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# Draft

# LBNL Institutional Plan

## FY 1996-2001

Prepared for the U. S. Department of Energy under Contract No. DE-AC03-76SF00098

Lawrence Berkeley National Laboratory
University of California
Berkeley, California 94720

June

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This document does not contain final agency decisions or opinions.

# PREFACE

The FY 1996–2001 Institutional Plan provides an overview of the Lawrence Berkeley National Laboratory mission, strategic plan, core business areas, critical success factors, and the resource requirements to fulfill its mission in support of national needs in fundamental science and technology, energy resources, and environmental quality.

The Strategic Plan section identifies long-range conditions that will influence the Laboratory, as well as potential research trends and management implications. The Core Business Areas section identifies those initiatives that are potential new research programs representing major long-term opportunities for the Laboratory, and the resources required for their implementation. It also summarizes current programs and potential changes in research program activity, science and technology partnerships, and university and science education. The Critical Success Factors section reviews human resources; work force diversity; environment, safety, and health programs; management practices; site and facility needs; and communications and trust. The Resource Projections are estimates of required budgetary authority for the Laboratory's ongoing research programs.

The Institutional Plan is a management report for integration with the Department of Energy's strategic planning activities, developed through an annual planning process. The plan identifies technical and administrative directions in the context of the national energy policy and research needs and the Department of Energy's program planning initiatives. Preparation of the plan is coordinated by the Office for Planning and Communications from information contributed by the Laboratory's scientific and support divisions.

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# I. DIRECTOR'S STATEMENT

The Lawrence Berkeley National Laboratory (LBNL) solves major national problems through the exercise of scientific excellence using our distinctive capabilities. LBNL has maintained its institutional distinction based upon our close partnership with the University of California, the size and scale of our research programs, and our accomplishments in science. Our location provides a rich environment, with an outstanding scientific and engineering staff and with joint faculty appointments, graduate students, and postdoctoral associates. We are proud of our 9 Nobel Laureates and 58 members of the National Academies of Science, Engineering, and Medicine. Our size is ideal for research facilities such as the Advanced Light Source, the National Center for Electron Microscopy, the 88-Inch Cyclotron and Gammasphere, and the Human Genome Laboratory, now under construction.

Our facilities, expertise, and program execution offer distinctive capabilities in the areas of molecular design, genome sequencing, and detectors and instrumentation, and are able to address the long-range problems of energy supply and efficiency. These capabilities stem from our tradition of accomplishments in particle beams and detectors for discovering antiprotons, quarks, and condensed nuclear matter; nuclear medicine and the understanding and treatment of diseases such as cancer; and energy sciences and materials research that ranges from highly efficient superwindows to new superconducting devices that are the most sensitive in the world.

Today, we are applying our fundamental capabilities in distributed computing and computational analysis to new challenges, including video conferencing on the Internet, modeling pollutant transport, simulating the energy performance of buildings, and solving the molecular structure of cancer-causing proteins. These capabilities are focused through our Center for Energy Research Networking and Advanced Computation Initiative.

Our collaborations with universities, other national laboratories, and industry contribute to understanding our world, improving the environment and health, and creating long-term value for the economy. We are setting a scientific agenda for the next ten years that reflects both the critical scientific needs of the nation and the Laboratory's distinctive capabilities that will address those needs.

LBNL's Vision 2000 began a major strategic planning effort to define the Laboratory's major objectives and provide the Laboratory, its employees, and the Department of Energy with a clear statement of our plans and goals for the future. Vision 2000 affirms fundamental research as our foundation. This FY 1996–2001 Institutional Plan describes progress towards our vision and brings focus to these efforts by illustrating how our distinctive capabilities and the resulting research programs make us a key element of the national laboratory system.

LBNL plans to strengthen its user facilities that are already serving national research needs. The Advanced Light Source (ALS) is now overcommitted to users on its existing beamlines and requires implementation of the DOE Research Facilities Initiative to achieve full utilization. With performance exceeding project specifications, the ALS has begun an era of scientific programs at the forefront of materials research, chemical dynamics, and structural biology. We have prepared a roadmap for the complete buildout of the ALS that supports DOE's strategic plans. To further enhance the potential of the ALS, the Laboratory's Structural Biology Initiative will also add user capabilities for studies in biological microscopy, crystallography, and spectroscopy. This program will combine the capabilities of our Laboratory with university resources to address national needs for instrumentation in macromolecular and subcellular structure determination.

Our advances in genome sequencing hold special promise for improvements in health and new biological understanding. LBNL's Human Genome Center, delivering the highest levels of sequencing productivity in the world, now supports a partnership with the National Institutes of Health to solve the genetic code of *Drosophila*, a model research organism whose code is undetermined. The information generated at the Human Genome Center has already contributed to the development of improved methods for screening genetic abnormalities, locating cancer genes, and diagnosing solid tumors.

In materials research, the Laboratory is addressing pressing national needs for establishing an institute for the molecular basis for materials design, characterization, and processing. We are directing our capabilities to those areas where some of our greatest strengths lie—atomically structured materials and devices with quantum-size effects, bioorganic and combinatorial synthesis, and nanoscale characterization.

LBNL will maintain its historic strengths in high-energy and nuclear physics, providing leadership for the B Factory at the Stanford Linear Accelerator Center (SLAC) and the STAR detector at the Relativistic Heavy-Ion Collider (RHIC). The Laboratory's competencies also provide an outstanding opportunity to help design and fabricate key detector and accelerator systems at the Large Hadron Collider in Europe. The 88-Inch Cyclotron continues its leadership as a low-energy nuclear physics accelerator. The Cyclotron hosts the Gammasphere, the world's highest resolution gamma-ray spectrometer, which provides insights into nuclear structure.

To meet the nation's need for energy supply technologies, the Laboratory continues research at the forefront of inertial confinement fusion. To this end, we will continue to develop heavy-ion accelerators as fusion energy drivers. They offer the most promising prospect for efficient and reliable pellet ignition for civilian power production by the middle of the 21st century.

To address the national need for improved energy efficiency, our leadership in advanced building technologies and electrochemical research is being applied to new lighting systems and superwindow technology, and to restructuring the way innovative building systems can be incorporated into residential and commercial designs. This research advances from our accomplishments in such specific areas as the development of building and appliance codes and standards, low-emissivity windows, and high-frequency fluorescent lighting. We also serve as an international resource for energy efficiency technologies and provide technical assistance on energy supply and demand to developing nations. To improve the detection and recovery of oil and gas, LBNL also continues to pioneer advances in electromagnetic and seismic methods for imaging subsurface resources.

The Laboratory geoscience capabilities also position us for leadership in environmental remediation technologies, with research programs in improved subsurface characterization methods, development of predictive models, and risk-assessment methodologies, including the development of techniques to isolate and clean up sites contaminated by radioactive materials and toxic chemical wastes (including bioremediation techniques). For example, we have developed new polymer gel technology for immobilizing subsurface contaminants in place, with the technology currently being tested at leaking waste tanks at Hanford.

We are making progress on our management goal to deliver the best research support services at the lowest cost. We have achieved this through the consolidation of administrative departments and staffing. The administrative savings are being reinvested in necessary maintenance of our research infrastructure. We also have sustained our commitment to the environment and to safety in day-to-day operations. We have established new outreach and retention programs to ensure an ethic that fully respects diversity and encourages excellence through the Office of Work Force Diversity. A focused communications program is being directed towards improving the national and regional understanding of our research contributions and activities.

LBNL's distinctive university affiliations build on the historic alliances with the University of California and position us to contribute to programs at hundreds of universities nationwide. Our collaborations with other government agencies, including the National Institutes of Health, the National Aeronautics and Space Administration, and the Environmental Protection Agency, add value for all our citizens, as is fully appropriate for this unique DOE multiprogram national laboratory.

As Lawrence Berkeley National Laboratory charts its course into the 21st century, we will continue to refine our strategic objectives and articulate clearly this institution's contribution to the Department of Energy. Our ultimate goal is to see that our people and our programs continue to serve as unique and valuable resources for the Department of Energy and the nation.

Charles V. Shank
Director

# II. THE LABORATORY MISSION

The Lawrence Berkeley National Laboratory is a multiprogram national research facility operated by the University of California for the Department of Energy (DOE). Its fundamental mission is to provide national scientific leadership and technological innovation to support the DOE's objectives. LBNL's mission addresses four distinct goals:

- To perform leading multidisciplinary research in the energy sciences, general sciences, and biosciences in a manner that ensures employee and public safety and protection of the environment.
- To develop and operate unique national experimental facilities that are available to qualified investigators: the Advanced Light Source, National Center for Electron Microscopy, 88-Inch Cyclotron, and National Tritium Labeling Facility.
- To educate and train future generations of scientists and engineers to promote national science and education goals.
- To transfer knowledge and technological innovations and foster productive relationships between LBNL research programs, universities, and industry to promote national economic competitiveness.

## CORE COMPETENCIES AND FOUNDATIONS

The ability of the Laboratory to advance its mission depends upon its "core competencies." These are an integration of research disciplines, personnel, skills, technologies, and facilities that produces results of value to our sponsors and customers. The core competencies can be applied to rapidly changing national needs and new research problems while, at the same time, undergoing evolution themselves.

Underlying many of our core competencies in specific technical areas are fundamental capabilities or "foundations." LBNL has identified seven core competencies and four foundations as follows.

## Core Competencies

- **Bioscience and Biotechnology:** Structural biology; genome research; bioinstrumentation; molecular cytogenetics; medical imaging; biology of human diseases; biomolecular design.
- **Particle and Photon Beams:** Analysis and design of accelerators; beam dynamics; high-brightness ion, electron, and photon sources; advanced magnet design and R&D; high-frequency rf technology; x-ray optics and lithography; induction linacs and neutral beams for fusion energy.
- **Characterization and Synthesis of Materials:** Advanced spectroscopies and microscopies based on photons, electrons, and scanning probes; ceramics; alloys; heterostructures; superconducting, magnetic, and atomically structured materials; bio-organic synthesis.
- **Advanced Technologies for Energy Supply and Energy Efficiency:** Subsurface resources and processes; building technologies; electrochemistry; fossil fuel technologies; energy analysis.
- **Chemical Dynamics, Catalysis, and Surface Science:** Reaction dynamics; photochemistry of molecules and free radicals; surface structures and functions; heterogeneous, homogeneous, and enzymatic catalysis.
- **Advanced Detector Systems:** Major detectors for high-energy physics, nuclear science, and astrophysics; scientific conception and project leadership; advances in particle and photon detection; implementation of new concepts in detector technology.

- **Environmental Assessment and Remediation**: Advanced instrumentation and methods for environmental characterization and monitoring; human health and ecological risk assessment; indoor air quality; subsurface remediation of contaminants; geologic isolation of high-level nuclear waste; actinide chemistry.

## Foundations

- **National Research Facilities:** Advanced Light Source; National Center for Electron Microscopy; 88-Inch Cyclotron and Gammasphere; National Tritium Labeling Facility.
- **Computation and Information Management:** High-speed networking and distributed computing; processing and analysis of scientific images; data-acquisition and analysis systems; scientific information systems; database technology.
- **Engineering Design and Fabrication Technologies:** Custom integrated circuits; integrated accelerator systems; superconducting magnet assemblies; insertion devices for synchrotron radiation; large-volume semiconductor detector technology; laboratory automation; advanced CAD/CAM facilities for large systems; facilities for materials processing and fabrication.
- **Education of Future Scientists and Engineers:** Undergraduate, graduate, postdoctoral, and faculty involvement in scientific and engineering research through close ties with the University of California system; educational programs for elementary schools, high schools, and colleges.

# DIVISION STRENGTHS

LBNL benefits from its close working relationship with the University of California at Berkeley, as well as other universities, laboratories, and industrial institutions. As indicated in the organization chart, the Laboratory is structured to integrate these relationships with its mission in the most effective way possible. The core research strengths of each of the LBNL divisions are as follows:

## Energy Sciences Divisions

- **Chemical Sciences**: Chemical physics and the dynamics of chemical reactions; structure and reactivity of transient species; electron spectroscopy; surface chemistry and catalysis; electrochemistry; chemistry of the actinide elements and their relationship to environmental issues; atomic physics.
- **Earth Sciences**: Structure, composition, and dynamics of the earth's subsurface; geophysical imaging methods; chemical and physical transport in geologic systems; isotopic geochemistry; physicochemical process investigations.
- **Energy and Environment**: Building energy efficiency; environmental effects of technology; energy storage and distribution; fossil-energy conversion; industry, transportation, and utility energy use; national and international energy policy studies.
- **Materials Sciences**: Advanced ceramic, metallic, polymeric, magnetic, biological, and semi- and superconducting materials for catalytic, electronic, optical, magnetic, structural, and specialty applications; exploration of low-dimensional materials; development and use of instrumentation, including spectroscopies, electron microscopy, x-ray optics, nuclear magnetic resonance, and analytical tools for ultrafast processes and surface analysis.

## General Sciences Divisions

- **Accelerator and Fusion Research**: Fundamental accelerator physics research; accelerator design and operation; advanced accelerator technology development for high-energy and nuclear physics; accelerator and beam physics research for heavy-ion fusion; beam and plasma tools for materials sciences and engineering; operation of the Advanced Light Source.
- **Nuclear Science**: Relativistic heavy-ion physics; medium- and low-energy nuclear physics; nuclear structure; nuclear theory; nuclear astrophysics; weak interactions; nuclear chemistry; studies of transuranium elements; nuclear-data evaluation; detector development; operation of the 88-Inch Cyclotron.
- **Physics**: Experimental and theoretical particle physics; advanced detector development; particle database for the high-energy physics community; astrophysics; applied mathematics; innovative educational programs for high schools.

