF construction and the long-term goal of reliable accelerator operations.” The new organization provides single-point accountability, a single line of authority, participation by all stakeholders, and an authority and responsibility chain that includes accountability for those controlling the resources.

The highest priority during the past few months has been to establish a long-term sustainable program serving all users safely, reliably, and predictably. To that end, LANL has completed an outage 20 days ahead of schedule; started a user program; received proposals for Program Advisory Committee (PAC) review on March 12, 2001; evaluated those proposals and scheduled instrument time; and started the user-facility production on July 1, 2001. The user program will run through December 23, 2001; it will run 2544 hours for the Lujan Center this year. This goal will be accomplished by implementing the governance, management, and science plans to realize the full potential of LANSCE and the Lujan Center.

Tasks that were completed durting the Major Accelerator Outage include:

- Interim Safety-Assessment Document (ISAD)
- MPF-963 cooling tower tie-in
- Nuclear-facility maintenance
- IPF shield wall construction
- IPF transition region modifications (where the H- beam is stripped off for the IPF)
- Accelerator maintenance (a lot of time was spent looking for weak capacitors)
- Facility maintenance
- Accelerator start-up in a systematic way

The Lujan Center Received 152 proposals for the 2001 run cycle, a 2-to-1 oversubscription. LANSCE has implemented a standard 28-day operating cycle with contingency allocation built in. It has identified funding and has developed a detailed project schedule and plan to install a switchyard kicker, which will allow a 500% increase in beam time, in 2003. These actions will:

- produce a 500% increase in the beam available to the proton radiography program
- provide about 20% more beam time for the Lujan Center and the WNR
- make an ultra-cold neutron program possible
- make changeovers between Line X and Line D operations more efficient, increasing beam availability
- provide stable accelerator operation at fixed beam intensity, yielding more reliable beam delivery for all programs

LANSCE is greatly improving its scattering instrument suite with new construction and upgrades that include HIPPO, SMARTS, PROTEIN (first beam on sample December 2000), NPD Upgrade, PHAROS, ASTERIX, and IN500.

Beam delivery to the user program has been reliable thus far, but current is limited by the target moderator system. LANSCE has had the best performance of the proton storage ring ever; however, the target overheated. It settled on 56 μA as the optimum operating power. The Lujan target moderator-reflector serves two tiers of flight paths, but because of its unitary design, its modification is difficult and disruptive. LANSCE has redesigned and rebuilt the target and the heat-removal system. It has funding and is developing a plan and schedule to replace the Lujan target moderator if necessary. The current target will last through this run cycle. Funding and parts to assemble the spare are in hand; assembly planning has begun. It will be installed during the next outage if no solution is found.

In summary, since the BESAC report,

- DOE, NNSA, the LANL Director, and LANL senior management have made a commitment for success at LANSCE.
- LANL is responding to the BESAC recommendations for governance.
- The LANSCE Division completed the outage and started up 20 days earlier than scheduled.
- The user program started as promised on July 1, 2001.
- LANSCE is operating with high reliability at less than full power, which affects only one user, who will be accommodated during the contingency time.
- Funding for the kicker magnet is in place, and the project is under way.
- Funding to build a replacement target for the Lujan Center is in place, and the target will be installed during the next outage.
- LANL is succeeding at the activities needed to operate the LANSCE user facilities safely and reliably.

El-Sayed asked if hosting foreign nationals has been affected by the security changes. Lisowski responded affirmatively. LANL has to spend a lot more time getting foreign nationals onsite.

Plummer noted that they had money to upgrade to 100 μA and asked how they will do that. Lisowski responded that they are operating reliably at 100 μA. They could have gone to 120 μA, but are limited by the target. When the new target is installed next year, they will increase the operating power.

Greene commented that she was impressed with what she had seen here and hoped that this success carries over to the SNS. Lisowski noted that they had fixed some of the problems in achieving good reliability and still need support to get to the point where they can guarantee 85% reliability.

Mayes asked what the time table was for engineering the new target and reflector. Lisowski said that they have a long-term plan for upgrading the facility, including the target, and expect to do all this by the end of the 2002 outage.

Lester asked how they could develop the user community. Lisowski responded that Alan Hurd has a development plan that addresses that issue, but getting 1000 users by the time the SNS comes online is a stretch.

Michael Holland asked what the factor of two was. Lisowski said that that referred to the beam time requested.

Richmond suggested that she write a letter to James Decker reflecting how pleased the Committee was in the LANSCE progress but supporting additional interaction with and input from users. The suggestion was taken as a motion and seconded by Kohn; it passed unanimously. Richmond then introduced **Pat Gallagher** of the Office of Science and Technology Policy (OSTP) to speak about neutron science, which is the topic of an IWG. OSTP is authorized (under PL 94-282, National Science and Technology Policy, Organization, and Priorities Act of 1976) to:

- Lead interagency efforts to develop and implement sound science and technology policy and budgets
- Build strong partnerships among federal, state, and local governments; other countries; and the scientific community
- Evaluate the scale, quality, and effectiveness of the federal effort in science and technolo A number of recent reports have been issued about neutron facilities:
- *Improving Federal Laboratories to Meet the Challenges of the 21st Century: An Action Plan*, a report of the National Science and Technology Council IWG on Federal Laboratory Reform (July 1999), called for better coordination among facilities.
- *Cooperative Stewardship*, a report of the National Research Council (NRC) Committee on Developing a Federal Materials Facilities Strategy (1999), looked at biology and synchrotron radiation.
- *Synchrotron Radiation for Macromolecular Crystallography*, a report of the OSTP Working Group on Structural Biology at Synchrotron Radiation Facilities (January 1999), called for a standing working group to provide coordination.
- *Subpanel Review of the IPNS and Lujan Center*, a BESAC report (February 2001), called for OSTP to look at neutron scattering.

The OSTP needed to get all the stakeholders together in the Neutron Sciences IWG to look at the neutron-scattering use of facilities. Participating agencies included OSTP, Office of Management and Budget (OMB), DOE (several offices), NSF, NIST, and the National Institutes of Health (NIH). The IWG has held three meetings, and one is planned. It has conducted an extensive review of the existing reports and an extensive review of the facility-supplied data on source operations, instrumentation, staffing, users, etc. It has also initiated the production of a draft discussion paper to summarize assessment data, to frame terms of reference, and to outline a broad strategy.

Most centers are set up with a source that produces neutrons and a research facility that exploits neutrons. A single agency should be responsible for the source, but the research facility can be more generic and disparately shared. Data were gathered from all five operating (or previously operating) facilities. These data indicated that the current operating time is just about the same as that in 1990. The number of instruments available has increased about one-ninth during the same period; this is some improvement, but the loss of the High-Flux Beam Reactor (HFBR) and the shutdown of the HFIR are evident. At the same time, the number of users at the facilities has increased significantly. At NIST, the number of users per instrument more than doubled since 1990, and NIST's ratio has been much greater than that value for the other U.S. facilities since 1992. However, even NIST's number of users per instrument is significantly less than the European benchmarks. The quality of instruments may be influencing these values, so the laboratories were asked to rate their instruments. The result was that only 65% of the instruments were considered to be competitive-level instrumentation. When you look just at the competitive instruments, there was a potential increase of 35% in productivity when compared with the international benchmark of 50 users per instrument. Taking into consideration all the instruments these facilities have would require a 100% increase in productivity to bring them up to the international benchmark.

The group also looked at staffing and found that the United States is nowhere near the European facilities' level., The users in the United States are overwhelming the available staffing. Use levels are approaching or operating at the maximum facility burden. If productivity is to be increased, the way that staff productivity is being benchmarked has to be looked at. This exercise has led to a new way of thinking about facilities that involves a chain of performance that includes the source, the instruments, and the people. The U.S. facilities and program management have been putting too much emphasis on the source itself.

Sinha asked how he accounted for the higher productivity with similar staffing. Gallagher said about half is accounted for by instrument quality. They operate differently, employing a user-group approach rather than the HFIR emphasis on mission.

Plummer commented that NIST is dedicated to being a user facility and that the user community is so depleted that you cannot boost productivity. He asked how the IWG suggests building up that community. Gallagher replied that an important statistic is the type of people that are using the neutrons; 25% are professional neutron users, and >50% are casual neutron users. It was his opinion that very little prodding of the community will produce a strong response in facility use.

A break for lunch was called at 12:24 a.m. The meeting was resumed at 1:37 p.m. with the introduction of **Michael Holland** of OMB. He reviews the areas of science and technology that make up the business lines of the federal R&D. Energy is the smallest business line. BES and SC have a responsibility to make clear how they contribute to the larger business lines. He urged BES to take any opportunity to explain how its activities related to and contribute to the other federal R&D business lines.