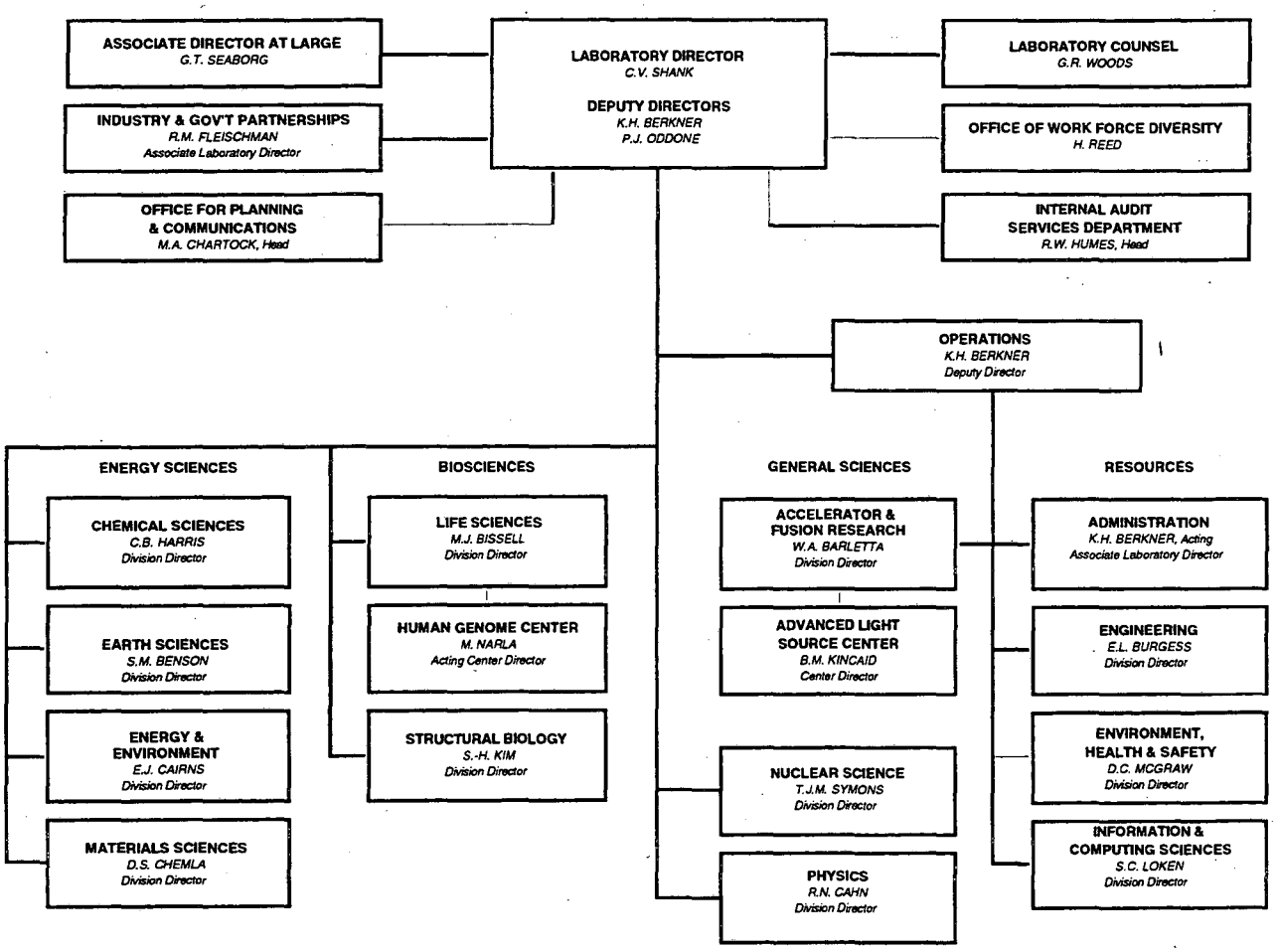
## Biosciences Divisions

- **Life Sciences**: Gene expression; molecular genetics and human genome studies; cellular differentiation and carcinogenesis; hematopoiesis; macromolecular structure; DNA repair; diagnostic and functional imaging; radiation biology.
- **Structural Biology**: Structural and molecular biology of nucleic acids and proteins; genetics and mechanisms of photosynthesis; photochemistry; mechanisms of mutagenesis.

## Resources and Operations Divisions

- **Engineering**: Engineering design, planning, and concept development; advanced accelerator components; electronic and mechanical instrumentation; scientific applications software development; laboratory automation; fabrication of detectors and experimental systems; shops and technical support for scientific programs and research facilities.
- **Environment, Health and Safety**: Technical support for safety and environmental protection; radiation associated with accelerator technology; advanced dosimeters; dispersion of radionuclides; waste management.
- **Information and Computing Sciences**: Advanced software engineering; information management; network development; scientific imaging and visualization tools; computation tools for the human genome project; biostatistics; agile manufacturing.

## LAWRENCE BERKELEY NATIONAL LABORATORY • UNIVERSITY OF CALIFORNIA



# III. LABORATORY STRATEGIC PLAN

## LBNL'S VISION AND STRATEGIC OBJECTIVES

LBNL's Strategic Plan and Vision 2000 establish the Laboratory's overarching goals and focus on our commitment to be a multiprogram laboratory that addresses scientific challenges of national significance. The four major goals of Vision 2000 are as follows:

> ***Distinguish ourselves as a premier DOE multiprogram national laboratory by performing research of the highest scientific quality. Build on our educational and technical resources to gain a competitive advantage for addressing problems of national significance and advancing the mission of the DOE.***
>
> ***Create value for the economy, enhance education, and contribute to the community through partnerships with industry, universities, and other laboratories.***
>
> ***Make LBNL the location of choice for facilities and programs. Our operational, administrative, and technical resources will integrate seamlessly with the research and engineering programs to make an LBNL that works. All of our activities will be conducted with full regard for the environment, health, and safety.***
>
> ***Commit to developing our people to their fullest potential. We value and seek diversity in our work force. We will create an environment that respects the individual, encourages leadership, stimulates innovation, fosters integrity, and demands excellence.***

To achieve these goals effectively and efficiently, LBNL's research programs are conducted in support of our national science and technology mission, and reflect our strategic planning efforts.

## SITUATION ANALYSIS

Lawrence Berkeley National Laboratory is dedicated to multiprogram energy research that addresses vital fundamental scientific, energy, economic, and educational interests. The preeminence of U.S. research and development capability and its long-term value for global competitiveness have emerged as important federal goals, along with needs for more efficiently improving health and the environment. National laboratories will be called upon to function as an efficient system that supports DOE's strategy for maintaining the foundations of science and technology, improving energy efficiency and supply, protecting the environment, and strengthening the nation's competitive advantage. We will be expected to carry out these missions in a manner that incorporates the highest standards for health, safety, and environmental protection.

- **Scientific foundations.** Basic science is the foundation for future technology development and underpins our understanding of matter and the universe. This effort includes a range of studies in the physical sciences, including research in high-energy and nuclear physics, planetary studies, astronomy, and astrophysics. Such research demands continuing development of investigative tools, including advanced accelerator/detector facilities and space technologies. Basic science studies span the scientific spectrum, including materials, chemical, geosciences, and life sciences research. Broadly based fundamental research is the ultimate source of long-term technological advancement of DOE's mission.

- **Networking, computation, and information management.** These efforts are focused primarily in the areas of advanced high-speed networking, distributed computing, and advanced computing systems. The next generation of processing and high-performance, network-mediated collaborative computing is vital to the success of science and innovation. This area demands continuous development of both hardware and software as well as telecommunication technology, and is vital to the nation's economic future.
- **Structural biology, biotechnology, and the human genome.** These efforts include research underlying the development of new medical treatments, including such modern techniques as genetic engineering; the use of monoclonal antibodies; and structural studies based on x-ray diffraction and spectroscopy, neutron scattering, and magnetic resonance imaging. These techniques demand continuing development of instrumentation and computation, and underpin the nation's biotechnology industry.
- **Materials for technological applications.** R&D efforts are needed for the development of superconducting, catalytic, polymeric, magnetic, biological, and tribiological materials as well as materials for electronic applications that will have long-term national economic benefits. Research efforts that span several program areas include those aimed at developing nanometer-scale artificially structured materials; materials for harsh chemical environments and high-radiation applications; and techniques for synthesis, processing, and characterization. This R&D demands continuous development of advanced facilities and instrumentation.
- **Energy supply and resource development technology.** Energy supply research is needed to improve the performance, economics, and environmental effects in such technologies as solar (e.g., photovoltaic cells, biomass combustion, and conversion), coal-burning, fission reaction, and fusion-based energy. Sustainable resources, including fusion energy, are key to the nation's R&D program. Resource development technology is needed to ensure the optimal, environmentally safe exploitation of resources, and the advancement of geosciences research for accurate prediction of natural disasters such as earthquakes and volcanic eruptions. Required activities include the development of better techniques for characterization, resource evaluation, and prediction of natural and induced processes.
- **Technologies to increase the efficiency of energy use.** These include fundamental research in chemical and combustion dynamics as well as development of more energy-efficient building technologies, industrial processes, and transportation systems. They encompass research on energy-efficient windows; lighting; heating, ventilating, and air-conditioning (HVAC) systems for buildings; and the development of vehicles using fuels derived from natural gas and biomass; as well as other advanced air and surface transportation systems. This research also includes development of improved methods for analyzing policies to increase energy efficiency, assessing alternative strategies for R&D investment and energy supply, analyzing policy responses to mitigate global climate change, evaluating environmental cleanup policy, and understanding the consequences of transferring better energy and environmental technology to the former Soviet Union and the developing world.
- **Understanding and controlling environmental risks**. Needs include geological and biological research on environmental response to pollution. Environmental contamination mitigation requires research on improved characterization methods, development of predictive models and risk-assessment methodologies, and development of techniques to isolate and clean up sites contaminated by toxic chemical wastes and radioactive materials (including bioremediation techniques)
- **Advanced manufacturing and industrial processes.** These efforts are broadly aimed at developing and applying new scientific insights to technology-driven techniques and to the improvement of industrial processes. Examples include the development of advanced robotics, the application of surface science research, studies of heterogeneous catalysis for crucial processes in the oil and chemical industries, and a collaboration of the textile industry with the national laboratories to explore advanced manufacturing techniques.

# LABORATORY CONSTRAINTS

Scientific and technological advances are critical if we are to achieve the nation's scientific, energy, economic, and environmental objectives. Despite the key role laboratories play in long-term economic security, national laboratory initiatives are constrained by limited budget resources. The costs of state-of-the-art facilities and added operational requirements limit the opportunities for setting new research objectives. Under these conditions, it is essential that initiatives be well coordinated and managed and involve effective scientific review. Setting priorities and improving cost effectiveness will be essential to initiating new programs that are vital to the national interest.

The national laboratory system must address performance improvements in many sectors of its research and support operations to meet stakeholder expectations and best management practices. These activities call for improvement in the quality of services and delivery of information at all levels, including environmental, health, and safety programs, and administrative systems. A laboratory must have sufficient research funding to support these performance expectations. Adequate program support will permit essential support services while maintaining LBNL's high level of research capability and performance. Efforts such as process improvement teams are underway to remove the barriers to research cooperation and assure efficient management and cost controls.

# OBJECTIVES AND STRATEGIES

LBNL has a distinguished history of scientific discovery, grounded in a spirit of multidisciplinary teamwork. Many available measures, such as citation analyses, peer reviews, and DOE evaluations, corroborate the Laboratory's preeminent scientific status. An essential part of the new landscape in which these changes must occur is the DOE's emerging strategic outlook—an outlook that recognizes science and technology as one of the Department's "core businesses." Among the goals of this business are the construction of productive user facilities, the application of new technologies to add value to the U.S. economy, and the enhancement of science training and scientific literacy in the U.S. Also included are central research goals, especially important as we consider our own role in contributing to the national interest.

An important DOE research goal focuses on providing "the science and technology core competencies that enable DOE's other business units [energy resources, national security, environmental quality, and industrial competitiveness] to succeed in their missions." In carrying out this enabling research, both basic and applied, LBNL has developed internationally recognized programs and facilities. In considering the full range of research that supports the DOE missions, LBNL is poised to make significantly increased contributions to the nation. We possess an outstanding set of core competencies, and we are dedicated to conducting research in these areas safely and with full regard for the public's expectations for environmental protection. We are committed to adding value to society by weaving our distinctive capabilities into a coherent program for the national laboratory system that carries us from the most basic studies to innovative developments of strategic value. It is in this context that LBNL's agenda for the future takes shape.

## Maintaining Scientific Excellence

The first part of Vision 2000, to "distinguish ourselves as a premier DOE multiprogram national laboratory by performing research of the highest scientific quality," is a primary objective that underpins our corollary goals. The scientific agenda for the next decade reflects both the research needs of the nation and the Laboratory's ability to contribute to those needs. Among LBNL's contribution to this agenda are endeavors that focus on the fundamental understanding of matter and its interactions, as well as the energy, health, and environmental missions.

- The Advanced Light Source (ALS) is a centerpiece for DOE research programs. As a tool for the characterization of advanced materials, the development of x-ray lithographic techniques, the study of chemical dynamics, and the pursuit of structural biology research, the ALS has a central role to play in some of the Laboratory's most important research thrusts, at the same time providing great opportunities for researchers across the country.
- Advanced distributed computing and networking capability are essential for achieving DOE's research and development objectives. LBNL has been instrumental in improving U.S. networking capability and contributes to DOE leadership in scientific computing and data management projects in a number of fields. Further advances in computing and networking performance are integral to advances in many energy research activities, such as high-energy and nuclear physics, combustion science, mathematics, engineering, materials, and the life and environmental sciences.
- The Human Genome Project, in which LBNL is a major player, and burgeoning activity in structural biology research serve as both evidence of biotechnology's current vitality and sure signs of dramatic advances in the future. Prospects include a much deeper understanding of the origins of genetic disease, insights into viral structures for custom-tailored pharmaceuticals, and microbial engineering to eliminate contaminants from the soil.
- In high-energy and nuclear physics, astronomy, and astrophysics, LBNL has been at the forefront for more than a half century. The quest to understand the universe and the properties of matter underlies fundamental science. Practical applications, such as improvements in medical imaging, also emerge from the scientific achievements themselves and from the technological developments necessary to carry out these challenging research programs. In addition, intellectual excitement plays a critical role in attracting talented students to the pursuit of science.
- Accelerator and detector technologies sustain central roles in the scientific future of the nation and the national laboratory system. The ALS, and forefront undulator magnet technology, are products of a mature research field that must continue to flourish at LBNL. Of particular immediate interest is the Heavy-Ion Fusion Accelerator Research effort, which holds the potential for induction linac technology as a practical means of producing fusion energy. Likewise, detector technology now finds applications in many fields of science, including medicine.
- LBNL must remain at the forefront in providing the nation with a range of technological options to meet both a growing need for energy and an increasing demand for minimizing the environmental impacts of its use. Areas of potential growth include many where LBNL has made pioneering advances: development of electromagnetic and seismic methods for imaging subsurface resources, development of advanced building technologies, studies of indoor air quality, and combustion research. A particularly important thrust for the Laboratory is research in heavy-ion fusion, where LBNL continues to play a pioneering role.
- LBNL is well-positioned for leadership in environmental protection and remediation. Programs include research innovations in chemistry to prevent pollution from products and the manufacturing process; characterization methods; predictive models and risk-assessment methodologies; and environmental biotechnology methods to clean up sites contaminated by toxic chemical wastes.

Major initiatives require that resources be mobilized throughout the Laboratory. Special emphasis must be given to support leadership in emerging areas of science, especially those single-investigator program areas supported by the DOE. LBNL is working with the DOE to anticipate needs and develop proposals that match the nation's most pressing technological needs. LBNL is also working to fully empower initiative champions and have the division directors involved in cross-divisional initiatives.

The Laboratory Directed Research and Development (LDRD) funds are vital for catalyzing and fostering new scientific directions and initiatives. LBNL is reviewing levels of funding for LDRD and assuring that the process supports the most promising research directions. The amounts allocated must be large enough to make a difference, and to significantly enhance the potential for establishing new directions. At the same time, significant LDRD funds also should be reserved for high-risk research whose probability of immediate success is low, but whose long-term scientific payoff may be high.

# Adding Value through Partnerships

The system of national laboratories provides the unique strength of multidisciplinary collaborations for tackling some of nature's and society's most intractable puzzles. A central objective for the next decade is to enhance relationships with university, government, and industrial research communities, the underlying aims being those enunciated in Vision 2000: "to create value for the economy, enhance education, and contribute to the community." Three strategies address strengthening LBNL's partnerships:

- **Develop partnerships with other laboratories, universities, and agencies.** In order to benefit fully from the competencies of the national laboratories, we must partner with federal and state agencies and universities to tackle problems of increasing complexity. Partnerships not only among different institutions, but also among different disciplines, are likely to be increasingly productive arrangements at national user facilities such as the ALS. These partnerships are essential to answer the nation's needs in such areas as materials research and development, computing and networking, and biotechnology.
- **Encourage productive partnerships with industry.** Impediments to collaborations with industry should be eliminated, including delays in negotiating industry–laboratory contractual agreements, administrative red tape, and lack of cofunding. Effective relationships between the Laboratory and private industry will benefit from administrative reforms that are underway.
- **Strengthen partnerships with the University of California.** One of the great strengths of the Laboratory is its close relationship with the UC Berkeley campus. Partnerships must fully join the multidisciplinary academic strengths on campus with the research facilities and technical infrastructure of the Laboratory. Because of the growing importance of interdisciplinary and facility-oriented research (such as the Structural Biology project being coupled to the ALS and Genome sequencing projects), partnerships with the campus should be strengthened and broadened to address industrial and national R&D needs and promote leadership in science, computing, and engineering.

# Optimizing the Way We Work

In an increasingly competitive national research environment, we need to demonstrate to the DOE and other sponsors that we will spend their research dollars wisely and effectively. LBNL is taking steps to control administrative demands for documentation, paperwork, and adherence to procedural regulation. A mutually respectful relationship and an effective integration of effort are challenges that must be met to deliver on our commitment to scientific and technological excellence. Five strategies address these challenges:

- **Communications.** Good communication plays a key role in working with DOE, other agencies, industry, and key audiences. It can also improve quality and productivity and motivate the Laboratory work force by demonstrating management's respect for every individual. LBNL has prepared a Communications Plan with 65 key actions directed at communications goals to advance our distinctive identity and visibility, strengthen relationships with constituencies, and build the sense of community within the Laboratory.
- **Streamlining.** As already noted, a consistent concern at all levels of the Laboratory centers on the increasing burden of regulations, often well-justified but sometimes restrictive and duplicative, and the growing demands for documentation and review. The Laboratory has established process improvement teams working in concert with DOE teams to address the need for streamlined, efficient, and cost-effective management systems.
- **Service Providers and Customers.** Scientists quite properly look increasingly to user facilities that facilitate rather than hinder their research and that minimize cost and inconvenience. Satisfied research customers should be recognized as the main deliverable of our user facilities. A strong customer orientation is required in management support areas . This strategy includes adequate technical resources and skilled support staff, resource analysis to ensure that facilities are fully utilized but not over committed, and expedited handling of scientists' needs ("one-stop shopping").

- **Online Systems for Administrative Functions.** An essential tactic in implementing each of the three strategies just discussed is a greater reliance on electronic communications and electronic information management. Despite the Laboratory-wide use of faxes, voice mail, electronic mail, and electronic information transfers, the penetration and use of these newer communication technologies are uneven throughout LBNL. An attainable objective is the replacement with on-line systems of virtually all of the Laboratory's paper transactions that make forms and procedures current and accessible, and that allow users to check the status of pending actions.
- **Total Quality Management.** Many of LBNL's strategies and initiatives previously taken in connection with corrective action plans, the Self-Assessment Program, and the new maintenance and operations (M&O) contract between the University of California and the DOE, can be seen as elements of "total quality management" at LBNL. However, to complete this quality program at the Laboratory, LBNL is promoting a culture where we measure and analyze our results and encourage greater communications to assure the development of quality and customer-focused programs.

# Respecting and Empowering Our People

This management objective is to develop our people to their fullest potential, value and seek diversity in our work force, and create an environment that respects the individual and fosters integrity. The objective is fundamental—to ensure a unity of purpose, and a respectful sense of community without which our research objectives become unattainable. Several strategies have been defined:

- **Communication that unifies our community.** A number of specific actions being implemented to address this strategy are included in LBNL's new Communications Plan, including town meetings, enhanced electronic communications, and more interdivisional meetings. It is equally necessary to encourage rapid vertical diffusion of accurate information and feedback.
- **Diverse work force.** Although Laboratory programs related to diversity in the work force have been in place since the mid 1980s, the term *work force diversity* has recently come to have a much broader meaning than mere gender and racial balance. The challenge and the goal is to *value* diversity in the workplace, and to establish diversity as a permanent part of the Laboratory's institutional culture. We are committed to equal opportunity and affirmative action, and we recognize these policies as the first and most important steps to achieving diversity in our working community.
- **Leadership training.** LBNL managers are often chosen primarily for their scientific achievements and imagination. However, their abilities to organize and manage or to inspire and lead a diverse staff are now critically important. An effective scientific leader cannot ignore the importance of a range of management skills, especially in communications, interpersonal relations, and personnel development. LBNL has instituted a program of training for all managers through operational and scientific program divisions.
- **Career growth .** More educational opportunities and job-related training and a wider awareness of opportunities are measures for addressing the professional development of LBNL employees. Innovative approaches are also being considered, including mentoring programs, job rotation, and short-term interdivisional job assignments, among others. The goal in all cases must be a realization on the part of all of our people that their development and growth as LBNL employees should be facilitated by a responsive management.
- **Broadening of the practice of mentoring.** Mentoring, cultivating a relationship in which an experienced employee gives personal and professional guidance to an employee with less experience, encourages employee empowerment, career growth, and better communication across the Laboratory. By formalizing mentoring, we not only sanction the mentoring relationship, but also ensure that the benefits of mentoring are available.

# STRATEGIC ACTIONS

LBNL is undertaking a range of scientific, operational, and administrative steps to implement the Strategic Plan and address the Laboratory's needs for the next decade. The following seven steps mobilize LBNL strengths through *investing in the future:* in our science, in our infrastructure, and in our people. These actions are only the first steps, albeit important and thematic ones, of a plan that will be further defined and elaborated in the coming months and years.

- **Allocate enhanced resources to support high-priority initiatives.** These resources will come from an increase in and some redirection of Laboratory resources. A target for the ultimate size of the LDRD funds lies between 4% and 6% of the Laboratory operating budget, which will better support critical new directions without diminishing our ability to encourage high-risk research. In addition, major Laboratory initiatives will have dedicated leadership to address major national science and technology issues.
- **Establish a strong industrial program.** Parallel with our strengthened commitment to new initiatives, the Laboratory must heed the growing expectation that scientific research deliver measurable value to society. A strong industrial program, supported in part by resources from the new technology transfer programs of the DOE, will ensure that our strengths in such fields as structural biology, materials science, and energy efficiency technologies are productively linked to the commercial sectors that can exploit them. Our goal is a level of precompetitive research that will bring in industrial funding equal to a significant fraction of our annual operating budget.
- **Reinforce our historic partnership with the University of California at Berkeley.** We will move vigorously to fortify the Laboratory's historic partnership with the UC Berkeley campus by engaging in joint planning at all levels. Already under way is a joint planning activity involving managers at the highest levels of the University and the Laboratory. Ultimately, upon realizing the goals embodied in this and the previous action, we envision a three-way cooperative link among industry, academia, and the Laboratory—a broad partnership that will put us in a much stronger position to exploit the opportunities of a changing scientific landscape.
- **Implement actions for making an LBNL that works.** Laboratory management has endorsed specific actions for administration, technical support infrastructure, and information and computing. In all cases, the goals of the recommendations are greater efficiency and more productive, mutually respectful relationships. These include developing a more seamless information and computing environment, reductions in paperwork, elimination of redundant activities, and streamlining decision making.
- **Provide training to enhance skills, career opportunities, and employee development**. Management and leadership training for our employees reflects an evolving consensus that management today is about empowerment—that team-building and communications are more essential skills than ever before. Further, we are putting increasing emphasis on formal career planning for each career employee—planning that includes training appropriate to each employee's skills and performance, and aligned with realistic career goals within the Laboratory's job classification structure. The central aim will be to reinforce strengths and correct weaknesses as a means of realizing each employee's full potential. A new program of supervisory training emphasizes the building of general supervisory skills, as well as the basics of leadership behavior. Among this program's tenets are the principles of maintaining the self-esteem of others, developing and maintaining productive relationships, and leading by example.
- **Establish a broad communications program.** The LBNL Communications Task Force has completed LBNL's 1994–1995 Communications Plan, which has been adopted by Laboratory management. The Plan supports the communications goals of DOE, and addresses three important elements:

  Distinctive identity and visibility—the Laboratory's distinctive mission, performance and contributions will be widely recognized and valued. Its unique nature will be encompassed in consistently applied written and graphic representations.

Strong relationships with constituencies—LBNL seeks strong mutual relationships with critical audiences, stakeholders, business, and community that emphasize the quality of the Laboratory's work and build confidence and trust through two-way interaction.

A unified laboratory community—the Laboratory work environment will be enhanced, and unity encouraged, through effective communications tools and techniques and through the development of stimulating activities and programs for employees.

# MANAGEMENT ISSUES

To maintain Lawrence Berkeley National Laboratory's scientific leadership and to ensure the full development of its capabilities and resources, LBNL has identified strategic management issues that it is addressing with DOE through institutional planning and other management forums. These issues, which continue to be developed as an ongoing process within LBNL's strategic planning activities, can be divided into five main categories: fulfilling our mission, implementing initiatives, modernizing our research facilities, further improving our ES&H performance, and improving efficiency in oversight and indirect costs.

## Fulfilling Our Mission

Limited DOE resources set constraints on the range and scope of LBNL's initiatives. In this environment, scientific excellence alone is no guarantee of success; the Laboratory must also demonstrate that its initiatives efficiently and effectively contribute to national needs and address problems of significance. The Laboratory is working with DOE, the scientific community, the state, and industry participants to establish priorities and to support initiatives that can best serve the nation under financial constraints. Examples from several key DOE program areas illustrate the Laboratory's priorities for initiatives.

- **Office of Computing and Technology**. To greatly enhance progress in the scientific programs of the Office of Energy Research (ER), LBNL proposes to create a world-class advanced distributed supercomputer and network environment—the Center for Energy Research Networking and Advanced Computation (CERNAC). The Center encompasses a broad range of computational and computer sciences activities to ensure that the production environment evolves to meet the changing needs of ER scientific research. Significant elements of CERNAC already exist at LBNL, and additional resources will be moved to LBNL from the existing National Energy Research Supercomputer Center. CERNAC represents an opportunity for significant cost savings for DOE, and can be fully operational at LBNL early in calendar year 1996.
- **Office of Basic Energy Sciences**. The Scientific Facilities Initiative is a key element to effective utilization of LBNL's major facilities, including the Advanced Light Source and National Center for Electron Microscopy. The Laboratory progress on beamlines development and utilization, and the capital investments for completion of the second floor of the Advanced Light Source building for user offices and laboratories need continued support. The Laboratory can serve the broader national scientific communities through the facilities initiative and by other capital investments.
- **Office of Health and Environmental Research**. LBNL's Human Genome Center and the Advanced Light Source give biologists access to advanced technology needed to address fundamental life science challenges: to understand the genetic and structural basis of energy-derived and environmentally derived health issues. LBNL is working with the Office of Health and Environmental Research to establish a scientific and management framework, including close collaborations with other DOE laboratories, that will ensure the success of these initiatives. The collaborations among DOE Genome Centers, for example, promise to significantly advance DOE's goals to sequence fully one-third of the human genome in the coming years.
- **Office of Fusion Energy**. The Elise accelerator project is poised to evaluate the potential for using intense and focused heavy-ion beams as drivers for inertial confinement fusion. The Laboratory is

constructing this test facility, as well as contributing to research in other elements of the national fusion energy program.

# Modernizing Facilities

The Laboratory will continue to give priority to modernizing and restoring facilities to sustain national programs while also achieving standards of excellence in the areas of environment, health, and safety. The Laboratory has integrated its work on the Site Development Plan with the processes of institutional planning, safety and health planning, and environmental restoration so that a safe working environment will be provided for implementation of DOE scientific programs. Critical elements of LBNL capital resource and modernization planning are implemented through:

- **Multiprogram Energy Laboratories Facilities Support (MEL-FS).** This program has been vital for replacing mechanical and electrical utilities, upgrading buildings, and improving segments of roadways at LBNL. A key element for the program in the 1990s will be the continued improvement of these systems and modernization of support buildings and infrastructure facilities. Recent reversals in the program's funding place the Laboratory infrastructure under severe stress.
- **General Plant Projects (GPP).** Small capital projects ($100,000 to $2.0 million) supported by GPP are essential for small program modifications and additions, for compliance with environmental, health, and safety standards, and for upgrades of obsolete and deteriorated equipment such as transformers, switching stations, boilers, chillers, and roofs. At $3.5 million, the current annual budget for GPP projects is inadequate to make substantial progress in meeting identified needs. Note that funds are allocated in accordance with the DOE CAMP system, which is integrated with the ES&H Management Plan.
- **General Purpose Equipment (GPE).** The Laboratory uses GPE funds to replace its essential support equipment. This equipment includes environmental, safety, and health equipment; mechanical and electrical engineering shop equipment; transportation vehicles, including shuttle vehicles; data processing and telecommunications equipment; and other equipment used by support divisions. In FY 1995, GPE funds are $1.7 million, but, compared with 1980, the purchasing power is equivalent to about $700,000, or one-half the 1980 funding. This level of need has resulted in equipment used beyond its normal lifetime, sustained high maintenance costs, and substandard equipment performance.

# Performance-Based Management

Appendix F of the contract between the University of California Regents and the Department of Energy for the operation and management of LBNL contains performance measures that are the components of the performance-based management system that the University and DOE utilize for Laboratory oversight. The DOE and the University have developed the measures as clear and reasonable objective standards against which the University's overall performance under the prime contract will be assessed. The performance measures are subject to annual review and may be modified by the agreement of the parties.

In addition, a self-assessment methodology has been established. The guidelines for science and technology assessment are summarized in a document entitled "Laboratory Science and Technology Assessment Process and Criteria." In essence, these guidelines prescribe the use of outside peer review committees, which assess the Laboratory's science and technology programs according to four criteria: quality of science, relevance to national needs and agency missions, performance in the construction and operation of major research facilities, and programmatic performance and planning. The result of each review is an overall rating of outstanding, excellent, good, marginal, or unsatisfactory. Furthermore, an extensive self-assessment program for all LBNL management, administrative, and operational activities has been established, with a particular focus on the environment, safety, and health performance of the Laboratory, as reviewed in Section V.