Richmond asked **Mike Alper** to give an update on LBL's Molecular Foundry, which is designed to be a national collaborative research center for nanoscale science and engineering, a portal to the LBNL major nanoscale user facilities, a source of training and education of the first generation of nanoscale scientists, and an internal LBNL nanoscience research program. Its focus is on a conjunction of hard and soft nanoscale materials and a linkage of "top-down" and "bottom-up" lithography, physics, and biochemistry. In a full research cycle, the Molecular Foundry will put design, synthesis, characterization, and analysis together in one place, constructing multicomponent, complex functional systems from nanoscale building blocks in a multidisciplinary environment that includes materials science; physics; polymer, inorganic, organic, and bio chemistry; molecular biology; and engineering.

Colocating the elements of the research cycle (design, synthesis, measurement, and analysis) will reduce the cycle time, allow rapid progress, and focus people and resources. At the nanoscale, the building blocks will be nanocrystals, nanorods, nanotubes, dendrimers, scanning probe tips, patterned surfaces, cell membranes, DNA, and proteins.

The major facilities that will support the Molecular Foundry are:

- Advanced Light Source
- National Center for Electron Microscopy (NCEM), upgraded to spatial, <1 ; spectral , ~0.2 eV; temporal; ~1 ms.
- National Energy Research Scientific Computing Center (NERSC), with an IBM RS/6000 SP with 2528 processors in 158 16-CPU SMP nodes and a 20-TB disk; it is the world's fastest unclassified supercomputer at 3.75 Tflops, capable of a 1024-atom first-principles simulation of metallic magnetism in iron, and the first complete application to break the 1-Tflops barrier.
- E-Beam Nanowriter

The Molecular Foundry will have six facilities of its own in (1) Inorganic Nanostructure Synthesis, (2) Nanofabrication, (3) Organic Biosynthesis, (4) Mammalian, Microbial, and Plant Cell Facility, (5) Imaging and Characterization, and (6) Theory and Computation. These facilities are about state-of-the-art instrumentation; direction by senior investigators; close ties to internal research program; permanent, dedicated scientific management; technical support staff; budget for maintenance, upgrades, and replacement; no charges to users; and dedicated, collaborative scientists and postdoctoral fellows. The postdoctoral scientist position is to help and teach outsiders and to copublish with them.

Expected capabilities of the different facilities are:

- Inorganic Nanostructure Synthesis Facility: chemical vapor deposition, molecular beam epitaxy, laser ablation, and automated nanoscale synthesis
- Nanofabrication Facility: e-beam lithography and microcontact/soft lithography
- Organic and Biopolymer Synthesis Facility:nuclear magnetic reasonance, electrospray–matrix-assisted laser desorption/ionization–mass spectrometry, spectroscopy/chromatography, peptides, DNA, carbohydrates, and hybrids
- Mammalian, Microbial, and Plant Cell Facility: biohoods, incubators, microscopes, and spectroscopy
- Imaging and Characterization Facility: scanning-tunneling microscope/atomic-force microscope, transmission electron microscopy, confocal microscopy, single-molecule fluorescence, focused ion beam, optical tweezers, and ultrahigh resolution spectroscopy beamline
- Theory and Computation Facility: structural, electronic, binding, magnetic, transport, optical properties

Nanoscience research accomplishments produced at LBNL include inorganic nanostructure synthesis, nano building units (nanotubes, q-rods, nanocrystals, and nanowires), nanolasers, nanopeapods (single-walled nanotubes with buckyballs inside them), organic and biopolymer synthesis, nanofabrication, engineering cells to bind materials, and DNA-directed grouping of nanocrystals.

These facilities will work together by soliciting proposals from all users with a review by a Proposal Study Panel (made up of LBNL and non-LBNL members) for quality, creativity, impact on field, ability of investigators to achieve goals, and dependence of research on unique capabilities of the Molecular Foundry. Successful candidates will be assigned a lead contact and housing in collaboration with the Advanced Light Source (ALS). Education and training will be provided to undergraduate students, graduate students, postdoctoral fellows, and visitors through short courses, summer schools, instrument-use courses, seminar program, and internships for undergraduates from local schools. The facility will be reviewed by the Scientific Advisory Board, the Director's Annual Review for the UC President, and DOE.

All of this will be organized at a workshop in the spring to:

- Inform the broad national community of plans to establish the Molecular Foundry,
- Solicit input on the design of the facilities,
- Begin to develop the collaborative teams,
- Coordinate with other Nanoscience Research Centers to minimize unnecessary duplication, and
- Begin to outline the logistical needs of the large numbers of collaborators coming to work in the center's facilities.

The Molecular Foundry is expected to be a terraced structure built into the hillside adjacent to the ALS, a 5-minute walk to NCEM and the nanowriter. The critical decision to proceed (CD-0) was made June 2001, and the conceptual-design report (CDR) is 95% complete. CD-1 is expected September 2001, and the start of construction is expected in the fourth quarter of 2002.

Stupp asked what the user mode would be like. Alper replied that some preparatory work will be done, such as building nanotubes. Permanent staff will be available to do things like this. The things the researcher wants to do with these tubes will be a collaboration between the researcher and the permanent staff.

Bucksbaum asked how much of the research budget will be used up with the users program. Alper responded, about half; there has to be an internal research program.

Richmond called upon **Douglas Lowndes** to give an update on the ORNL Center for Nanophase Materials Science (CNMS). One of the most challenging characteristics of nanoscale science lies at the intellectual interfaces of the traditional academic disciplines of physics, chemistry, biology, computational science, engineering, and the soft and hard materials sciences at the nanometer scale. The Laboratory is encouraging university-community involvement with a CNMS planning workshop. The ORNL center will be collocated with the SNS and the Joint Institute for Neutron Sciences (JINS) on ORNL's "new campus."

The CNMS will integrate nanoscale science with three synergistic research needs:

- Neutron science (SNS plus the upgraded HFIR), which represents an opportunity to assume world leadership using unique capabilities of neutron scattering to understand nanoscale materials and processes and a challenging nanoscience focus helps grow the U.S.-based neutron science community to levels found elsewhere in the world.
- Synthesis science (the CNMS will be a regional nanofabrication research lab)
- Science-driven synthesis, which has a key role as the enabler of new generations of advanced materials and whose evolution will be driven by theory, modeling, and simulation (TMS) at a Nanomaterials Theory Institute, stimulating U.S. leadership in designing new nanomaterials and investigating new pathways for materials synthesis.

The CNMS will have three scientific thrusts: soft materials led by Michelle Buchanan, complex nanophase materials systems led by Ward Plummer, and the Nanomaterials Theory Institute led by Peter Cummings. It will also have 9 to 12 multidisciplinary research focus areas that are anchored by permanent staff and long-term visitors (the core research staff) and are dominated numerically by graduate students, postdocs, and short-term visitors.

The Laboratory will have a CNMS advisory committee and a proposal selection committee as well as the SNS/HFIR User Group. The advisory committee, which will have nine members and experts in the three scientific thrusts and nanofabrication research, will be responsible for recommending research focus areas and priorities, reviewing ongoing research and educational activities, and recommending discontinuing a research focus area (or scientific thrust) for cause (e.g., lack of progress or having a lower priority than an emerging science). Access by visiting scientists will be gained through the proposal-selection committees, peer review, and a single application process.

The mode of operation of the CNMS will be flexible and multidisciplinary, involving 18 full-time equivalents (27 actual personnel) permanent research staff in 9 to 12 research focus areas that evolve and can be changed. They will collaborate with visitors from universities, industry, and other national laboratories, including up to 36 postdocs and hundreds of graduate students and short-term visitors per year. One-half to three-quarters of the FTEs will be from other institutions. This model of operation will make the Center responsive to the scientific community (because the advisory committee guides the choice of scientific directions and there will be a major university presence in both staffing and governance) and highly leveraged and coordinated (because the infrastructure investments in personnel and equipment will reflect regional and national needs). ORNL is looking for ways to maximize resources, promote multidisciplinary interactions, and enable research of a scope and depth beyond current national capabilities.

For nanoscience, neutron scattering is a unique tool for providing complementary information about nanoscale self-organization. It allows a subsurface probe of nanoscale organization in 3-D (bulk) materials, the study of complex sample environments, the use of delicate (biological) materials, the probing of structure on distance scales spanning the entire nanoscale regime, the use of neutron energies comparable to elementary excitations (which allows the gathering of dynamical information on transitions among a wide variety of states), and the exploitation of the large cross-section difference for hydrogen and deuterium (which enables a host of labeling studies of complex biological molecules and systems). Neutrons are an incomparable probe of magnetic structure of matter, both static and dynamic (i.e., fluctuations). Scattering cross-sections are proportional to static and dynamic correlation functions. Scattering data are directly linked to mathematical description of complex, interacting systems, making them an indispensable probe of coupled nanoscale collective behaviors. These unique capabilities of neutrons allow:

- Direct measurements of the correlation lengths (both static and dynamic) associated with spontaneous electronic phase separation and competing ground states, in highly correlated electronic systems
- Identifying molecular-level processes occuring at liquid-solid interfaces, in order to understand how processes differ for macro- and nano-materials
- Identifying the difference between activated and inactivated states of catalysts (how the catalyst is poisoned) using monolayer-sensitivity inelastic neutron scattering
- Making direct, in situ measurement of nanoscale phase separation kinetics (e.g., polymer blends and metallic alloys)
- Identifying the components and interactions of multiprotein complexes, perhaps to enable harnessing these “molecular machines” for functional nanostructures and nanotechnology.

Examples of science that can be carried out in nanoscience include the ability to perform simultaneous, time-resolved measurements of atomic- and nano-scale structure during synthesis and processing. Neutron reflectometry today is largely limited to specular reflectivity, giving only a layer-averaged chemical and magnetic depth profile from 0.5 nm to 1 m with no in-plane structural resolution. Nanoscience will enable unprecedented studies of nanoscale magnetism in artificially structured films and reduced dimensionality.

None of this will happen without samples. Neutrons are inherently nanoscale probes of matter, providing a unique opportunity to construct special environments for in-beam, time-resolved studies of nanoscale phenomena and for nanomaterials synthesis and processing and an opportunity for simultaneous measurements at multiple length scales, allowing the direct probing of the hierarchical organization of materials.

Some of the challenges this center will be able to address include:

- Control of self-assembly and nanoscale structure
- Understanding how morphology, symmetry, structure, and phase behavior relate to function
- New approaches for the rational design and fabrication of soft and hybrid materials
- H/D contrast for component-by-component imaging on all nanometer length scales.

A specific example is the study of highly correlated, complex transitional oxide materials, which entails challenges in choosing the right path, obtaining crystals, and characterizing. Here, neutron scattering offers enormous opportunities.

The Nanofabrication Research Laboratory will be operated as a regional research facility within the CNMS in collaboration with the university community. It will integrate soft- and hard-material approaches in the same structures by conducting research on directed self-assembly for nanofabrication. It will provide access to clean rooms, electron-beam lithography, high-resolution electron microscopy, various scanning probes, and specialized materials-handling facilities. And it will exploit the extensive synthesis capabilities of the CNMS to develop unique nanofabrication capabilities.

The plan to accomplish all this is highly leveraged and driven by input from university researchers. Infrastructure investments reflect directly expressed national and regional university needs, complement or extend existing ORNL and university capabilities, and ensure full use of other ORNL facilities for nanoscale materials research. Input has been received from 19 universities regarding CNMS mode of operation, research needs, and complementary nanoscience activities. A straw-man equipment list has been prepared with input from 15 universities. The effort is now in the conceptual-design phase. To further engage the scientific community, a CNMS planning workshop is scheduled in Oak Ridge in October. Its purposes are to engage the national and regional scientific community in planning the Center and its research and to identify candidate research areas and equipment needs; to identify user operations and infrastructure needs; to identify champions for research focus areas; and to integrate the Center with other ORNL facilities and capabilities.

In summary, the CNMS will accelerate discovery in nanoscale science by assembling the resources and creating the synergies needed to produce timely answers to the largest questions in nanoscale science by combining neutron science; synthesis; and theory, modeling, and simulation.

Stohr noted that not a lot of information was presented here on synthesis science and asked what synthesis capabilities will be available. Lowndes said there will be an equal amount on synthesis and theory, modeling, and simulation as a neutron science. Stohr asked how they would get ideas about instruments. Lowndes answered that they would hold workshops on developing tools for synthesis and neutron science. Stohr commented that they would need electron microscopes, etc. Lowndes responded that they will have all that:scanning electron microscopes, transmission electron microscopes, a scanning probe laboratory, etc.

Shen asked where the complementarity comes from. Lowndes answered, in the types of measurements you can make. In different systems, you have different capabilities. One of the capabilities of neutron science is to characterize biological structure.

Kohn commented that some imaging devices currently look at the nanoscale, but you need a macroscopic sample for neutron scattering. Lowndes pointed out that the increasing intensity of neutron sources will allow one to look at magnetic structure and a huge sample will not be needed. Kohn followed up that, unlike spatially specific instruments, the nanostructure neutron studies will require a substantial sample with a lot of lateral averaging. Lowndes said that that was true and that that is why the complementary probes will be available at the Center, too.

Richmond asked **Don Parkin** of LANL to review the progress and status of the Center for Integrated Nanotechnologies (CINT), a collaboration of LANL and SNL to develop the scientific principles that govern the performance and integration of nanoscale materials and to provide a national resource for training a new generation of researchers in nanoscience and nanotechnology. Some of the research themes include nanophotonics and nanoelectronics, nano-bio interfaces, complex functional materials, and nanomechanics. The strengths of the two institutions include capabilities and achievements in layered Q-dots and polymers and in the use of light to power some reaction center (e.g., photonic crystals).

In the nano-bio area, it might be desired to develop motor proteins, which would require knowledge and capabilities in molecular biology, genetic engineering, complexation chemistry, molecular modeling, self-assembly, solid-state physics, microfabrication, nanomechanics, fluid mechanics, micromechanics, and biochemistry. In nanomechanics, it might be desired to develop future nanomachines to test materials and perform work or tool development with the interfacial-force microscope at SNL or to explore new deformation mechanisms for high interface-to-volume ratios, which exhibit new phenomena in mechanical behavior.

In looking at structure-property relationships, scientists are finding (1) many materials with unique functionality that have complex crystal structures and (2) novel precursor chemistries that enable complex-materials synthesis. Other ideas are to tune the quantum dot-molecule interface and to develop an understanding of superconductivity through new electronic materials that enable new functionality.

LANL and SNL currently have core staffs for the four thrust areas. Support staff will be hired for operating and maintaining the fabrication and characterization equipment. The CINT facility will be built in Albuquerque. Users will come into the CINT Facility for Nano-Bio Interfaces and will interface with LANL for biosciences and LANSCE and with SNL for biomolecular materials. The CINT facility will contain laboratory suites for the synthesis, characterization, and integration of nanomaterials. In the physical layout of the Center, three capabilities will be centered around interaction areas and conference rooms: (1) a synthesis wing with hoods, benches, and equipment to handle chemical and biological materials for bench-top characterization; (2) an integration wing with a Class-1000 clean room for flexible fabrication; and (3) a characterization wing with scanning probes for nanomechanics, laser optics, and microelectronics.

CINT outreach will extend across all research sectors. CINT facilities will be a major national resource for universities. Postdocs, students, and visiting faculty researchers will comprise a major part of the CINT program. Access will be provided at no cost in collaboration with CINT researchers. It will also be a resource for national and federal laboratories and for industry. CINT would support:

- About 40 graduate research assistants, including visiting students and CINT resident students performing thesis work with supervision being provided jointly by university faculty and CINT scientists and financial support being provided for travel and salary;
- Undergraduate interns;
- About 20 postdoctoral associates selected through an internationally competitive program;
- Visiting scholars; and
- Associates, scientists, and faculty at LANL, SNL, universities, and laboratories with CINT-based joint research.

The CINT institutions will be holding workshops, symposia, and short courses and developing a nationally televised seminar series with a national technical university.

The management structure would have a director and executive committee to manage and coordinate CINT operations and to approve associate appointments; a technical steering committee to evaluate science opportunities, recommend the allocation of resources, develop collaborative and partnership mechanisms, and appoint postdoctoral selection committee; an external advisory committee to provide advice and guidance to the executive committee; an oversight committee to conduct LANL and Sandia management evaluations of CINT and BES program objectives; and a dedicated staff with appointments at SNL or LANL to conduct day-to-day operations. CINT has developed a timeline for implementation covering activities related to management, outreach construction, and CINT programs.

Bucksbaum asked how the three centers are working together. Parkin said that they had not gotten together, yet.

Goodman asked if there would be relocation of staff, and Parkin answered that there would be a large number of SNL and LANL staff at the Center.

Flynn said that he did not see any unique facilities at the New Mexico or Berkeley centers and asked what would be there that is not at lots of other places. Parkin pointed to new nanoscale programs with the associated equipment (e.g., electron-microscope probes) and personnel. All of these facilities would be state of the art. Alper added that, at Berkeley, the ALS, NERSC, and electron microscope probes are not necessarily unique, but the assemblage is.

Richmond introduced **Mihail C. Roco** to speak about the NSF's contribution to nanoscale science and technology. He started by giving an abbreviated timeline for the NNI:

November 1996	Nanotechnology Group established
February 2000	White House release of the NNI
November 2000	Congress enacts the NNI budget ($422 million)
April 2001	White House request for nanotechnology ($519 million)

He noted the increase from $65 million to $174 million in the NSF budget for nanoscale science and technology (NST) between 1997 and 2002. In the FY 2002 budget request, the NSF increased nanotechnology R&D funding by 16%, the Department of Defense by 21%, and DOE by 4%.