The long-term goal for LBNL's performance-based contracting is the integration of the measures, assessments, and reviews for an efficient and productive evaluation of LBNL's performance. The Laboratory and the University will continue to work with DOE to optimize the performance evaluation process, eliminate redundancies, and develop a system that provides positive feedback for improved performance.

# ES&H Performance

It is the policy of the Laboratory to integrate its performance in the areas of environment, safety, and health (ES&H) into the planning and conduct of all of its operations to protect the health of employees, the public, and the environment. The Laboratory has developed a comprehensive Corrective Action Plan; an Environment, Safety and Health Management Plan; and a five-year Environmental Restoration and Waste Management Plan. These plans integrate ES&H requirements into all LBNL activities in a prioritized manner, to assure that LBNL can meet DOE's Critical Success Factors for ES&H in the pursuit of world-class research. All new initiatives include specific identification of ES&H needs, and their Conceptual Design Reports and other supporting materials indicate ES&H requirements for program planning. Issues that continue to be addressed include:

- **Resources for required environment, safety, and health plans.** Management arrangements and interactions with DOE are being strengthened, and commitments must be obtained from DOE to ensure that the ES&H momentum can be maintained. LBNL has committed substantial resources to EH&S functions, but emphasis on documentation and compliance regardless of risk has diverted resources from needed improvement projects. Also, committed resources have been insufficient to fully develop and implement LBNL's ES&H plans and programs.
- **ES&H facilities for essential programs.** As indicated by the Tiger Team, many of LBNL's ES&H facilities are inadequate and in poor condition. Additional facilities are necessary to correct deficiencies identified by the 1991 Tiger Team Assessment, implement the Corrective Action Plan, and fulfill the personnel and program obligations in the Environmental Restoration and Waste Management and the Environment, Safety and Health five-year plans. Construction has begun on a new Hazardous Waste Handling Facility to upgrade, consolidate, and relocate existing waste handling operations. Construction is scheduled for completion in 1996.

# Improving Oversight and Administrative Efficiency

DOE, LBNL, and UC need to work together to eliminate redundancy in the review process, such as minimizing unnecessary paperwork in the existing procedures for compliance presently required for the National Environmental Protection Act (NEPA). Performance-based management and the Self-Assessment Program hold promise for improving the efficiency of Laboratory operations.

- **Paperwork reduction.** The existing framework for Cooperative Research and Development Agreements must be streamlined and made more timely. In addition, paperwork required for NEPA compliance should be reduced. Both of these actions would facilitate effective decision making and encourage industrial partnerships. The DOE–Laboratory process improvement team is working to address this issue.
- **Excessive reviews.** LBNL program and support activities are subject to more than 300 reviews annually. These costly reviews require considerable time and effort by both the Laboratory and DOE. By emphasizing biennial and triennial reviews instead, DOE and the Laboratory could work together to streamline the review process, increase productivity, and reduce costs. The current performance-based contract between the University of California Regents and the Department of Energy calls for the elimination of redundant oversight.

DOE, LBNL, and UC are taking steps through improved directives and are assessing mechanisms to control drivers of any unnecessary indirect costs. Opportunities for consolidating redundant and/or non-value-adding activities are important to this process.

# IV. CORE BUSINESS AREAS

## INITIATIVES

LBNL's mission to provide national scientific leadership and technological innovation is based on its ability to build and make available its unique resources. These resources allow LBNL, with the other DOE laboratories, to maintain leadership in basic research, to focus on fundamental and applied research in support of the DOE and other federal and state agencies, and to maintain global technical leadership through science and mathematics education. The following key LBNL initiatives support the Laboratory's mission:

**Basic Energy Sciences**

- Advanced Light Source Roadmap
- Molecular Design Institute
- New Chemistry for the Environment
- Electron Beam Microcharacterization Facility

**Computation and Technology Research**

- Center for Energy Research Networking and Advanced Computation

**High-Energy and Nuclear Physics**

- Large Hadron Collider
- Relativistic Heavy-Ion Collider

**Health and Environmental Research**

- Genome Sequencing
- Transgenic Research
- Structural Biology
- Environmental Biotechnology
- Boron-Neutron Capture Therapy
- Computational Biology
- Advanced Risk-Based Environmental Technologies and Remediation

**Fusion Energy**

- Heavy-Ion Fusion Drivers

**Energy Efficiency and Renewables**

- Building Performance Assurance
- Energy Technologies for Developing Countries

**Other Sponsors**

- Advanced Lithography
- X-Ray Etching of Microelectromechanical Systems

# Basic Energy Sciences

## *Advanced Light Source Roadmap Initiative*

The Advanced Light Source (ALS) produces the world's brightest light in the soft x-ray and vacuum ultraviolet range of the spectrum. This synchrotron radiation source is used for basic and industrial research and development across a broad spectrum of the physical, chemical, and life sciences, as well as such technological areas as materials analysis, microstructure fabrication, and macromolecular crystallography. To exploit fully the state-of-the-art capabilities of this newly constructed national user facility, the Laboratory has developed a roadmap that would provide for installation of the full complement of insertion devices (undulators and wigglers) in the ALS storage ring, full instrumentation of the insertion-device beamlines, and completion of the second floor of the ALS building with user offices and laboratories, thereby enhancing the ability of the ALS to expand the nation's scientific and technology base. The organization of the roadmap is structured around beamlines, primarily the insertion-device beamlines and continuing with the bend-magnet beamlines. Also included is the scientific and technological motivation for the particular beamlines. The intent is to arrive at a complete facility that can service a wide community over a broad spectral range and do it in a balanced way. No single scientific discipline can be completely serviced by only one beamline. Indeed, ease of transferability of end stations between beamlines is an important goal of this plan.

**Particle Analysis for Industry (Beamline 10.0).** Outreach efforts in the Bay Area semiconductor industry reveal a strong need for spectromicroscopy of small contaminant particles on silicon wafers. The advantage of spectromicroscopy is that it provides not merely elemental composition but also (by use of microXANES and microESCA) the chemical binding nature of such particles. Trial experiments are presently being performed for Intel on Beamline 7.0, but it is already clear that our existing beamlines are not optimum for microscopy, since they have been designed with a strong emphasis on high-energy resolution. Spectromicroscopy for particle analysis is not demanding on energy resolution, and so a monochromator designed to match the desired energy dispersion into the desired spatial resolution would yield higher signals by a factor of 30 or more. The beamline is illuminated by a U5 undulator identical to that already commissioned and demonstrating performance up to design level. The beamline is based on a spherical grating monochromator with moderate resolution. Experimental stations include an imaging photoelectron microscope for microXANES, a scanning photoemission microscope for microESCA, and a scanning transmission microscopy facility.

**Chemical Dynamics/High-Resolution Spectroscopy (Beamline 2.0).** The chemical behaviors of highly reactive, severely strained, or unstable molecular species and of molecules in excited electronic and vibrational states underlie important processes, such as the combustion of fossil fuels and the manufacture of specialized materials. Fossil fuels account for more than 90% of the nation's energy consumption. Even slight improvements in combustion efficiency or pollution reduction achieved through a systematic understanding of the fundamental chemistry in combustion and industrial processes would have tremendous economic and environmental implications. The availability of the ALS, together with advances in spectroscopic techniques, lasers, molecular-beam methods, and imaging and computational techniques, will make possible new photoionization, photodissociation, and photoelectron studies of important chemical species. The beamline is based on a U10 undulator and will have separate branches for photodissociation studies and for high-resolution spectroscopy. It will be equipped with molecular-beam experimental chambers and a collection of short-pulse infrared, visible, and ultraviolet lasers. This beamline will provide a dedicated chemical dynamics/high-resolution spectroscopy facility for a national user community and will enhance the nation's science and technology base in this area.

**Circular Polarization for Magnetic Materials (Beamline 4.0).** Materials containing d- and f-band elements are the basis for a large industry, including magnetic storage media and superconductors. Unlike the microelectronics industry, however, there is no fundamental understanding at the microscopic level of the mechanisms controlling these materials' behavior. A key impediment to the theoretical understanding of d- and f-band materials is the strong coulomb correction, involving an interplay between the charge and spin degrees of freedom. At this beamline, a battery of powerful

spectroscopic techniques, including photoemission, circular dichroism, and electron spin polarization analysis, will be targeted specifically at this interplay. Studies will fall into two general categories: (a) magnetic effects in materials with or without long-range order, and (b) low-energy excitation features. The beamline will require an undulator capable of delivering high-brightness/soft-x-ray radiation with a variable circular polarization. Several alternative technologies are under investigation, including the elliptically polarizing undulator with phase-adjustable energy and polarization. The advantage of an undulator over a wiggler is that an undulator will permit high spatial resolution in the study of magnetic microstructures.

**Clusters, Coherence, and Biomicroscopy (Beamline 6.0).** Supported metallic clusters are crucial to heterogeneous catalysis, and play important roles in the petrochemical industry and in the control of atmospheric pollution. Inhalable carbonaceous clusters constitute a demonstrable mortality and morbidity health problem. In these cases, the relevant length scale is 1 nm to 100 nm. In cell biology, the present resolution limit of optical microscopy is 250 nm. With x-ray microscopy using Fresnel zone plates, this can readily be reduced to 50 nm. The beamline will be enclosed in a noise- and dust-isolated room. It will be based on a U3.65 undulator and will have separate branchlines for imaging and scanning x-ray microscopes and for a coherent optics research area. The room will also house the existing imaging x-ray microscope on Beamline 6.1, and will also include a white-light branchline for development work. Pop-up mirrors will direct undulator light to one branchline at a time.

**Superbends.** The ALS storage ring, as originally configured, comprises a triple-bend achromat magnet lattice. Each of the 12 superperiods of the lattice contains three combined-function magnets (bend magnets) that are sources of synchrotron radiation. At the normal operating energy of 1.5 GeV, the critical photon energy of these magnets is 1.56 keV, which limits the useful photon flux from these sources to photon energies less than 8 keV. Replacement of the central bend magnet in a sector of the lattice with a high-field (nominally 4-Tesla) superconducting dipole magnet (superbend magnet) would extend the generation of high-flux, high-brightness x-rays to photon energies of up to at least 30 keV without the use of a high-field wiggler. The extended spectral range would enhance the utilization of the ALS by increasing the attractiveness of the bend-magnet sources to a broader range of users in the industrial, academic, and laboratory research communities. In addition, using superbends rather than wigglers to provide high-photon energies would preserve the ALS straight sections for the very-high-brightness undulators that best make use of this scarce resource. An Accelerator and Reactor Improvement and Modification project is now underway that would result in the replacement of bend magnets in three sectors with superconducting dipoles. Associated support, vacuum-chamber, power-supply, control, and cryogenic systems would also be constructed, installed, and commissioned under this project.

**X-ray Microscopy (Beamline 7.3).** The numerous spectromicroscopy techniques that form the backbone of the scientific programs associated with the previously described undulator beamlines do not invariably require the ultrahigh brightness of the undulator sources in all circumstances. In addition, there are numerous experiments for which preliminary measurements, development work, and rapid access on a bend-magnet beamline are advantageous before advancing to the undulator beamline. Beamline 7.3 will feature a monochromator explicitly designed for maximum performance in a spectromicroscopy environment. It will also have a circular polarization capability for magnetic contrast microscopy. This beamline is based on a spherical-grating monochromator with moderate resolution. In addition to spherical- and plane-mirror focusing and elliptical-mirror refocusing optics, there will be an aperture for circular polarization selection. The experimental station comprises an imaging photoelectron microscope for microXANES. The facility will be designed for rapid, low-cost implementation and is expected to be especially attractive to industrial collaborators.

**Infrared Microscopy and Spectroscopy.** The ALS offers a unique capability in the areas of infrared microscopy and spectroscopy, in part because of its broad, continuous spectrum, which blankets the spectral region from the visible through the infrared to millimeter wavelengths, and in part because its brightness has been calculated to be between 10 and 1000 times greater than that of black-body sources. It also benefits from a pulsed time structure. Because infrared beams can be efficiently redirected with high-reflectivity mirrors, infrared beamlines could be constructed at the ALS bend-

magnet ports that are otherwise blocked by insertion devices in the following sector, thereby enhancing the utilization of the facility. There are a number of such sites available. The majority of the research envisaged will center on adsorbates on metal and semiconductor surfaces, but other topics, such as high-temperature superconductors, "metallic" hydrogen and other materials in high-pressure cells, and time-resolved electronic responses of candidate materials for high-speed detectors, will also be given attention.

Full utilization of the ALS to exploit emerging needs of users from industry, academia, and government laboratories requires insertion devices (undulators and wigglers) and beamlines to carry the light from the insertion devices and bend magnets to the experimental end stations. It also requires completion of the 1877 gsm (20,200 gsf) of office, light laboratory, and support space for users in the unfinished second floor of the ALS building. Project costs include all safety systems necessary for full compliance with applicable regulations, orders, and ALS design specifications. In compliance with the National Environmental Policy Act (NEPA), an Environmental Assessment was prepared for the ALS and a finding of No Significant Impact was issued in 1988. In compliance with the California Environmental Quality Act (CEQA), an Initial Study Report was prepared and a Negative Declaration adopted in 1987.

Advanced Light Source Roadmap Initiative
Resource Requirements ($M)[a]

| Category | Prior Years[b] | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Operating | 0.1 | 0.0 | 0.0 | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 8.1 |
| Construction: Beamline 10.0 | 0.0 | 0.0 | 0.0 | 0.8 | 1.9 | 1.8 | 0.2 | 0.0 | 4.6 |
| Construction: Beamline 2.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.3 | 0.6 | 0.0 | 0.0 | 3.0 |
| Construction: Beamline 4.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.1 | 2.0 | 2.2 | 0.9 | 6.5 |
| Construction: Beamline 6.0 | 0.0 | 0.0 | 0.0 | 0.8 | 1.6 | 2.0 | 2.1 | 0.8 | 7.2 |
| Construction: Superbends | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 1.8 | 3.6 | 2.3 | 8.3 |
| Other Construction[c] | 0.0 | 0.0 | 0.0 | 3.1 | 6.8 | 11.8 | 7.1 | 3.2 | 32.0 |

[a]Preliminary estimate of actual-year LBNL Budget Authority (B&R code KC), per 1994 Conceptual Design Report.
[b]For production of conceptual design report and environmental assessment.
[c]Bend Magnet beamlines funding sources include GPE and ARIM, not included here.

## *Molecular Design Institute Initiative*

The Molecular Design Institute, centered at Lawrence Berkeley National Laboratory, would be dedicated to the development and application of novel approaches for designing materials and devices. The two existing paradigms for materials production—chemical synthesis and lithographic patterning of complex, interconnected structures—are converging towards similar nanometer length scales. The Molecular Design Institute would integrate these two methodologies. The focus would be on combining the ability of chemists and biochemists to build increasingly large and complex architectures at the molecular level with the ability of physicists to construct devices down to the 10-nm level. By integrating these sciences, new technologies would be developed that would have a critical impact in the defense area and on the nation as a whole, with applications in sensors, electronics, photonics, structural materials, and coatings.