About 32 countries are funding NST. Several of those countries have picked a product to be developed vertically (e.g., high-density storage). The U.S.-government investment increased by 56% in FY 2001, while the foreign-government investment increased by 74%. A bill in the Senate now would establish a 5-year plan for NST support. The elements of the NNI at NSF are:

- Fundamental research
- Grand challenges (for research on major, long-term objectives)
- Centers and networks of excellence
- Research infrastructure (metrology, instrumentation, modeling/simulation, user facilities)
- Societal implications and workforce education and training (for a new generation of skilled workers; nanotechnology will affect the legal, ethical, social, and economic aspects of society)

The nanoscience and engineering drivers are

- Phenomena at the nanoscale
- The science of a large number of objects acting as systems
- Atomic- and molecular-scale structures and the ability to manipulate them
- Relationships between functional nanostructures
- Instrumentation for single molecules and clusters
- Understanding the cell and modern biology
- Assembling and connecting at the nanoscale

Synergies should be exploited systematically, such as the nano-bio-IT (information technology) synergism of three-dimensional assembling and the integration of new nanodevices in systems. The principal areas of investigation funded by the NSF include:

- Biotechnology (biostructures, mimicry, and bio-chips),
- Nanostructure by design and novel phenomena (physical, biological, electronic, optical, and magnetic),
- Device and system architecture (interconnect, system integration, and pathways),
- Environmental processes (filtering, absorption, low energy, and low waste),
- Multiscale and multiphenomena modeling, and
- Education and social implications.

Examples of programs at the NSF include the synthesis and processing of nanoparticles, the establishment of a national nanofabrication user network, the development of nanoscale instrumentation, setting up a partnership in nanotechnology, exploring biosystems at the nanoscale, nanoscale modeling and simulation, and issuing Small Business Technology Transfer (STTR) and SBIR solicitations on nanotechnology. Current solicitations for the NNI in FY 2001 include:

- Within NSF: Nanoscale Science and Engineering
- Within DOD: Defense University Research Initiatives on NanoTechnology (DURINT) and the Defense Advanced Research Projects Agency's (DARPA's) Simulation of Bio-Molecular Systems, Molecular Electronics
- Within DOE: Nanoscale Science, Engineering, and Technology

In FY 2001, NSF is supporting research in emerging areas of nanoscale science and technology and in collaborative research and educational activities with larger and longer grants than in exiting programs. As an outcome of its FY 2001 solicitation, 102 awards totalling $76 million were made to all research directorates and for all NSF themes. Other NST support at NSF includes awards in the core program and three centers for education and training (at the University of Washington, the University of California at Davis, and the City University of New York). An example of the FY 2001 interdisciplinary group awards is one on biologically based assemblies of electronic materials at the nanoscale at the University of Texas.

NSF support for NST has three major themes:

- Scientific and engineering frontiers at the nanoscale: novel phenomena, structures, and tools;
- Create a balanced infrastructure for nanoscale science and engineering; and
- Education and training and the revitalization of connections between disciplines.

The current investment (FY 2001) is $150 million, about 4% of which is NSF research. The FY 2002 request calls for funding for individuals and small groups in research and education; for facilities; and for planning interagency interactions. Additional grand challenges envisioned for

FY 2002 are (1) Nanoscale Instrumentation and Metrology and (2) Manufacturing at the Nanoscale.

The emphases of NSF are on education and training. Therefore, it stresses the integration of research and education (affecting more than 3000 students per year along with technicians, teachers, and faculty), curriculum development (including new courses, course modules, and summer courses), education and outreach programs, and international education opportunities and collaborations.

Richards commented that this sounds like a nano-gap scare. Competition is good, but a workshop to see what duplications are being committed might be good. Roco responded that the scientific community has working groups that oversee and coordinate the work of different groups and agencies to ensure the best outcome. Thomas commented that this initiative was the result of an interagency cooperation. The foci of the centers of the different agencies are quite different as are the foci of even the different centers of a given agency. The work is generally relevant to the mission of the funding agency.

El-Sayed asked why these examples are so biologically oriented. Roco responded that all biosystems work at the nanoscale. Biosystems can be used to perform specialized tasks, or they can be used as models for physical or chemical tools.

Stupp asked his opinion of the current administration's commitment to nanoscience. Roco said that PCAST (the President's Committee of Advisors on Science and Technology) is very supportive. There is no science advisor, yet. The IWG has a 5-year plan but cannot publish it until is reviewed and approved by the administration.

Kohn asked, given the educational function of NSF, what is available in reports and monographs on the subject or if there are special schools or training sessions on the topic of NST. Roco cited a book, *Nanoscience Research Directions*. Another monograph is in development, and there are about 15 courses offered in the United States on the topic.

A break was called at 4:01 p.m. The meeting was called back into session at 4:22 p.m. Richmond introduced **Eric Rohlfing** to provide an update on the Linac Coherent Light Source (LCLS).

BESAC has been concerned with the science that could be done on the LCLS. It asked for a description of the the first experiments that might be conducted at such a facility. The scientific case was directly tied to the decision on proceeding with LCLS construction [Critical Decision 0 (CD0), Conceptual Design]. The first experiments were aimed at defining (in some detail) the first classes of experiments that would be mounted on the LCLS, providing the basis for the experimental requirements for the LCLS conceptual design report (CDR). These first experiments were assembled through the LCLS Scientific Advisory Committee. These reviews were presented to and discussed by BESAC in October 2000. A unanimous vote recommended that BES approve CD0 contingent upon a positive external peer review.

That external peer review was completed in November 2000, but was not sufficiently strong to proceed with CD0, and BES delayed approval of CD0. There was strong support for the LCLS project, but the scientific case and level of community support was not yet sufficient. BES held a workshop of 20 to 25 scientists on the scientific applications of ultrafast, intense, coherent X-rays that focused on the scientific applications of a source with the LCLS's specifications with an emphasis on ultrafast dynamics, nonlinear optics, and X-ray imaging. That workshop resulted in a report that complements and broadens the LCLS scientific case. The workshop more clearly defined the areas of science that the LCLS (in baseline operation) can potentially affect:

- Multiple core-level excitation or multiphoton processes in atoms,
- Volumetric excitation of nanoscale matter by X-rays,
- Structural determinations for large biomolecules or nanocyrstals via X-ray imaging, and
- Dynamics in condensed phases.

But the workshop also made obvious that the scientific community believes that a shorter LCLS pulse is still highly desirable to extend X-ray probes into the time regime of atomic motion in molecules and solids and to defeat the destruction of the electronic and molecular structure in imaging experiments. There are, however, realistic proposals for shortening the LCLS pulse.

The impacts of the BES workshop included the realization that the scientific community has been sufficiently canvassed to develop the best scientific case. No more workshops will be convened (at least for a while). But, the scientific program for the LCLS will continue to evolve and be very strongly coupled to advances in XFEL (X-ray free-electron laser) physics. The decision to proceed with the CD-0 was made in June 2001. The CD-0 was signed by the Acting Director of the Office of Science, and a preliminary project budget validation was completed with a total estimated cost of $175 million allotted to construction and support for the first set of experiments. The LCLS collaboration is now authorized to prepare a CDR. With good progress and funding availability, the project's engineering and design could start in FY03, and construction could begin in FY04.

Bucksbaum asked how they arrived at the $175 million figure. Galayda said that that is a midrange estimate that takes into consideration the effects of inflation. Certainly, the scope of the project could be changed. Hodgson responded that the cost of the accelerator has not changed.

Rohlfing turned the floor over to **John Galayda**. The LCLS will use the downstream one-third of the Stanford Linear Accelerator Center (SLAC), adding two experimental halls. It will pick up a factor of 10^6 in brightness in comparison with current machines. Its job is to get all the electrons in a beam to act as one giant electron by bunching them up with synchrotron radiation within an X-ray beam for a few tenths of a meter until the bunches reach saturation (maximum bunching). This process is started by making a collimated beam from an electron gun with a high-enough current density to produce X-ray lasing.

SLAC is pursuing R&D on the electron gun. Agreement with predictions is good for configurations tested thus far. Facility upgrades are planned to study configurations with lower emittance. The gun produces pulses 1 mm in length. They go to compressors that use magnets to get the slower electrons to catch up with the faster electrons. It would be possible to produce pulses as short as 20 femtoseconds (fs), except for the coherent synchrotron radiation (the trailing electrons catch up to and accelerate the electrons at the front of the bunch, which is the product of coherence). As the beam progresses, it gets degraded, so more undulators are required to achieve saturation.

Coherent synchrotron radiation (CSR) sets a lower limit on the LCLS electron-bunch length. Results from ANL's Advanced Photon Source (APS) and Conseil Européen pour la Recherche Nucléaire [CERN; now European Organization for Nuclear Research (Organisation Européenne pour la Recherche Nucléaire)] show a stronger effect than expected. A new ANL model fits the latest data, but the question remains whether the model is accurate. The LCLS bunch compression can be retuned to accommodate this increased CSR, and recent modeling results can predict this behavior.

Moving downstream 100 m from the compressors, the beam comes to an undulator with a titanium strongback mounted in eccentric-cam movers. The magnet material is 100% delivered, the poles are >90% delivered, and assembly is under way.

ANL is also working on beam diagnostics in the undulator, including a diamond [C(111)] screen to extract and observe the X-ray beam and its superposition on the e-beam. The diamond wafer has been exposed to an electron beam in the Final Focus Test Beam (FFTB) with the same electric fields as in the LCLS. No mechanical damage was produced in the diamond. Tests of its crystal structure are planned to see if it still acts as a monochromator.

In X-ray optics, LLNL has conducted tests of damage to a silicon crystal after exposure to a high-power laser with a similar energy deposition; the threshold for melting is 0.16 J/cm^2, as predicted by the model. LLNL has also performed a fabrication/test of the refractive Fresnel lens, which is made of aluminum instead of carbon and is machined with a diamond point. Measurements from the Stanford Positron Electron Asymmetric Ring (SPEAR) are presently under analysis. This lens would focus the beam on the sample in the X-ray spectrometer.

In FEL physics, a more complete analysis has been completed of the HGHG (high-gain harmonic generation), the LEUTL (Low-Energy Undulator Test Line) experiments are ongoing, and the VISA (Visible Infrared Amplifier Experiment) experiment achieved saturation. A test with the LEUTL with nine undulators showed that saturation was achieved early in the chain of undulators and then beam starts unbunching. The near-term R&D goals are to perform a thorough investigation of gun operation at LCLS parameters, to conduct an experiment/model comparison at 1-mm-mrad emittance and 0.5 to 1 nC, and to proceed further with studies of bunch compression and coherent synchrotron radiation by installing a bunch compressor in the SLAC linac and continuing start-to-end modeling (short bunches are ideal for advanced accelerator R&D).

In X-ray laser physics, the goal is to use the LCLS to explore means of producing ultrashort bunches (< 50 fs). Alternative techniques will be investigated. A chirped-beam self-amplified, spontaneous-emission–FEL has been proposed for high-power femtosecond X-ray pulse generation, which represents a possibility for shorter-pulse operation by use of a two-stage undulator.

For the LCLS construction, $6 million has been requested in FY 2003 for project engineering and design, and $3 million has been requested for R&D with which to start construction in FY 2004, commission the injector in FY 2005, and install the undulators and experiments and commission the LCLS in FY 2006.

He summed up with three observations and statements:

- LCLS research activities span the full range of challenges to be met in creating and exploiting an X-ray laser.
- SLAC has supplemented its extraordinary capabilities with the expertise and resources at partner labs to make LCLS possible.
- LCLS can be a reality by 2007.

Sinha noted that the 10^{10} increase in brilliance is not as important as shorter pulses and asked why they did not sacrifice brilliance for shorter pulses. Galayda replied that there are a lot of concerns whether that can be done.

Kohn asked what warm dense matter is related to and what do you do with it. Galayda responded that it is an area [physical state] you cannot get by other means because it takes so long to produce it by other means that it blows up. It reflects the Jovian core or brown-dwarf-star physical states, but it is also related to bomb design.

Bucksbaum asked if early saturation is bad. Galayda said that it is easy to push the rest of the instrumentation upstream. The only drawback is if you have already bought the undulators.

Johnson asked if there will be some inherent chirp in the 50-fs version of the bunch. Galayda said that there is still a residual energy spurt. The interesting thing is that the temporal coherence of the LCLS is on the order of 10 to 20 fs, so there will be an abrupt modulation of the intensity at that time scale, making the peak power difficult to detect. Once the bunch gets shorter, the correlation between the energy and the peak power becomes very good.

Richmond asked **William Millman** to speak on planning for the Committee of Visitors (COV), which will first look at most of the chemical-science activities. The visitation will take place Sept. 19-21, and most of it will be dedicated to the actual operations of the offices visited. The BESAC charge is:

1. For both the DOE laboratory projects and the university projects, assess the efficacy and quality of the processes used to (a) solicit, review, recommend, and document proposal actions and (b) monitor active projects and programs.
2. Within the boundaries defined by DOE missions and available funding, comment on how the award process has affected (a) the breadth and depth of portfolio elements, (b) the national

and international standing of the portfolio elements, and (c) the balance of activities within the Division in the area of chemical sciences.

3. Comment on future directions proposed by the Division and BES management and on opportunities that might not have been presented.
4. Comment on how the process for these reviews might be improved.

Activities within fiscal years 1998, 1999, and 2000 will be covered. Four groups will look at the files and documentation, two at grants and cooperative agreements (with universities and other government agencies) and two at contracts (with national laboratories). Carl Leuberger of the University of Colorado will be the chair. Group 1 will cover Atomic, Molecular, and Optical Physics and Chemical Physics. Group 2 will cover Separations and Analytical Chemistry. Group 3 will cover Photochemistry and Radiation Science and Electrochemistry. Group 4 will cover Catalysis and Chemical Transformation and Chemical Engineering.

They will be provided:

- A history of the DOE Chemical Sciences published in 1992
- A broad agency announcement
- Copies of special solicitations
- A copy of 10 CFR 605 - Office of Science, based on 10 CFR 600
- A copy of the BES review procedures for laboratories

They will (1) assess the efficacy and quality of the processes involved in writing grants and contracts; (2) judge the breadth, depth, and quality of activities; and (3) consider future directions. To check this process for possible improvement, the COV will look at the over-all evaluation conducted during the two and a half days, the information provided, time utilization, personal interactions with the scientific staff, and the file systems.

Crow asked if they will look at the solicitation requests and proposal guidelines. Millman said, yes. Goodman asked if there was a plan to go to a fast-lane submission. Millman replied that there is an interagency group looking at electronic submission of proposals.

Richmond requested members to talk about their visions for BES over dinner and said that that would be the first topic of discussion at 8:00 a.m. the next day. She called for public comment. There being none, she adjourned the meeting for the day at 5:34 p.m.

Friday, August 3, 2001

The meeting was called to order at 8:02 a.m. Richmond asked the Committee to look at the charges given to the Committee on the previous day by James Decker and to use those charges as the point of departure for the morning's discussion. She opened the floor to general discussion to judge the sentiment of the Committee. Afterwards, she said, the Committee would be polled for its reactions to the nanoscience research center presentations of the previous day.

Long noted that two of the nanoscience research center presentations did not mention what experimentation would be performed at those centers.

McCurdy asked Dehmer and Thomas what the program or overall philosophy of these centers was to be.

Dehmer said that BES is trying to break from the current paradigm used by the laboratories. It does not want to map old concepts onto this new attempt at discovery. These new centers are to service the scientific community in a new way and to highly leverage existing research resources. A model for these centers would be the Combustion Research Center at SNL. What will go on at these centers will be very different from what goes on at the laboratories now. The laboratories that took the advice of BESAC the most were the ones that were successful in getting initial funding for a conceptual-design (CD) effort. During the review of the CD, BES will bring in a panel to consider the research that is planned at these centers.

Thomas added that these centers were conceived in the interagency process and are important to the National Nanoscience Initiative. The concept was that people could plan, design, execute, analyze, apply, and revise research at these centers.

Sinha commented that, if these centers are to be gateways to the large neutron and X-ray facilities, there must be a mechanism put in place for the center users to get special access to those facilities rather than putting in a proposal to use those facilities and then waiting for beam time. To make these centers useable, their operations have to be integrated with those of the large facilities (e.g., reserving beam time specifically for center users). Nanoscience research must focus on how the properties of materials differ when they are confined in very small systems, giving them interesting properties. You cannot use X-rays or neutrons to study a single nanosystem, but you can study scattering from large assemblages of, say, microdots and characterize them very well.

Tromp said that what he missed in the presentations was the scientific view of what is planned to be accomplished. It is clear that neutrons and X-rays are going to be used, but the definition of what is going to be accomplished is not clear. He said that two of the proponents (the New Mexico team and ORNL) do not have programs in nanoscience and nanotechnology now. DOE needs to get credible scientific programs in nanoscience and nanotechnology now or it will not be in a position to do anything with these centers in the future. He noted that nanoscience is a fast-moving but decidedly low-tech field and that you can almost make state-of-the-art nanodots in your kitchen. This does not require a $100 million investment.

Mayes said that the centers need to enunciate what they want to accomplish. She expects that the workshops that are already scheduled will accomplish that. It is desirable to have these centers near large neutron and X-ray facilities because, when a researcher is doing statistical investigations on the nano scale, that is when the support of these large facilities is needed. Furthermore, close coordination with the X-ray or neutron sources is needed to ensure that the resources of these large facilities are available in a timely manner.

Kohn said that, to his mind, the intellectual understanding of what this means is lacking. What is important is scaling up from the atomic to the microscopic scale. The current representations of nanoscience go up to a centimeter and indicate a great variety in what nanoscience is. When you are asking questions, unless the questions are properly asked and unless the scientific technique becomes worthy of the hundreds of millions of dollars invested, this initiative will not be successful. The kind of meeting that was described in the previous day's discussions to check out the scientific promise needs to be done. We need to know what we are going to get out of this investment scientifically. We should have a meeting that asks the question of what nanoscience is, what concepts underlie it, and what happens at this scale.

Richmond interrupted the discussion for a scheduled presentation by **David Garman** and **Sam Baldwin** on collaboration between BES and EERE. They showed the world primary energy supply by source from 1850 to 1997 (with oil, natural gas, and coal usage increasing the most during the past half-century) and reviewed the U.S. 1998 energy-linked emissions as a percentage of total emissions (which showed electricity producing the most SO_2 and transport producing the majority of other pollutants) and the projections of energy use (doubling to quadrupling in the next century).