Three major research areas would be addressed through this interdisciplinary effort:

- Combinatorial synthesis of materials.
- Development of nanometer-scale building blocks for constructing new materials.
- Connectivity and integration of these building blocks to form complex structures and devices.

The first area will extend the recently developed combinatorial methods of synthesis/analysis that are having a huge impact in biomedical research, to the discovery of new solid-state materials. This requires applying the lithographic and analytical methods developed for physics to the synthetic methods of chemistry. This technology could lead to the discovery of a range of materials with greatly improved properties for use in devices and complex structures. The latter two areas will focus on developing tools that will allow the fabrication of structures and devices in a largely unexplored size realm, i.e., 2 to 100 nm. Manipulation of structures on the nanometer level by physicists and chemists has revealed a remarkable size dependence of their properties. Consequently, like the combinatorial project described above, the properties of these nanostructures, and devices incorporating them, open a new realm of materials research. The Institute would bring together scientists from academia, government, and industrial laboratories. Initially, it would include participants from the Lawrence Berkeley National Laboratory, the University of California campuses at Berkeley and Los Angeles, Pennsylvania State and Rice Universities, and the California Institute of Technology, with industrial scientists from AT&T, IBM, Intel, Motorola, and Symyz.

Molecular Design Institute Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.0 | 0.7 | 3.7 | 3.0 | 3.0 | 3.0 | 13.4 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual-year Budget Authority from DOD.

## *New Chemistry for the Environment Initiative*

New Chemistry for the Environment is to be a coordinated program focused on ways in which new "environmentally friendly" chemistry and biochemistry can be developed to replace existing polluting reactions and processes in the synthesis of bulk, fine, and specialty chemicals, including fuels, agro-chemicals, pharmaceuticals, etc. It is based on UC Berkeley's strengths in chemistry, chemical engineering, and the various fields of biology. Emphasis would be on developing methods that make use of new sustainable feedstocks, produce "clean" products to replace the ones that pollute the environment, and avoid the production of pollutants as byproducts of chemical syntheses by designing highly selective processes that produce only the desired product.

The program would examine both new and existing products. Research into new products would include new-fuels studies (such as synthetic routes to new cleaner fuels like hydrogen); new chemistry and biochemistry (such as synthetic routes to new pharmaceuticals, and specialty and commodity chemicals); and new materials research (such as synthetic routes to "cleaner," biodegradable materials and polymers). Areas of research into existing products would include new techniques of production by avoiding or limiting the use or generation of hazardous and polluting substances (e.g., reagents, solvents, and catalysts). Another important topic would be examination of new feedstocks targeted to replace nonrenewable (fossil) sources and hazardous feedstocks, and to increase energy efficiency over existing feedstocks. Finally, research into "reuse" of solvents and "byproducts use" would examine reactions designed to allow reuse of reagents, solvents, and catalysts, and/or allow use of unavoidable byproducts.

The program would involve multi-investigator, multidisciplinary teams from materials sciences, chemical sciences, and structural biology at LBNL. It would directly support the strategic directives of DOE in general, and the Offices of Energy Research, Fossil and Energy Efficiency in particular, in the mission areas of economic productivity and environmental quality.

New Chemistry for the Environment Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.5 | 1.0 | 2.0 | 2.0 | 2.0 | 2.0 | 9.5 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Estimate of actual-year LBNL Budget Authority (B&R Code).

## *Electron Beam Microcharacterization Facility Initiative*

The Electron Beam Microcharacterization Facility (EBMF) Initiative will support the Department of Energy's Basic Energy Sciences Program by providing state-of-the-art electron-beam instrumentation, laboratories, and techniques for the characterization of advanced materials at high resolution. The facility will be an essential and integral part of DOE's National Center for Electron Microscopy (NCEM) and as such will be operated as a national user facility. Research at the EBMF will focus on establishing the link between microstructures and properties of solids in order to provide the scientific basis for understanding the behavior of a broad range of advanced materials, which is important for fundamental science and new technologies. Following the established mode of operation of the NCEM, access to the facility will be controlled by an external steering committee representing industry, universities, and government laboratories. As such, the facility will provide essential support to all of DOE's materials research programs in metals, alloys, and ceramics, as well as superconducting, semiconducting, and magnetic materials.

The three critical elements of a national research user facility are state-of-the-art instrumentation, a forefront research effort, and a supporting infrastructure. The EBMF is designed to provide essential support for all three elements. The research program at the facility will be centered on electron optical instrumentation and techniques for the microstructural and microchemical characterization of materials at high spatial resolution. A Z-contrast scanning tunneling electron microscope with chemically sensitive imaging capability, and subnanometer probe size for high-resolution imaging and diffraction will complement the structural imaging capabilities of the NCEM's One-Ångström Microscope, funded in FY 1994. The capability to obtain spectrum images at nanometer resolution will fill a need critical to many materials programs to identify the structure and composition of nanometer volumes of materials. These capabilities and techniques will be further developed by NCEM scientists and made fully available to researchers in other DOE and industrial research programs.

The EBMF will also provide laboratory space for a medium-voltage instrument, which will supply unique capabilities for *in situ* characterization of the dynamic behavior of materials. At 400 kV, the instrument will allow samples of representative thicknesses to be observed with minimal radiation damage. The machine will be equipped with a high-speed video camera to record mechanisms and kinetics of transformation, deformation, and reactions in solids. Special stages will be constructed for experiments exploring materials behavior under extreme conditions of temperature, stress, electrical fields, or environmental parameters. In addition to such stages as a high-temperature environmental cell with thin-film diamond windows, there will be provisions to develop specimen holders and instrument configurations for specialized, narrowly focused experiments such as an *in situ* diamond anvil cell for high-pressure studies or an *in situ* nano-indenter for studies of friction, wear, fatigue, and the early stages of deformation. A supporting laboratory will be dedicated to simple microlithography for novel sample geometries. Research at this facility will support different materials research efforts within DOE's Basic Energy Sciences Program.

Sufficient laboratory space has been included to install supporting instrumentation, prepare samples, perform thermomechanical treatments, make measurements, and precharacterize materials before examination by advanced electron optical techniques. Additional laboratory space will be important for industry, university, and government scientists who need to finalize experiments or perform sample preparation, as well as for resident scientists to perform materials research prior to electron beam microcharacterization. In addition to laboratory space and equipment, the EBMF will provide facilities for

workshops to educate industrial and university scientists and professionals in electron beam characterization, theory, computing, and sample preparation. The facility will also allow the NCEM to lead the materials characterization community in topical discussion meetings and workshops focused on forefront developments in the field. It is anticipated that an Environmental Assessment and Initial Study would be prepared for this facility in compliance with NEPA and CEQA.

Electron Beam Microcharacterization Facility Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.0 | 3.0 | 4.4 | 0.0 | 0.0 | 0.0 | 7.4[b] |
| Equipment | 0.9 | 4.7 | 2.3 | 0.6 | 0.0 | 0.0 | 8.5 |

[a]Preliminary estimate of LBNL actual-year Budget Authority (B&R code KC).
[b]Amount representing equipment obligations.

# Computation and Technology Research

## *Center for Energy Research Networking and Advanced Computation Initiative*

To greatly enhance progress in the scientific programs of the Office of Energy Research (ER), LBNL proposes to create an advanced distributed supercomputer and network environment—the Center for Energy Research Networking and Advanced Computation (CERNAC). The Center encompasses a broad range of computational and computer science activities to ensure that the production environment evolves to meet the changing needs of ER scientific research. Significant elements of CERNAC already exist at LBNL, and additional resources will be moved to LBNL from the existing National Energy Research Supercomputer Center. CERNAC represents an opportunity for significant cost savings for DOE, and can be fully operational at LBNL early in calendar year 1996.

CERNAC is committed to the dual goals of smooth, reliable service for those who require great computing capacity and the most cost-effective high-performance technology for those who require advanced computational capability. These goals will be achieved through the evolutionary development of a network-based distributed supercomputer environment. CERNAC computational and computer scientists will collaborate with colleagues at the University of California at Berkeley and the Mathematical Sciences Research Institute (MSRI), as well as with industrial partners, to influence both the development of the necessary computing architecture and its integration into a production environment. The proximity of these three institutions—CERNAC, UC Berkeley, and MSRI—plus the strong presence of the computing and communications industries in the San Francisco Bay Area, will provide a wealth of synergistic interaction in the areas of computer science, mathematics and algorithm development that is unobtainable anywhere else. In addition, the Energy Sciences Network (ESnet) will continue to lead the global Internet in providing the infrastructure for the computing, information, and communications needs of ER scientists and the broader DOE research community. The Multicast Backbone (MBone), the World Wide Web, and other services over ESnet will become the primary means through which information is disseminated and business, including seminars, is conducted.

The creation of CERNAC will inaugurate a major change in the way LBNL and the ER community approach science. Science has traditionally advanced through the interplay between theory and (physical) experiment. The implementation of CERNAC will bring a third type of science, *computational experiment,* into equal prominence as a driving element of scientific progress. In recent decades, scientists have come to realize that advanced computational techniques have application beyond conventional support of physical experiments, and can be used directly to advance our understanding of both real and hypothetical phenomena. Such applications involve simulation, sophisticated numerical algorithms, and innovative

imaging and visualization techniques, and they apply to the entire range of ER scientific disciplines. A few specific examples where LBNL plays a vital role are combustion research in the chemical sciences, protein folding in structural biology, and subsurface microbial transport in the earth sciences.

With its historical relationship to the UC Berkeley campus, LBNL offers a unique environment for the location of a high-performance computer center responsive to the needs of the Office of Energy Research. Laboratory scientists and associated campus faculty in mathematics, physics, chemistry, and biology, working on computational problems with mathematical modeling and algorithmic perspectives, assure constant attention to new and untried approaches. Such work can be crucial in pointing toward significant advances in scheme accuracy and efficiency. Areas of particular expertise at LBNL include networking, video conferencing, distributed collaborative computing, and computer graphics. At the same time, the CERNAC environment will build on computer science advances such as the NOW (Networking of Workstations) project being pioneered at UC Berkeley, and on network and large-scale distributed systems work being done at LBNL, together with the advanced numerical mathematics programs being performed at both institutions. This co-location environment will provide unparalleled opportunities because:

- Advanced system developers have to be "close" to the system they're working on for the hard job of monitoring, analysis, and system integration. The architecture being developed in NOW can be used to provide a supercomputing environment much larger and more scalable than the current, closely integrated systems.
- Synergies between science and numerical mathematics are more likely to occur when practitioners of both fields work together in a close-knit environment.
- The education and evolution of the user community can occur naturally in the easily accessible, education-oriented environment of Berkeley.
- The combination of a major, high-performance computing facility with an associated computation science staff and the intellectual environment of LBNL, UC Berkeley, and MSRI will attract researchers and developers in a way unequaled by other locales.
- Close ties to Silicon Valley provide a powerful cycle:
  - Supercomputer users will work with computer and computational scientists to build usable advanced systems.
  - The computer science community will form partnerships with industry to convey the lessons to industry.
  - Industry will incorporate more features needed by computational scientists into commercially supported products.

Interweaving all these efforts are graduate students and postdoctoral fellows who easily cross disciplinary boundaries and exchange tools, algorithms, software and—most importantly—ideas.

CERNAC at LBNL will provide an exciting environment for research, an indispensable tool for computational scientists, and a powerful resource for computing within the Energy Research and the broader DOE scientific community. It will allow users to do more science within their constrained budgets than would be otherwise possible.

Center for Energy Research Networking and Advanced Computation Initiative
Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 40.0 | 39.7 | 40.9 | 42.1 | 43.4 | 44.7 | 250.8 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of total Budget Authority (B&R code KC07). Portions of work to be contracted to other laboratories to be negotiated.

# High-Energy and Nuclear Physics

## *Large Hadron Collider Initiative*

CERN's Large Hadron Collider (LHC) is destined to dominate high-energy physics for many years after its completion between 2002 and 2005. LBNL is working to secure major roles in both accelerator work and for the ATLAS detector. The accelerator work is being coordinated with efforts at Brookhaven National Laboratory (BNL) and Fermilab National Accelerator Laboratory (FNAL). LBNL's expertise in superconducting magnets, and superconducting cable in particular, is sure to be important to the project. In addition, LBNL will undertake design and fabrication of beam-tube vacuum components and make contributions to specific accelerator physics areas for which it has expertise.

An LBNL team, drawn in large part from the SDC effort, will play an important role in charged-particle tracking for the ATLAS detector. This will include involvement in the development of both silicon strip detectors and pixel devices. The latter will be developed using the Physics Division's Microsystems Laboratory. For the pixel work, LBNL expects to design and fabricate pixel-detector elements, on-detector readout electronics, and off-detector control and readout electronics. We will contribute to the software and to the mechanical design. We may actually construct a portion of the full pixel structure at LBNL.

In collaboration with UC Santa Cruz, LBNL will design, fabricate, and test a significant portion of the silicon tracker for ATLAS, including the rad-hard front-end electronics. In collaboration with both UC Santa Cruz and UC Irvine, LBNL will work on the data-acquisition and control electronics for the silicon strip readout. In collaboration with UC Irvine, LBNL will have a role in the ATLAS data-acquisition system and in the level-2 trigger.

The major LBNL accelerator contributions will be in three areas: beam-tube vacuum, interaction-region quadrupole magnets, and accelerator physics. The vacuum contributions include (1) design and fabrication of the warm (room temperature) vacuum system for the eight straight sections of the LHC, comprising altogether approximately 3.2 km of beam tube; (2) design and fabrication of the neutral beam dumps downstream of the interaction regions for the two large detectors—ATLAS and CMS ; and (3) fabrication of the beryllium beam tubes at the center of the interaction regions for ATLAS and CMS.

Development of interaction-region (IR) quadrupoles is a joint task with FNAL. LBNL will work with FNAL on the development of a conventional IR quadrupole design, which FNAL will scale up and fabricate as full-scale prototypes. LBNL will then develop an advanced IR magnet design, based on an improved superconductor also being developed at LBNL. One-meter-long prototypes of these magnets will then be fabricated at LBNL. This advanced IR quadrupole may replace the conventional quadrupole. LBNL will also provide cabling technology and strand-coating technology to the LHC project.

The primary LBNL accelerator physics efforts for LHC will be in tracking and beam-dynamic calculations and in calculation and measurement of the impedances of accelerator components seen by the proton beams. Depending on the timing of the U.S. agreement to participate in the LHC, LBNL may also contribute to beam instrumentation and to beam loading compensation of superconducting RF cavities.

LBNL will perform analysis, design, and fabrication work on the beam feedback system needed to stabilize the central beam motions in the LHC. The technologies needed are similar to those being developed at LBNL for the B Factory system, but are more challenging due to the need to preserve beam density in the absence of radiation damping. A NEPA and CEQA review will be performed by LBNL for activities proposed to take place at LBNL under this initiative.

Large Hadron Collider Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 1.9 | 5.0 | 6.6 | 8.6 | 9.3 | 5.5 | 36.9 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 3.9 | 7.8 |

[a]Preliminary estimate of LBNL actual-year Budget Authority (B&R code KA).

## *Relativistic Heavy-Ion Collider Initiative*

LBNL played a seminal role in defining relativistic heavy-ion physics and continues to maintain its leadership role. The Relativistic Heavy-Ion Collider (RHIC) is now under construction at BNL, and LBNL is the lead laboratory for the first approved RHIC experiment, the Solenoidal Tracker at RHIC (STAR) detector. LBNL's Relativistic Nuclear Collisions Group is providing a focus for these RHIC activities. With 47 physicists, engineers, and technicians (including the spokesperson and project director) from LBNL working on this experiment, the STAR collaboration now consists of over 350 physicists and engineers from 34 institutions internationally.

The goal of the experiment is to study particle production at midrapidity on an event-by-event basis to identify the phase transition from normal nuclear matter to quark matter. An event-by-event measurement of the produced particles at midrapidity provides the opportunity to select on events with extreme values of temperature (particle spectrum), flavor (strangeness content), shape (particle momenta), and size (two-particle correlations). Furthermore, the study of high-$p_t$ particle production as a function of energy and mass of the colliding system may also be an attractive experimental approach to identify the presence of quark matter.

The experiment will consist of a TPC and a silicon vertex tracker located inside a solenoidal magnet to provide tracking, momentum analysis, and identification of charged particles; a time-of-flight array to extend the particle identification to higher momentum; TPCs to provide tracking at large pseudo-rapidities; an electromagnetic calorimeter; and a multilevel flexible trigger. Projects at LBNL now receiving support from RHIC detector R&D funds administered by BNL include TPC improvements for measurements at the high track densities anticipated at RHIC, integrated electronics for advanced detectors, and development of a high-bandwidth data-acquisition system. Research is also proposed in the area of heavy-ion beam cooling for improved luminosities at the collider. These projects and the proposed STAR program are being developed in compliance with DOE orders and all other applicable ES&H requirements. LBNL expects this R&D effort and the detector engineering to continue over the next few years.

Relativistic Heavy-Ion Collider Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 4.0 | 4.5 | 5.0 | 5.0 | 5.0 | 5.0 | 28.5 |
| Construction | 3.4 | 2.1 | 1.0 | 1.0 | 1.0 | 1.0 | 9.5 |

[a]Preliminary estimate of LBNL Budget Authority (FY 1995 dollars), including equipment (B&R code KB).

# Health and Environmental Research

## *Genome Sequencing Initiative*

A Genome Sequencing Initiative is intended to leverage the technology and expertise that thrive in the Lawrence Berkeley National Laboratory's Human Genome Center (HGC) towards megabase sequencing

challenges. The HGC is oriented almost exclusively towards developing and implementing directed methodologies for cost-effective and accurate high-throughput human DNA sequencing. This work has five components. The first three components of the Center are all involved with new technology development for sequencing and are based on a collaboration between biologists, the automation group, and computer scientists. The fourth component is the sequencing production effort itself. The fifth component of the HGC is the biology effort that interfaces with and performs experiments derived from the completed sequence data.

The first component of the HGC, the biology component of the new technology group, has developed a directed strategy of DNA sequencing in which high-resolution physical maps are generated so that a small set of standard primer binding sites are positioned every 300 base pairs. This mapped set of templates is then sequenced. Using this strategy, templates can be selected in a minimally redundant fashion, which means that template preparation requirements are reduced tenfold and sequencing reactions can be reduced fivefold. In addition, sequence assembly is straightforward because all the templates are mapped in relation to each other, with a resolution of about 30 base pairs, prior to sequencing. The biology group is continuing to optimize the biological procedures of the directed process.

The second component of the Center is the automation group, which is developing instrumentation to support the directed sequencing approach. Some of the modules have been completed and are currently in use: an image station that captures and analyzes the mapping information from agarose gels, a colony picker, a robotic library replicator, and a modified Biomek that sets up polymerase chain reaction assays and sequencing reactions. A water-based thermocycler and a 12-channel oligonucleotide synthesizer are being rigorously tested by the biologists prior to entering production. Novel methods to analyze polymerase chain reaction fragments as well as preliminary plans to integrate some of the initial modules are in the early planning stages.

The third component of the HGC is the informatics group. The major goal of the group is to develop software that facilitates the sequencing effort. The developmental effort is aimed at all aspects of the process, beginning with the physical mapping efforts, continuing through the generation of the high-resolution map and template selection, followed by sequencing and assembly of templates, and concluding with the analysis and dissemination of the sequencing information. The programs that keep track of and display the physical mapping data are nearing completion. The emphasis of the work is shifting now to sequence assembly, editing, and analysis. Another aspect of the work is focused on developing mechanisms to make the data publicly accessible as it is being generated.

The fourth component of the Center is the production effort. A team of about six FTEs can currently generate 600–700 thousand base pairs per year. The goal of the production effort is to maintain this rate as well as to add additional teams in the next few years and increase the productivity of each team.

The final component of the HGC is the biology program, which has been reconstituted to be closely integrated with the overall sequencing effort. The biology effort will play a role in selecting templates beforehand and then developing biological programs to interpret such a large amount of data in a meaningful way. This program is addressed in the Environmental Assessment and Environmental Impact reports for the Human Genome Laboratory.

Genome Sequencing Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | | | | | | | |
| DOE | 8.0 | 8.5 | 8.9 | 9.4 | 9.8 | 12.0 | 56.6 |
| NIH | 8.2 | 10.6 | 14.4 | 16.1 | 13.4 | 14.0 | 76.7 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual-year Budget Authority from DOE (B&R code KP) and NIH.

## *Transgenic Research Initiative*

A significant opportunity exists for LBNL to expand its transgenic capabilities and utilize the resources associated with the HGC. To fully realize the value of the mapping and sequencing information generated by the HGC, new genes must be identified and their biological function characterized. The genetically engineered mice will clearly play a fundamental role in the discovery of important human genes and the understanding of their function in biology and disease. The Transgenic Initiative is intended to advance LBNL's expertise in generating transgenic animals and enable LBNL's Transgenic Facility to better serve the greater scientific community.

The facility produces transgenic animals for LBNL investigators, enabling major studies of gene function in development and disease. The facility currently constructs animal models for such disease conditions as atherosclerosis, sickle cell disease, thalessemias, Down's syndrome (utilizing DNA provided by the HGC), and cancer. Other LBNL transgenic projects include the study of such basic biological questions as the control of steroid receptors, RNA editing, and novel interlukin sequences. In parallel with the generation of transgenics, the facility has developed the capability for inactivating genes in mice through targeted mutagenesis of embryonic stem cells. This system has proven effective for the production of germ line chimeras with high frequency. In addition to supplying LBNL investigators with these model transgenic animals, the facility has also, on occasion, made these services available to outside investigators, thus enhancing opportunities for technology transfer with both the industrial and academic communities.

To optimize the relationship between the facility and the HGC, new technologies need to be pursued. These include: (1) improved construction of *in vivo* libraries of regions of the human genome in transgenic mice; and (2) methods for creating large targeted deletions in mice of regions syntenic to areas of the human genome being deciphered by the LBNL HGC. The development of the Yeast Artificial Chromosome (YAC) system in sequencing and transgenics has provided a technically feasible approach for creating *in vivo* libraries of large defined segments of the genome. *In vivo* libraries provide the ability to study novel phenotypes in the animal as well as enable the complementation of existing mouse mutations. The latter approach allows for the recovery of previously undetermined human homologues for existing mouse mutations.

This initiative will position the LBNL Transgenic Facility to serve as one of the premier transgenic facilities. The facility is ideally set up to provide cost-effective transgenics for investigators who do not possess the capabilities or resources to generate their own transgenic animal models. LBNL's transgenic expertise extends beyond mere production of transgenic animals. The facility possesses a strong instructional component. It provides inexperienced investigators with advice on construct design and preparation as well as instructions for screening and maintenance of the transgenic lines. The facility thereby provides a rational course for planning well-designed experiments, minimizing the number of DNA constructs and transgenic animals entailed, and ensuring successful results.

Transgenic Research Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.73 | 0.40 | 0.45 | 0.50 | 0.50 | 0.60 | 3.18 |
| Construction | 0.38 | 0.00 | 2.00 | 2.00 | 0.00 | 0.00 | 4.38 |

[a]Preliminary estimate of actual-year Budget Authority (B&R code KP).

## *Structural Biology Initiative*

Resources at LBNL and on the UC Berkeley campus jointly constitute an unparalleled center of excellence in structural biology. Even apart from the facilities being developed at the ALS, these two institutions offer expertise in electron crystallography, high-voltage electron microscopy, nuclear magnetic

resonance (NMR) spectroscopy, time-resolved Fourier-transform infrared spectroscopy, and scanning tunneling microscopy.

Accordingly, an active effort is under way, coordinated by senior managers at LBNL and UC Berkeley, to accelerate the exploitation of relevant skills and resources at the two institutions. A series of workshops has been proposed to look at the most fruitful areas of effort and to take active steps toward increasing cooperation in these areas between campus and laboratory, thus further enhancing the vitality and visibility of structural biology research in Berkeley.

Activities at the ALS are an essential part of the future of structural biology research, and have been strongly supported by the Office of Health and Environmental Research. New applications of advanced imaging, diffraction, and spectroscopy techniques will greatly strengthen both our local efforts and DOE's national program in structural biology. The ALS will offer major new resource opportunities for life sciences research in several emerging areas of scientific emphasis:

- **X-ray crystallography:** To conduct static and dynamic analyses of macromolecular architecture with precise wavelength tuning. The facility addresses the high demand for beam time with a multiuser configuration and user-friendly design and operation.
- **X-ray spectroscopy:** To determine biochemical properties at high spatial and temporal resolution within cells and organelles. Many experiments will exploit the capacity to control the polarization of synchrotron radiation.
- **X-ray microscopy:** To investigate tissues, cells, and organelles in near-native states at a resolution that may approach macromolecular dimensions. Among the benefits of x-ray microscopy at the ALS will be element-specific imaging and the ultimate possibility of three-dimensional imaging.

The structural biology programs at the ALS will rely initially on experimental stations at the ends of three beamlines. The first, from a wiggler source of both soft and hard x-rays, will branch into several experimental areas for both x-ray crystallography and spectroscopy. The second beamline will come from a polarized wiggler for applications in structural biology and the materials sciences. The third beamline for biomicroscopy is presently attached to a bend magnet beamline, but the intent is to establish this capability on an undulator beamline. The majority of the operating (and equipment) funds identified below are for fabrication, development, and operation of these beamlines. The supporting laboratories will be constructed on the second floor of Building 6 and in the adjacent Building 80, as part of the ALS Structural Biology Support Facilities. A categorical exclusion under NEPA and a categorical exemption under CEQA were prepared for associated modifications to Building 80.

Structural Biology Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 8.2 | 5.5 | 4.1 | 4.1 | 4.1 | 4.1 | 30.1 |
| Construction | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.6[b] |

[a]Preliminary estimate of actual-year LBNL Budget Authority (B&R code KP).
[b]Includes prior-year funding.

## *Environmental Biotechnology Initiative*

Ongoing environmental research at Lawrence Berkeley National Laboratory is focused on pollution prevention, bioremediation, waste site characterization and monitoring, hazardous waste treatment, human exposure and comparative risk assessment, and ecological risk assessment and restoration. The research is multidisciplinary and involves diverse departments within several divisions. Through the Environmental Biotechnology Initiative, programs would be established under key focus areas that bring together not only the capabilities at LBNL, but also link those established within academic institutions, industry, and

government research institutions. The goal is to build bridges that link different capabilities within the DOE laboratories and associate universities and to focus on key environmental clean-up problems by enhancing synergy rather than competition among the various institutions.

Both basic and applied research programs in the following areas are being established: agriculture and forest related wastes, mining and processing of ores, actinides, petroleum exploration and refining, computer/metal electroplating wastes, groundwater, sewage, marine wetland, marshes and sediment pollution, base closure remediation, and water-poor regions with large populations. Six thrust groups are briefly described below.

**Ecotoxicity.** This program focuses on determining the effect of pollution on small animals such as nematodes, worms, shellfish, and amphibians. Studies include the monitoring of reproductive cycles and DNA damage as a result of being exposed to different levels and types of pollution in the Bay Area. This program is linked to the Health Risk Assessment program by working with cell biologists on developing more sensitive assays and a better understanding of the regulation system involved in having DNA damage and a negative cascade effect on normal metabolic functions.

**Health Risk Assessment.** Research is concentrating on the development of assays using primary human cells and measurement of enzyme levels to determine how pollutants are actively metabolized. The EPA has a list of potential carcinogenic pollutants. However, most of the work done in this area has been done on rats and mice. We are assessing the health risk to humans by determining which pollutants, if ingested, inhaled, or absorbed, can be deleterious to our body cells by causing abnormalities in cell structure and function.

**Molecular Evolution and Ecology.** California has many contaminated sites due to activity from the armed forces and industries such as oil refining, metal electroplating, mining, and agriculture. Nature has the ability to deal with some of the contamination by genetically altering certain microbial and plant species to either completely mineralize the contaminant or detoxify the pollutant. Our research will focus on how the microorganisms and plants evolve through genetic mutations, either spontaneously or by induction, to "deal with" or "handle" the pollutant in a toxic environment. By better understanding the regulation and expression systems of specific organisms, we can metabolically or genetically engineer "super organisms," such as microorganisms with more active enzymes or plants with better absorption capacities that can be used in bioremediation efforts.

**Structure–Function Relationships.** Some of the barriers to using microorganisms more effectively in the field for remediation have been due to the lack of understanding of a cell's physiology in a natural environment. Microorganisms grown under laboratory conditions such as on agar (solid) media or in submerged culture (fermentors) exhibit a different structure and function than what is found in nature in soil, in water, and on plant surfaces. The research focus will be on linking engineering with microbiology to design bioreactors that would function more closely to what goes on within the subsurface or water column. This technology would improve soil treatment methods for field applications. In addition, physiological studies would yield information on the limits for optimization in field treatments. For example, microorganisms are notorious for developing biofilms that stick and clog soil pores. Finding a way to inhibit that formation yet enable the microorganism to bind to soil particles would improve the bioremediation treatment for certain soil matrixes.