It is important to reduce emissions, and basic research will play a large role in this effort. The Office of Energy Efficiency and Renewable Energy (EERE) has four foci (divisions): Building Technology, Industrial Technology, Transport Technology, and Power Technology. It also has a Federal Energy Use Department. An analysis of residential and commercial building energy use indicates that energy is mainly used for heating, cooling, and lighting. In the buildings sector, one area that has been flagged as holding great potential for energy-efficiency savings is lighting; here there needs to be fundamental research in the core issues. Materials science is being looked to for developing advanced lighting sources through the use of heterostructure semiconductor interfaces, electrically conducting polymers, quantum-dot nanoclusters, etc.

In industrial energy use, a small number of industries (petroleum, chemicals, forest products, agriculture, and steel) make up a large amount of the energy demand. A big difference in the energy use of these industries could be made by:

- Efficient, high-temperature separations
- High-temperature membranes, reactive membranes, and filters
- Separation mechanisms in multicomponent systems

- Improved process control
- Sensors with high sensitivities and high operating temperatures
- Improved chemical and petroleum-refining operations
- Advances in heterogeneous catalysis, surface chemistry, homogeneous catalysis, metaloorganic chemistry, separation science, materials properties, synthesis, and diagnostics
- Computational fluid dynamics for multiphase flows and heat transfer

In the transportation sector, cars and light trucks use 57% of the energy. The range of topics in which BES help is needed includes fuel cells; electrocatalysis; ionic transport in polymer electrolytes; fuel-processing catalysis; engines; real-time, high-sensitivity multispecies measurements; soot formation and evolution; aerodynamic drag; and computational fluid dynamics for low-speed flow and turbulence.

Bioenergy has been boosted by low prices for farm products, but single-purpose biofuel plants (ethanol, power, etc.) are not economically viable by themselves; they must produce a mix of outputs. This situation requires optimization among these outputs and addressing problems in feedstock production, biochemical pathways, bioproducts, and combustion.

In power technologies, the scientific issues include photovoltaics (materials, growth and characterization), geothermal (flow of fluids through fractured media, characterizing geology, and geochemistry), wind (modeling mesoscale atmospheric phenomena for wind forecasting for utilities), and high-temperature superconductivity (materials).

There have been many good partnerships in sponsoring models, workshops, common oversight (peer reviews by joint panels), and colocation (e.g., the BES/LBNL work on fundamental laser-material interactions). Additional, new opportunities for EERE and BES to work together need to be found.

EERE has been under budget pressure to demonstrate the impact of the research that has been funded. The NAS/NRC review went beyond realized economic benefits to also ask what kind of (1) options benefits and costs and (2) knowledge benefits and costs have been produced. Technology is currently reaching the limits of what engineering can do to lower energy costs (a factor of 10) and it now needs to look to basic research to provide opportunities for additional energy savings.

El-Sayed noted that demand is rising faster than efficiency savings and asked what demands are produced by computers. Baldwin responded that 3 to 4% of the demand across the country is produced by computers and cited the LBNL website as the source for those statistics.

Long asked what a quad is, and Baldwin responded, a quadrillion British thermal units.

Shen asked why there was the decrease in energy use in the 1970s. Baldwin responded that there were decreases in demand during the 1970s because there was a push on energy efficiency during the oil shortages. Those figures show how demand can be affected by efficiency. But even the high-energy-use trajectory has energy efficiency factors built into it.

Kohn commented that the NEP says that energy production should be increased while enhancing the quality of the environment and asked how one does that. Garman responded, by shifting fuels, you can increase energy use and improve the quality of the environment at the same time (e.g., displacing wood as a fuel by electrification). Kohn asked if EERE automatically reports effects on the environment of energy-efficiency technologies. Garman said, absolutely. We do that when we go before Congress for budget hearings.

Lester asked if they had been able to get joint projects and exchanges of ideas among DOE offices. Garman said that they recognized that “stovepiping” is an issue. Baldwin said that he had surveyed where collaboration has worked or not. The Combustion Lab was repeatedly cited as an example of excellent cooperative effort. Garman said that collocating scientists at the bench level is also very productive. Kirchhoff commented that collocated basic and applied government and industry researchers worked on the heavy-duty diesel engine program, where the diagnostics have led to a major redesign of such engines. Also, in the Office of Industrial Technology, the characterization of emissions from petroleum refineries by BES, EERE, and industry people sought potential sources of polyaromatic pollutants.

Moore asked if EERE contributes to climate research. Garman answered that it looks at CO_2 production. Baldwin added that it also looks at opportunities to provide effective and efficient energy supplies for populations. There are several examples of such efforts. Garman continued that it considers markets (e.g., the electric grid) when it considers the deployment of efficient energy production and supply.

Crow asked what role renewable energy plays in the current NEP. Garman said that the reason why wind and solar were decreased was to provide more weatherization programs that would provide a larger, quicker payback in energy savings. When increased weatherization funds were made available, greater amounts could be devoted to R&D, consistent with the NEP.

Marvin Singer was introduced to present a summary of the Fossil Energy (FE) R&D. He started by noting that the Combustion Research Laboratory and the High-Temperature Materials Research Laboratory at ORNL are good examples of how stovepiping is overcome to the benefit of the whole Department.

The major functions of the Fossil Energy Program are (1) to maintain the readiness of the nation’s emergency crude oil stockpile and the Northeast Heating Oil Reserve and (2) to encourage innovative technology and sound regulations to maximize the clean, efficient, and affordable development of fossil-fuel resources. Three R&D areas of interest are fuel and power systems, natural-gas technologies, and oil technology. The first deals with utilization technologies, and the second and third deal with producing a smaller environmental footprint and reducing wastes for extraction and production processes. In support of the Clean Coal Initiative, FE pursues more-reliable energy sources, fuel cells, and carbon sequestration.

The initial FE R&D FY 2002 budget request of $366.5 million was reduced quite a bit as a result of the NEP, but Congress has been more generous. The House markup increased it to $471.75 million, and the Senate markup to $487.5 million. As part of a realignment of federal agencies, FE inherited a laboratory from the Bureau of Mines.

Much of FE's R&D is demonstration of technologies. In addition to the Advanced Metallurgical Research Program and R&D performed under the Clean Coal Power Initiative, FE performs research on materials, the Vision-21 plant of the future, sequestration, turbines, fuel cells, power-plant improvement, and fuels for its Fuels and Power Systems Program and on oil and gas exploration and production, gas hydrates, delivery infrastructure, and cleaner fuels for its Gas and Petroleum programs. Sequestration research has increased significantly since its inception and now includes exploratory research on CO_2 separation, capture, and sequestration. The Vision-21 program is working toward a near-zero-emission power plant that can use a variety of fuels by varying the use of modules in the plant. It has an ambitious schedule and focuses on technologies that reduce emissions. The drivers for the program are protecting the environment, reducing reserve margins, and producing an insurance value in options for the future. Areas that BES may be able to play a role in developing this concept include oxygen and hydrogen membranes, gas and particle flow modeling, plant simulation and integration, combustion modeling, gasification and combustion, and materials for turbines and fuel cells. The FE materials program focuses on coatings and protection, new alloys, functional materials, and ultrahigh performance. It is directed at gasification systems, fuel cells, heat engines, advanced steam generators, gas separation, and advanced combustion systems. A good deal of the current research is performed at ORNL.

Fuel cells are being considered for providing power reliability for energy-critical segments of the economy. The hourly outage costs for such businesses can be significant:

- Cellular communications: $41,000
- Telephone ticket sales: $72,000
- Airline reservations: $90,000
- Credit-card operations: $2,580,000
- Brokerage operations: $6,480,000

The goals for the fuel cells of the future are a cost of $400/kW installed and an 80% electricity efficiency.

FE has a Core Technology Program. The major players are the national laboratories [particularly Pacific Northwest National Laboratory (PNNL)] and universities. They perform modeling and simulation and research methods of cost reduction for manufacturing. The limits of fuel-cell technology are being reached. What is needed is another round of scientific investigation. FE has identified a number of fuel-cell research topics that might be fruitful:

- Quantitative microstructural characterization of electrodes and correlation with measured electrochemical performance and modeling

- Direct measurement of activation overpotentials on electrodes of known triple phase boundaries
- Measurement of gas diffusion in porous electrodes; effect of pore size and pore fraction
- Determination of charge transfer mechanisms on electrodes
- Investigation of fuel reformation mechanisms and kinetics on different anodes

A joint SC/FE workshop might be worthwhile to consider these topics and how the two offices might work together on them.

In the area of gas hydrates, imaging techniques that give high resolution of the hydrates and the sediments that bear them at shallow depths are needed. In the Natural Gas and Oil Program, research topics of common interest include reservoir characterization through the analysis of fluid flow through porous media (including modeling and computer simulations, analog studies of outcrops, and geophysics). In the Clean Fuels Program, needed basic research includes advanced catalysis, advanced separation systems, and improved reactors.

He closed by pointing out that a treasure trove of information about these programs is available at www.fe.gov.

Kohn commented that Singer had not said much about Clean Coal and asked how the jump in funding occurred. Singer responded: presidential initiative. It requires industry cost sharing. There have been 40 to 50 demonstration plants over the years. This is not a discontinuity but a rejuvenation of the program.

Sinha stated that much of the fossil-fuel research is being carried out by the oil companies and asked if they were cutting back on their research. Singer said that they have cut back research significantly. FE’s work is closely coordinated with industry R&D.

Mayes asked what research is being done on the end use of energy, such as traffic patterns. Singer said that FE has not done anything like that; rather, that is the province of Energy Efficient and Renewable Energy.

Richmond renewed the discussion of nanoscience and technology, specifically the research centers.

Taylor stated that the progress that has been made by the national facilities during the past 10 years has been outstanding. The FE and NE (particularly the GEN-IV) presentations clearly pointed out areas in which research needs to be done in the nanosciences: catalysis, surface phenomena, and separation science. In these other programs, progress will be made in the applied sense, but, in order to make the real transitions into new things for the future, the advances will be built on the basics. She looks for these nanoscience centers to be addressing those research areas. You have to go back to these building blocks, and that is what these nanoscience centers are about. However, you need to know what you are looking for in order to find it.

McCurdy noted that each of the original five proposals had a list of university partners. We did not hear very much about the university partners in the presentations of the successful centers. These centers have an opportunity to change the nature of the relationship between universities and the national laboratories. Also, there were not any attendant plans for bringing theory to nanoscience or for where the science is going to go.

Flynn commented that it is critical that the laboratories get into the nanotechnology business. The concept of how these centers will work and how they will operate with universities is important. The normal way that DOE works will not work in this situation. They must develop new types of programs to entice the best people into this area to partner with the national laboratories. He did not hear such programs discussed here. A lot of work needs to be done. Also, what is meant by “beyond nanotechnology” needs to be defined better. Most people would probably define it as biology and self-assembly, and many people are already working on these topics.

Lester wanted to emphasize that these centers have the potential to be world-class characterization facilities. But they still need to couple with the intellectual leaders in the field. A user facility should allow such leaders to do things that they would not have been able to do otherwise, and that was not clearly articulated in the presentations. Who in the nanoscience community will be able to participate in, stimulate, and cross-pollinate the activities that will occur at these laboratories? That was of concern to her and needs to be defined.

Bucksbaum commented that these centers are not really user facilities; they are research institutes with a visitor-outreach component. That is a good way of operating and is similar to the Science and Technology Centers of the NSF. That type of facility can work well, but one has to think of what value will be added to those visitors and that thinking has not been clearly defined. These centers may be gateways, but the NSF presentation shows there is no coordination between the special facilities and their centers. There was no discussion of NSF-funded researchers getting any special relationship with the facilities. Mechanisms for such coordination should be established if DOE is to get good value out of these centers. Another point is that these centers are not designed to cover the field of nanoscience and nanotechnology in any coordinated way that would result in any interlaboratory competition. There was a bit lacking in the area of chemistry, not because BES is not interested in chemistry but because that was the mix that came out of this selection process. The people at the top should be thinking hard about whether they need a second round or some other means to recover some of that lost capability. The selection process should be rethought by DOE to provide greater coordination.

Broholm said that the importance of the nanoscience area lies in a meeting of length scales. Challenges in technology become stimulating and interesting basic research projects. The nanotechnology centers can help to foster a link between academic research and technology based on this fact. The current public attention to the importance of reliable and clean energy sources represents a responsibility and opportunity for BES. While he would not advocate a narrow program, he stated that it is important to keep a focus and emphasis on energy efficiency, conservation, and production in BES nanotechnology centers.

Richmond said that there needs to be an emphasis and mechanism to push harder for people to go into producing new materials. She was impressed with the Fossil Energy and Energy

Efficiency and Renewable Energy presentations. She wished there was some way to use these facilities (1) to educate the community that is not at national laboratories and (2) to work hard on the issues that need to be solved. Where are the needs right now? If the centers could be a mechanism for taking the engineering side and presenting it to those who are not normally in contact with that viewpoint so they could see what they need to develop in the very fundamental areas in order to contribute to this effort, that could be an important service that these centers could provide.

Shen noted that DOE has had great success with its large facilities, such as synchrotrons. These nanocenters are somewhat different. The Materials Research Laboratory (MRL) is a good example of what we are looking at with these nanocenters. The DOE labs, which are very successful, are an assembly of many small facilities. LBNL is a good example of this. It would be very helpful to look at what has been done in the past in related cases to see what has been successful. Second, how do you define nanoscience? The making of nanostructures should be emphasized. But he was concerned that the reviewers of these programs feel strongly that only the making of nanosize structures was defined as nanoscience. We should take a broader view than that. That is an engineering problem; BES should be concerned with the intellectual and scientific problems. Third, three out of five proponents were selected for five possible centers. That indicates that there was a selection process. But he was not sure if there was enough competition and hoped that there would be more competition in the next round of proposals. The FE and EERE presentations were very interesting, and he would like to have some of the documents that were mentioned in those presentations.

Moore congratulated BES for breaking down the interdisciplinary barriers in this area. Certainly, the Combustion Research Facility (CRF) is a good example of a laboratory that has brought together representatives of disparate disciplines as well as blending basic and applied research successfully. In the nanosciences, as in the CRF, it is the people that count.

El-Sayed stated that nanoscience is in an initial state. Extensive fundamental research need to be done. New properties are observed that need to be understood. This is why this is an interesting period. We should not rush too fast to turn on the technology switch before we understand the science. This would be a grave mistake. There are a lot of scientific problems that needs to be solved in understanding the nano-surface, the nano-contact to our macroscopic World and the changes in properties upon self-assembly. The workshops could help us determine what science should be focused on that might accelerate realizing the potential use of nanoparticles in efficient energy production.

Johnson supported these centers but would have liked to have heard more about how individual investigators would take advantage of the centers. In previous discussions, we had expressed the hope that the excitement over nanoscience would attract more minorities and women into science. None of the three centers mentioned any outreach to those communities. The ORNL presentation had no HBCUs (historically black colleges and universities) in their list of 19 participants, and the Sandia presentation did not mention outside participators, such as the University of Texas at El Paso.

Long very much liked the idea of the collocation of the centers with facilities that have design, synthesis, acquisition, and analysis capabilities and being able to carry out these functions in a timely fashion. In terms of characterization, it should be like MRL, which has a suite of instruments nearby that are easy to get access to and allow performing analyses with experts in the selected techniques. These facilities should be available on an "easy-access" basis and should have some time dedicated to the center users.

Stohr noted that Berkeley has a tremendous internal strength; it has a light source that can actually look at nanoscale objects. That is different from hard X-rays and neutrons that can only see average values. He saw as a challenge for the Berkeley site the link to the outside community and coupling to that community. The Oak Ridge proposal is too biased toward neutrons. A few days before, he would have said that neutrons would be a natural technique to study nanoscale phenomena. Neutrons' strength is that you can look at averaged phenomena. But the Oak Ridge group clearly needs to identify the fraction of the program in nanoscience that is well-addressed by neutrons. It is likely a small fraction, but perhaps a significant one. The Oak Ridge group should also emphasize the peripheral facilities and capabilities that round out the picture in nanoscience, such as electron microscopy, tip-type spectroscopies, and synthesis of nanostructures. The Los Alamos/Sandia group has the overall concept together but is the farthest behind. It does not have leaders in the field. They need to get into this venture on a smaller scale. There are areas in nanoscience where you can get started with little money. They should start there now so, when the centers are started, they will know where the problems are and what their strengths are. They will then be able to move from an in-house program to an outside one.

Plummer would not comment on the centers because of a conflict of interest. He did comment that he was impressed with the lack of a transfer of information from these centers to the Committee. The input to this Committee is important. The mode in which this review is being conducted does not transfer information and is not productive. Almost every one of the questions being brought up here has been discussed, and there is an answer to each of them. The Committee, however, is not getting those answers. The next time BESAC meets, it should interview the key people in the centers and their partners. Then the Committee can get answers to these questions. There have been two questions raised here saying that there is no theory. A third of the program is theory, and a third is advanced synthesis. The information is not getting transferred. The 20-minute slide shows do not do anything. Maybe the centers need 1.5 hours each to respond to the Committee's questions, and maybe the centers should bring their partners with them. The questions raised here strike some common themes. Perhaps the Committee should formulate a list of questions that all the centers could respond to at the February meeting. If this program is just another way to funnel money to the national laboratories, it is already a failure. There has to be a new mode of operation between the universities and the national laboratories, and this Committee is the watchdog.

Richmond suggested that Sharon Long poll the members of the Committee about what questions they would like to see addressed at the next meeting.