**Natural Augmentation.** Since, in many instances, microbial populations have been exposed to pollutants over time within a given site, natural selection occurs and enables these microorganisms to use the pollutant as a food substrate. Augmenting this population would have an advantage in that more biomass should theoretically have to have more food in order to survive. However, in some cases, this approach backfires, and the population dies out or no longer desires to eat the pollutant. Studies will center on optimizing natural augmentation by incorporating biophysical parameters such as moisture, pH, salinity, and redox potential that would improve and stabilize microbial metabolic processes occurring in soil or water systems and evaluate competition factors, such as waste products, soil binding properties, and gas–water interface effect on nutrient transport, that may affect establishment of the desired population.

***In situ* Microbial Monitoring.** Bioremediation has been described as a black box by engineers since we do not have the technology to verify "balancing the equation." Therefore, improved systems to monitor microbial activity in the soil are needed. Research has begun on use of cold radioisotopes to monitor carbon metabolism, and applications of this technology are being studied for metal uptake and detoxification. We will need to focus on developing improved systems of biomarkers and biosensors for use in the field. One possibility is to integrate biopolymers with engineering knowledge to create semiorganic sensors.

In addition to the main research thrust groups, this LBNL program has direct links with the BEST (Bioremediation, Education, Science and Technology) program to enable students to obtain hands-on experience in the laboratory and field operations and with CAL-EPA to validate and certify new environmental biotechnology for field applications. This program focuses on integrating all of the existing capabilities within LBNL and establishing key synergistic links with outside laboratories. By using this approach, much time and money will be saved in solving several key environmental pollution problems within the DOE and DOD, as well as in the state of California.

Environmental Biotechnology Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 55.0 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL Budget Authority (B&R code KP, and Work for Others).

## *Boron-Neutron Capture Therapy Initiative*

A brain cancer called glioblastoma multiformae afflicts some 5000 people a year in the U.S. alone and is almost impossible to treat by currently available means. One highly promising treatment approach is Boron-Neutron Capture Therapy (BNCT), in which the patient is given a medicine that contains boron. The boron selectively accumulates in the malignancy. The cancerous area is then exposed to a beam of neutrons. After capturing neutrons, the boron nuclei break apart, emitting very short-range radiation to destroy the cancer cells. Although glioma is the top-priority target because its location and complicated geometry make it so resistant to complete removal through surgery, other cancers might prove treatable with BNCT if suitable boron compounds can be developed.

Now the time is right to re-examine BNCT in a tightly focused program of applied research and development that culminates in clinical trials. Two key advances have made it attractive: new, more-effective $^{10}B$-enriched tumor-seeking compounds are available, and improved neutron sources can be made using accelerator technology rather than nuclear reactors. LBNL is in a unique position to host the development of this "next-generation" BNCT because of its accelerator expertise, bounty of surplus equipment from the decommissioned Bevalac accelerator, and long tradition of collaboration with medical centers that have world-class cancer research programs.

To take advantage of these strengths, LBNL has formed a clinical working group, the West Coast Neutron Capture Therapy Association, that brings together personnel in all the relevant specialties from national laboratories and major university medical centers. We are seeking DOE support of a multifaceted BNCT program, encompassing technology development, basic science, clinical trials, and technology transfer. The goal is an aggressive, parallel-track R&D program that will build an LBNL treatment facility, develop $^{10}B$-enriched compounds and supporting clinical techniques such as dosimetry and delivery verification, and conduct clinical trials on human patients by 1997.

Boron-Neutron Capture Therapy Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.4 | 1.9 | 2.9 | 3.3 | 3.3 | 3.3 | 15.2 |
| Construction | 0.3 | 2.8 | 1.7 | 0.0 | 0.0 | 0.0 | 4.9 |

[a]Preliminary estimate of LBNL Budget Authority (B&R code KP).

## *Computational Biology Initiative*

The Computational Biology Initiative seeks to link the revolutionary gains made in computer science and information management with the recent strides made in biology research for the understanding of complex data types and the inherent diversity of living things. National laboratories effectively link expertise in data management with the biologists who are the data users and generators. One goal of the initiative is to produce a prototype of a federated database that would permit a user to access a variety of databases in diverse formats across the Internet with a common interface and data model. The prototype federated database will then become a tool for more direct computational biology research in the Life Science and Structural Biology Divisions. A second area of interest is the effect of energy sources and environmental mutagens and carcinogens on nucleic acid structure. Our long-term goal is the establishment of a Center for Computational Biology at LBNL.

DOE has supported a number of biology databases in genomic and structural biology, and the biology community has come to assume ready access and ease of data query and retrieval. As the use of databases has grown, it has become clear that even a common database management system does not ensure the ready ability to query individual databases across the network. LBNL has played a critical role in the early development of database management tools, and will be involved in making additional tools for design, translation, data entry, browsing, and retrieval. The Computational Biology program at LBNL would draw on three major areas of biology represented within the Laboratory, as well as on the expertise of the Information and Computing Sciences Division. The biology areas within the Life Sciences Division and the Structural Biology Division include: the Human Genome Center, the Department of Radiation Biology and DNA Repair, and the Department of Cancer Biology. This effort would represent an interdivisional activity at LBNL, as well as an interoffice partnership within DOE.

The diversity of information systems in biology reflects the specific needs and applications of the biologists. However, the information necessary for the integration of new data so that the data's true impact can be ascertained often resides in databases that have no apparent connection and share no common structures or links. For example, information about gene sequences, map location, gene regulation, the relationship with other genes, and the structure of the proteins that are encoded resides in half a dozen databases. A prototype federated database linking each of these more specialized databases could be used in a number of projects, including analysis of NMR data, modeling of protein folding at both the secondary and tertiary level, and ascertainment of conserved structure–function relationships through comparison across evolutionary time.

Yet even before a prototype is available, important questions in the field of computational biology will need to be analyzed. Genome informatics has developed a number of ways to assemble sequences or maps of chromosomes. Most comparisons are done two at a time. Even under these circumstances, only short pieces of sequence can be used because of the amount of time required for the accurate comparison. However, in order to identify sequences important in the control of gene expression, it will be necessary to compare many sequences against many others, all at the same time and in a precise way.

As DNA sequences become available, the determination of the putative sequence of the gene product, a protein, becomes a simple application of the translation of the genetic code from DNA to protein structure. However, neither the three-dimensional secondary structure nor the tertiary structure can readily be calculated. As with attempts to model the interactions of mutagens with DNA, the flexibility of the units, and the number of monomers means that it is not feasible to search for all of the possible solutions. In

reality, many of the techniques, such as energy minimization, give no assurance that the biologically interesting structures are observed. New algorithms for training of expert systems, as well as for consideration of the actual solvent conditions and modeling of the hydrophobic effect will also be undertaken.

Computational Biology Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.25 | 0.50 | 0.80 | 1.50 | 2.00 | 2.00 | 7.05 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL Budget Authority (B&R code KP).

## *Advanced Risk-Based Environmental Technologies and Remediation Initiative*

The initiative provides integrated, interdisciplinary methods, technologies, and approaches to support the development of risk-based environmental policy on problems of national importance, such as remediation of subsurface contamination, urban air pollution, and stratospheric ozone depletion. This is a partnership between LBNL and DOD/McClellan Air Force Base. A memorandum of understanding is in place whereby McClellan and LBNL will "collaborate with regard to environmental research, technology development, and field demonstration of promising environmental technology."

The initial focus of the collaboration is the development of a methodology and user-friendly software, called SELECT, for evaluating and comparing environmental remediation technologies with respect to their risk reduction and cost effectiveness. The software builds upon and integrates existing codes for various sub components of the methodology, such as transport and transformation of multimedia contaminants, background and site-related exposures, and relative ranking by carcinogenic hazard for chemicals of concern. Key components of the research program are:

- Subsurface site characterization data from contaminated sites at McClellan are being used to test and advance subsurface fate and transport models.
- Exposures to volatile organic compounds (VOCs) and heavy metals will be modeled for people living near the base, base personnel, and site-cleanup workers. Multiple exposure pathways also will be modeled.
- Cancer risk estimates will be developed based on linear extrapolation from rodent cancer tests. We propose to reduce uncertainty by addressing gaps in the current process.
- To improve remediation effectiveness, technologies and strategies will be identified according to their potential for risk reduction and cost effectiveness.
- To ensure that there is a net reduction in health risk, the secondary effects of any chosen remediation will be evaluated. Exposure reductions anticipated as a result of various remediation technologies employed at the most hazardous sites will be calculated.

This project will develop a new, integrated science-based methodology for use on information networks to facilitate more risk-reducing and cost-effective environmental remediation. A broadened perspective on cancer risk will be provided by ranking and comparing possible hazards from exposures to site contaminants with background exposures to naturally occurring chemicals in the diet and with other exposures to synthetic chemicals in indoor and workplace settings. The methodology will also advance and integrate scientific understanding of exposure pathways and human health effects with environmental remediation. Specific research proposals will be reviewed for NEPA and CEQA compliance requirements.

Advanced Risk-Based Environmental Technologies and Remediation Initiative
Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 3.0 | 13.5 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual-year Budget Authority (B&R codes EM, KP).

# Fusion Energy

## *Heavy-Ion Fusion Drivers Initiative*

The U.S. Heavy-Ion Fusion Accelerator Research (HIFAR) Program is acquiring research expertise and experience to assess and develop heavy-ion accelerators as drivers for an inertial fusion energy source for commercial power generation. The results of the successful single-beam transport and multiple-beam experiments provide encouragement and justification to conduct larger, more complex experiments. LBNL's contribution to the investigation of a full-scale fusion driver is the Heavy-Ion Fusion Driver Initiative. As part of the initiative, LBNL has started work on a new accelerator known as Elise, an induction linac system. The features of a full-scale fusion driver, yet to be demonstrated, include the components for beam merging with minimal phase-space density dilution, transition from electrostatic to magnetic focusing, transport using bending and focusing magnets, drift compression, and focusing onto a small target. Through Elise, LBNL will investigate many of these important accelerator components and beam manipulations.

The Elise accelerator is part of a proposed ILSE (Induction Linac Systems Experiments) Program. Elise will demonstrate the electrostatically focused portion of a fusion driver at full driver scale in beam-size and line-charge density. It will also provide a beam for a variety of experiments on beam transport, bending, longitudinal bunching, and transverse focusing — manipulation that will be used in a fusion power plant. However, the ILSE Program is necessary for a full demonstration of the feasibility of heavy-ion fusion. This goal will be achieved by construction of a four-beam injector, additional acceleration modules, beam combining hardware, and a magnetic transport system. This additional hardware would demonstrate beam combining and magnetic transport. Both are essential elements of a fusion driver. The additional acceleration modules would accelerate the beam from 5 MeV to 10 MeV and enable a more accurate analysis of the behavior of a full fusion driver.

The following table shows the level of funding needed to complete the Elise accelerator and support a minimal base program. Additionally, the heavy-ion fusion base program will continue theoretical studies and small experiments required to investigate fundamental aspects of heavy-ion fusion physics. It will also address the design of an experimental program that will began in FY 2001 with a support level of $8 million. The table also includes additional funds required to fulfill the complete ILSE program. These costs include all required protective systems for ES&H hazards, which are similar to those of the existing HIFAR program. A Conceptual Design Report addresses ES&H requirements and NEPA/CEQA documentation.

Heavy-Ion Fusion Drivers Initiative Resource Requirements ($M)[a]

| Category | Prior Years | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|---|
| Operating | 2.2 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 8.0 | 27.7 |
| Construction: Elise | 3.1 | 3.6 | 4.8 | 4.8 | 4.8 | 4.5 | 0.0 | 25.6[b] |
| Construction: ILSE | 0.0 | 3.6 | 8.2 | 10.2 | 7.2 | 0.0 | 0.0 | 29.2[b] |

[a]Preliminary estimate of LBNL Budget Authority (B&R code AT) in FY 1995 dollars. Construction costs include 8.61% LBNL overhead.
[b]Includes R&D associated with construction, and preops. Some of this budget will be contracted to other labs or industry.

# Energy Efficiency and Renewables

## *Building Performance Assurance Initiative*

LBNL has launched the Building Performance Assurance Initiative to address the need to improve commercial building performance in the area of energy savings. Over the last 15 years, LBNL researchers have played a critical role in developing the technology base for several new highly efficient, energy-saving building components (e.g., electronic ballasts, low-E windows) that have now achieved widespread use in buildings. Another big savings can occur—first through the integrated systems analysis of an individual building's energy use, and then through implementing, commissioning, energy-use tracking, and diagnostic procedures that will assure proper performance of the building over its life cycle.

Commercial building performance in the U.S. consistently falls short of its potential, with costly results to people and institutions. Energy use in commercial buildings accounts for $85 billion per year, more than half of which could be saved if the experience in a small number of unique, carefully designed and operated buildings could be widely replicated. Such individual buildings have been designed, built, and operated to use less than half the energy of typical design practice today, and with levels of comfort, health, and productivity that exceed today's norms. The challenge is to develop and standardize a set of integrated building life-cycle information systems that will incorporate all of these techniques so that they lead to significant cost savings in U.S. energy resources.

The technical prescription to assure better building performance is conceptually simple: (1) using computer-based design tools, develop integrated building systems that meet occupant comfort and performance needs at less than half the energy intensity of today's new buildings; (2) construct the building as designed; (3) employ sophisticated but cost-effective commissioning procedures—a series of controlled subsystem functional tests during the startup of a newly constructed building—to verify that the building initially operates as designed; and (4) implement appropriate performance tracking and diagnostics procedures to ensure that ongoing operation continuously meets occupants' needs and building efficiency criteria.

The Building Performance Assurance's main project is comprised of a number of related advanced development projects to create the following elements:

- The Building Life-Cycle Information Support System provides the information infrastructure for data exchange and archiving. A standard information infrastructure allows interoperable software tools to share information throughout the building life cycle.
- Design tools such as PowerDOE (formerly DOE-2) and the Building Design Advisor provide architects and engineers with the capability to predict the energy consequences of various design alternatives.

- Commissioning information tools verify that the major building heating, cooling, lighting, and controls systems are capable of operating as designed.
- Performance evaluation and tracking tools continuously monitor and document building performance parameters and eventually link to diagnostic tools that provide automated assistance in improving ongoing building performance.

The project not only brings together the expertise of all parts of the Center for Building Science in the Energy and Environment Division, but also includes collaboration with the Information and Computing Sciences Division and the UC Berkeley campus. Several of these projects also have industrial partners and will produce useful near-term impact data as the research proceeds. This overall program is expected to change the total life cycle of buildings to make them ultimately more resource efficient and productive, thereby yielding major reductions in building operating costs and energy use impacts.

Building Performance Assurance Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 2.5 | 4.0 | 5.0 | 5.0 | 5.0 | 5.0 | 26.5 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL Budget Authority (B&R code EC, and Work for Others).

## *Energy Technologies for Developing Countries Initiative*

The purpose of this initiative is to provide assistance to developing and transitional countries in their choice and application of energy technologies. The program supports technology choices that—when compared with typical current technology—produce or use energy more efficiently, cause reduced levels of emissions of pollutants and greenhouse gases, and are economically competitive or superior on a life-cycle cost basis.