Stupp stated that these centers should be used by DOE to articulate the vision of what comes beyond nanoscience. The importance of nanoscience is that, by having access to synthetic articulation of manual objects, you will open the door to organize a much more complex system at many different length scales that will give you properties that would never emerge from the crystals or amorphous materials that we know. Nanoscience is just Step 1 of a larger goal for which we do not have a name, yet. There is a supernanoscience somewhere out there that no one, as yet, has labeled. We need to think hard about what that is. DOE should use these centers to launch that vision. This larger goal will require real teams of people in the universities, national laboratories, and industry. We need a mechanism to set up such teams. That goal was not articulated in the proposals. One gap that is obvious is that biology has to be integrated into this effort either as an inspirational tool or as a synthetic tool. Clearly, that expertise is not represented in these proposals, except in a small group in the Berkeley proposal. Indeed, the country does not have that capability. Another big gap is organic chemistry. Another monomer is not going to do it. What is needed is the kind of organic chemistry that is used in the pharmaceutical industry. But those scientists do not know anything about the nanoscience and nanotechnology world. The chemistry of today has not been cast in the proper way to create nanostructure devices and to learn what might be the advantages of such devices. DOE needs to take the initiative to take a hard look at what is going to come next. Highly organized systems, not an isolated carbon nanotube or quantum dot, are going to solve the problems of society. The way these nanoscience centers presented themselves to the Committee is not going to solve these problems. It is an issue of creating new capabilities.

Richards noted that the molecular machines have a very different basic physics; they have a different statistical thermodynamics. They are very different from what we are familiar with. We do not know the fundamental chemistry and science of the nanoworld. And yet, we are spending vast amounts of money on it, even without a focus to the research.

Crow noted that he had benefitted from being on the review committees and hearing about all the science and the collaborations in the reviews. He observed that the centers were developing as they were described before. He said that DOE has to be careful about what value will be added to the external collaborators; that is what is going to drive their participation. That value is a funding plus an intellectual issue. Refinements will, of course, be needed as the construction phase is approached. These are, indeed, collaborative research centers that leverage the capabilities of larger research facilities and also leverage academic research programs. Perhaps the thrust areas will be a driving force for new science, or perhaps the small, integrated (academic and national laboratory) research teams centered on a research thrust will be a driving force. Industrial participation was not mentioned in the presentations at this meeting, but it was mentioned in the earlier, fuller descriptions of the centers. He did not believe that the narrow characterization of nanoscience offered by others on the Committee was justified. There are many nanoscale properties of bulk materials (e.g., strengthening mechanisms) that operate on the nanoscale and should be investigated. The interface between the centers and the host facilities is important. A major benefit of collocation is closing the loop among several steps in the research process and allowing that research to progress efficiently and effectively.

Smalley said that nanoscience and technology is such a broad term that it is almost meaningless, but anyone who was having difficulty defining nanoscience now should just wait 5 years. It would be a pity if these centers have the constant burden of justifying the previous investments in large facilities, such as the ALS. The major challenge of these centers will be to find some focus that has a clear relationship to the mission of the agency. Look at the fraction of energy production and use that produces CO_2, nearly all of it. Look at the energy-demand projections for the next century. Energy has to come from somewhere else. The hopes of the world are based on the science that will be done in the next 20 years. He would have preferred that the solicitation for nanoscience centers had gone out extramurally. DOE's history has been based so much on big machines and keeping the national laboratories strong. Energy should be the focus of DOE, and there was not one slide on that topic in all the presentations. Energy production and use is the critical problem of the next century.

Greene noted that one thing that will be needed is a lot of communication among the centers as this (hopefully) new mode of operation is started up to move new ideas from the laboratory bench to the marketplace. There was a lot of overlap among the presentations with, perhaps, too much stress placed on nanofabrication. A lot was missing in the arena of materials (such as phase separations). These subjects were decided not to be nano. That was a mistake. The nanolaboratories should be contributing to an understanding and advancement of these fundamental issues in a cross-collaborative manner.

Richmond introduced **Gail Marcus** to review the science efforts of the Office of Nuclear Energy, Science, and Technology (NE). It is a small applied program that reports to the same management as does SC. It operates a number of research-oriented programs:

The Nuclear Energy Plant Optimization (NEPO) Program conducts cooperative research with industry to develop and deploy advanced technologies that improve the long-term reliability and efficiency of existing nuclear power plants. It is funded at a level of $5 million and addresses aging effects on nuclear power plants.

The Nuclear Energy Research Initiative (NERI) is designed to provide long-term R&D to address key issues affecting the future use of nuclear energy and to preserve the nation's nuclear science and technology leadership. It is funded at $35 million, which is not cost-shared, and conducts exploratory projects on innovative reactor technologies. A recent solicitation elicited 575 proposals, 12% of which were funded. This program involves a lot of international collaboration and collaboration among laboratories, universities, and industry. It is an incubator for ideas for the next generation of nuclear reactors (Generation IV, or Gen-IV). This is the beginning of a new research program that renewed a program whose funding had gone essentially to zero. NERI covers many materials issues, which offers possibilities of cross linking with BES.

The International NERI (I-NERI) program is a response to interest expressed by foreign governments in developing a new generation of nuclear reactors. It is a bilateral, cost-shared collaboration to conduct R&D. Bilateral peer review of proposals is conducted by joint teams. This program is just getting started. The first two agreements (with Korea and France) were put in place during the past six weeks. Solicitations are yet to go out. Topics to be covered include next-generation reactor designs (with higher efficiency, lower cost, and improved safety); advanced nuclear fuels and fuel-cycle technology; innovative technologies for plant design, fabrication, construction, operation, and maintenance; and fundamental nuclear science.

Nuclear Energy Technology (NET) is an effort led by the Nuclear Energy Research Advisory Committee (NERAC; parallel to BESAC) to identify, assess, and develop advanced nuclear-energy technologies that can compete in all markets with the most cost-efficient energy alternatives. It is looking at innovative options for a long-term research program (implemented, say, in 2030) that would improve the safety, economics, waste minimization, proliferation resistance, etc. of the Gen-IV technology. NERAC has brought in the international community and established the Generation-IV International Forum. With more than 100 experts from nine countries, that Forum has formed teams to look at various technologies.

The Advanced Accelerator Application (AAA) program is a potential research area that is to conduct scientific and engineering research in the areas of transmutation and separations technology to enable significant reductions in both the quantity and radiotoxicity of spent nuclear fuel; provide a vehicle for tritium production as a back-up capability to support national security needs; and conduct advanced nuclear science, materials, and systems research. NE has partnered with DP, which has an appropriate facility at LANL. Currently, NE is scoping out what the program might be. Its future will be determined by Congress during this budget cycle.

The Advanced Radioisotope Power Systems Program was established in 1961 to develop, demonstrate, and deliver compact, safe nuclear-power systems and technologies for use in remote, harsh environments, such as space. NE continues to develop lighter, longer-lasting sources and has a very small effort to develop a fission-based source.

NE produces isotopes for medical and research applications. The Department supplies the ones that are not economical to produce. At BNL, ORNL, SNL, and LANL, NE works closely with SC on the research and production aspects of this work.

The office’s University Programs maintain and support the U.S. nuclear-engineering-education infrastructure to meet the present and future technology needs of the United States. Direct support is provided to 49 educational institutions in 28 states. NE provides scholarships and reactor support to universities. These are in areas such as nuclear engineering education research, nuclear fuel, matching grants, fellowships/scholarships (including minority awards), reactor sharing, reactor upgrades, radiochemistry, and nuclear engineering education recruitment.

Infrastructure is managed (such as ATR and the HFIR), providing hot cells, safety upgrades, building maintenance, and maintaining shut-down facilities in a safe manner.

Richards noted that she had mentioned reducing toxicity of nuclear power waste and asked about the economics. Marcus replied that that program is not an NE program. Yucca Mountain is currently under Secretarial review. NE’s Gen-IV program is looking at waste minimization.

Kohn commented that there is a great difference in attitude toward nuclear power around the world and asked where the best opportunities for making advances in making nuclear power more attractive lie. Marcus responded that, in regard to public opinion, the United States is becoming more positive in attitude toward nuclear power. The need to limit CO_2 emissions has contributed to this change in public opinion. NE has an ongoing roadmapping activity to determine just where the most promising advances lie.

Crow asked if there are any cooperative activities. Marcus said that they used to be part of NE but are now under a different office. NE needs to keep close contacts with them. Security issues form a barrier to such contacts, though.

Richmond said that she will forward a letter to Robert Card about BESAC's support of the nanoscale efforts and its willingness to participate in the planning and oversight for those efforts. She asked the Committee for input about what to discuss at the next meeting. She called for other comments. Kohn noted that the Committee had considered two major themes, nanoscience and energy, and commented that the interface between those two efforts should be close.

Richmond called for public comments. Don Parkin of Los Alamos National Laboratory said that he was extremely pleased with the comments from the BESAC membership, particularly those focusing on the nanocscience research centers' interaction with the university community and the development of models for forming teams among the laboratories, universities, and industry. The New Mexico center has a user meeting scheduled for Sept. 28-29, and BESAC members are invited to participate. The issue of facilities and how they fit into the model for these centers will be a major focus of that meeting, contributing to the functional planning and the development of the approach for constructing the center.

There being no further public comments, Richmond declared adjournment at 11:30 a.m.