The new program consists of seven elements: (1) energy technology adaptation, (2) demonstrations, (3) key country programs (including China and India), (4) one-stop shopping network, (5) training, (6) applied R&D, and (7) institution building in developing countries and Eastern Europe. Initial work on the program began within the Office of Policy, Planning and Education during FY 1993. The program continued in the Policy Office in FY 1994 and was transferred to the Office of Energy Efficiency and Renewable Energy in FY 1995. During the transition, the specific program disappeared, but the activities contained within the initiative continue to receive financial support.

This program will be especially valuable in responding to needs of developing countries, the former Soviet Union, and Eastern Europe for technical assistance in limiting greenhouse gas emissions in a highly cost-effective manner. It will also provide important benefits in reducing future global oil demand and in helping to establish international markets for U.S. energy technology. This program is an important United States contribution to support recommendations made by the Intergovernmental Panel on Climate Change and the United Nations Conference on Environment and Development. The program will be conducted consistent with applicable DOE orders and regulations. The resources indicated below are for LBNL's activities for the national DOE program. Specific research proposals will be reviewed for NEPA and CEQA compliance requirements.

Energy Technologies for Developing Countries Initiative
Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 1.2 | 1.5 | 2.0 | 2.2 | 2.4 | 2.8 | 12.1 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual-year Budget Authority (B&R code PE).

# Other Sponsors

## *Advanced Lithography Initiative*

Since the creation of the first integrated circuit in 1960, there has been an ever-increasing density of devices manufactured on semiconductor substrates. From the very-large-scale integration (VLSI) era of the mid-70s to the present, chip densities have increased from 100,000 transistors per chip to over 1 million per chip. The increasing device count was accompanied by a shrinking minimum feature size, from 2 μm in the late 70s to less than 0.5 μm in current 4-megabit DRAMs. The challenge to continued U.S. industrial competitiveness in microelectronics will be to develop techniques of lithography and pattern transfer at minimum feature sizes of less than 0.25 μm. This will lead to densities of over $10^9$ transistors per chip. The advanced lithography program at LBNL's Center for X-Ray Optics (CXRO) focuses on the enabling technologies essential for soft x-ray (SXR) and extreme ultraviolet (EUV) optical imaging systems. These systems will be required for the creation of 0.1 μm features, implying the existence of 1-Gbit DRAMs by the year 2000. CXRO's lithography program will concentrate on the development of EUV/SXR interferometry for at-wavelength (130 Å) testing of optics, nanofabrication facilities for zone plates and reflective masks, high-precision metrology, and the necessary processing for pattern transfer.

LBNL's initiative responds to programmatic needs established by both the Department of Defense and the Department of Energy to provide collaborative support for this emerging area of science, which supports essential U.S. technological capabilities. A successful program requires an integrated consortium of industrial, university, and national laboratory scientists to break new scientific and technical ground well in advance of the competition and to train a new generation of scientists to carry the project to fruition in the 21st century. The consortium will need dedicated laboratory research facilities with modern high-brightness, partially coherent x-ray and EUV sources, expertise in short wavelength nanometer-scale structures, and the synthesis of new materials whose structures are controlled at the atomic level. Strong participation of a consortium of local microelectronics companies will ensure quick and effective transfer of all relevant technologies.

The ALS, a unique national resource for EUV interferometry and metrology, will be utilized by the collaboration. Additional laboratory equipment dedicated to advanced lithographic research for nanoelectronics applications also will be required. These facilities will include insertion devices, bend magnets, and beamline components; metrology stations to test all optical surfaces and coatings; and advanced EUV interferometers for testing optical surfaces and integrated optical systems, as well as equipment that will support the fabrication of nanostructures and the synthesis of artificially structured materials. Specific initial elements are to include:

- A high-brightness coherent undulator beamline for at-wavelength EUV interferometry
- A direct-write electron beam "nanowriter" for diffractive optics and mask patterning
- Component and system EUV interferometry
- An EUV metrology bending magnet beamline for absolute radiometry and calibrations

A continued investment would further the consortium efforts and lead to improved American competitiveness in this critical technological area. Costs include operational procedures and equipment

design in compliance with DOE ES&H orders and regulations. As proposals under this program are developed, they will be reviewed for NEPA and CEQA documentation requirements.

Advanced Lithography Initiative Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating[b] | 4.0 | 3.0 | 3.0 | 2.0 | 0.0 | 0.0 | 12.0 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual-year Budget Authority from DOD.
[b]Costs are primarily for equipment.

## *X-ray Etching of Microelectromechanical Systems Initiative*

Microelectromechanical systems (MEMS) represent the next phase of the microfabrication revolution. These systems are made by applying processing techniques developed for the semiconductor industry to the design of microscopic sensors, actuators, motors, and passive devices. This technology provides a powerful tool for mass production and miniaturization of mechanical systems to a dimensional regime not available to traditional machining operations. The synergy with integrated circuit manufacturing provides the potential for integration of mechanical systems with associated electronics.

One technique specifically developed for the creation of high-aspect-ratio devices is called LIGA (a German acronym for Lithographie Galvanoformung, Abformung). LIGA is a combination of deep x-ray lithography, electroplating, and injection-molding processes that allows the fabrication of microstructures with lateral dimensions as small as a micrometer, vertical dimensions of several hundred micrometers, and 0.1-micron tolerances. This type of x-ray lithography depends on the existence of synchrotron radiation sources that can provide a sufficient flux of highly parallel x-rays in the 3–10 keV range. The ALS is an excellent source of radiation for this application. The techniques of deep x-ray lithography are used in the construction of passive structures, micromotors, acceleration sensors, microgears, and linear comb drives. We have demonstrated the basic processes in collaboration with JPL, SNL-CA, and SSRL. The technologies we will develop in support of micromechanical fabrication are:

- Design and construction of a bending magnet beamline, preferably an ALS superbend-magnet port. The beamline will include:
  - An exposure station with sufficient throughput and ease of use for advanced industrial prototype development and manufacturing support.
  - A white-radiation beamline for resist exposure modeling.
- Refinement of electroplating techniques in a variety of materials, in collaboration with SNL-CA.
- Improvement of the properties of resists used in deep x-ray lithography.
- Design and fabrication of novel micromechanical devices that exploit the properties of deep x-ray lithography for academic and industrial clients.
- Networking with other U.S. Light Sources and the German programs.

This technology can revolutionize the energy, automobile, aerospace, and medical fields in the same manner that integrated-circuit process technology revolutionized the electronics industry. LBNL seeks solutions to the basic problems that currently slow the acceptance of this technology.

X-ray Etching of Microelectromechanical Systems Initiative
Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.3 | 1.2 | 2.4 | 2.8 | 3.0 | 3.0 | 12.7 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate at LBNL actual-year Budget Authority from DOE (ER-LTA) and Work for Others, including DOD and NASA.

# PROGRAM DIRECTIONS

## Office of Energy Research

### *Basic Energy Sciences*

#### Materials Sciences

LBNL is one of the world's leading centers of research in materials sciences and the chemistry and physics of materials that are important to both the production and efficient use of energy. In addition, outstanding programs exist in advanced energy projects, in engineering and geosciences, in biological energy research, and in applied mathematics. Several of these programs are expected to expand, as indicated below.

Basic Energy Sciences (BES) programs in materials sciences will continue to emphasize new and forefront research projects for the synthesis, processing, and characterization of advanced materials. Expanded areas include the design and construction of synchrotron-radiation instrumentation and its application to important programs in materials sciences and advanced materials synthesis and fabrication technologies, especially at the atomic scale. Leading programs continue in x-ray optics, electron microscopy, solid-state physics, surface sciences, catalysis, polymers, biomolecular materials, metallurgy, electrochemical materials, electronic materials (including super- and semiconductors), ceramics, and materials chemistry. The ALS, a third-generation synchrotron-radiation facility, produces the world's brightest beams of ultraviolet and soft-x-ray radiation. The commissioning of the injection system and storage ring has been completed. The ALS, Center for Advanced Materials (CAM), Center for X-Ray Optics (CXRO), and National Center for Electron Microscopy (NCEM) are organized interdisciplinary research centers that bring DOE resources to bear on scientific challenges of national importance.

In support of the ALS, the Laboratory is conducting research on storage-ring physics and engineering, ultrahigh-vacuum technology, instrumentation and feedback systems, insertion devices, beamline optical systems, and magnet systems. At CXRO, research is conducted on advanced optical-system components for the utilization of high-brightness photon beams.

CAM will continue major research efforts selected because of their potential impact on U.S. industrial strength. The research focus evolves with new discoveries and with the changing needs of U.S. industry for fundamental research to underlie its technology base and developmental activities. The following programs presently constitute the major emphasis of CAM.

- The Surface Science and Catalysis Program focuses on studies of advanced catalysts for clean fuels, pollutant reduction and methanol synthesis, and the atomic-scale surface structure and chemical and mechanical properties of solids and adsorbed monolayers. Advanced surface instrumentation includes nonlinear optical techniques, scanning tunneling and atomic-force microscopies, and advanced Raman spectroscopy.

- The Electronic Materials Program focuses on theoretical and experimental studies of basic materials problems pertinent to the development of advanced electronic and optical materials. Semiconductor thin-film crystal growth and characterization, and comprehensive investigations of structural properties of heterointerfaces are pursued.
- The Polymers and Composites Program pursues polymer synthesis and studies of the relationships between polymer processing and microstructure, focusing on anisotropic materials and surface interactions between polymer liquids and metals.
- The High-Performance Metals Program addresses the mechanisms of structural failure, including fatigue and fracture in metals and intermetallics, and is concerned with the theoretical and experimental studies of the properties and development of metal alloys, formable steels, advanced intermetallics, and materials for high-field superconducting magnets.
- The Ceramics Science Program supports research on the development of predictive, quantitative theories of densification and microstructure development, the application of these theories to produce and evaluate advanced structural ceramics with improved high-temperature performance, and a new understanding of fatigue and other failure mechanisms in ceramics.
- The Biomolecular Materials Program explores the application of recent advances in biochemistry, molecular biology, and bioorganic chemistry to the synthesis of novel materials. Emphasis is on the use of natural, genetically engineered, and "created" enzymes; novel (bio)polymers; and self-assembling thin films to control surface properties and form the basis of sensors.
- The High-$T_c$ Superconductivity Program focuses on basic science, including theory, synthesis, and characterization of new materials, and on thin films and their applications, including devices such as SQUIDs and bolometers.

NCEM, a national user facility, is supported by the DOE Metallurgy and Ceramics Program but contributes substantially to research in other fields, such as biology and geology. The heart of NCEM consists of two microscopes: the High-Voltage Electron Microscope, the most powerful microscope of its kind in the U.S., and the Atomic-Resolution Microscope, with a resolution of 1.5 Å—currently the highest resolution in the U.S. To maintain U.S. leadership in electron microscopy, we are proposing to enhance the Center through the design and acquisition of new state-of-the-art microscopes.

Research at NCEM is carried out on a wide range of materials, including studies of high-temperature superconducting materials, structural materials, magnetic materials, ceramics, and amorphous silicon semiconductor materials. Research on the structure and properties of transformation interfaces has the goal of determining the atomic configuration at structural boundaries and the relationship between structure and properties at the interface.

LBNL participates in the DOE Center of Excellence for the Synthesis and Processing of Advanced Materials. The Director of the Materials Sciences Division is the national coordinator for the focus area on Nanoscale Materials for Energy Applications, one of seven focus areas in the Center. This area of research has attracted the interest of a number of federal agencies, and LBNL is hopeful that its research program can, with appropriate collaborative infrastructure and operating support, make a major contribution to the field. Materials Sciences Division investigators also lead projects in the other six focus areas: Metal Forming, Materials Joining, Hard Magnets, Surface Hardness, Corrosion Coatings, and Polymers.

## Chemical Sciences

DOE's Chemical Sciences Program supports focused research in several LBNL divisions. Efforts in the Chemical Sciences Division emphasize chemical physics, dynamics and mechanisms of chemical reactions and combustion processes, catalysis, electron spectroscopy, atomic physics, photochemistry, theoretical chemistry, and chemistry of the actinide elements and their relationship to environmental issues. Programs in the Energy and Environment Division focus on advanced combustion and the mechanisms for minimizing emissions and improving fuel efficiency. In the Structural Biology Division, programs in photochemistry and the chemistry of electronically excited molecules are being conducted. In the Nuclear Science Division, a

study of the chemical properties of the heaviest elements is being conducted. In the Physics Division's mathematical department, a study of hydrodynamical computational models for combustion processes is being carried out. This research is directed toward developing high-accuracy techniques that take into account both turbulent flow and the chemical interactions of these combustion processes.

The extensive chemical physics research includes several major programs. One program focuses on spectroscopic studies of the structures of reactive intermediates. Laser-induced fluorescence, multiphoton ionization, and negative-ion photodetachment are used to study reactive species such as free radicals and cluster ions that may be important in combustion processes, reactive plasmas, and high-technology manufacturing processes. Techniques such as crossed molecular beams are used for advanced and novel studies of the dynamics of important reactions with the goal of understanding elementary chemical reactions under single-collision conditions or through laser excitation. LBNL has been at the forefront in the development of crossed-molecular-beam techniques, and this research on reaction dynamics and combustion is expected to grow during the next several years with the development of dedicated chemical dynamics beamlines at the Advanced Light Source.

The program in reactivity at surfaces and interfaces will involve molecular studies of interfacial phenomena using new techniques in laser spectroscopy and x-ray scattering. The program is designed to gain an understanding of chemical reactivity in key areas of energy science, including nearly all catalytic reaction systems, solar-energy conversion technologies, light-assisted chemical syntheses, electrochemical energy-conversion technologies, and corrosion phenomena.

Chemical energy research at LBNL has revealed new reactions between transition metals, such as rhenium, and organic molecules that are important to the improvement of catalysis involved in coal-conversion processes. Continuing program areas focus on the fundamental chemistry of important environmental and fuel species, including aqueous and gaseous species of carbon and sulfur. Catalytic conversion of carbon monoxide and hydrogen to gaseous and liquid fuels is studied to develop more efficient catalysts for hydrocarbon production.

The research programs in theoretical chemistry have the goal of accurately predicting chemical reaction dynamics, especially those that are too complicated to be solved experimentally. The program on photochemical and radiation sciences includes research into the photochemistry of materials in the stratosphere (with applications to the role of trace gases in the "greenhouse effect").

Research in the actinide chemistry program in the Chemical Sciences Division has two thrusts: (1) the design and synthesis of sequestering agents for treatment of actinide poisoning and for possible application to spent reactor fuels, and (2) the preparation and study of new compounds incorporating actinides. A program to investigate the chemical properties of the heaviest elements (Z of 102 to 106) at the furthest reaches of the periodic table is being undertaken in the Nuclear Science Division.

Research in the energy and environment area includes theoretical and experimental programs on ignition, reactivity, turbulence, and energy transfer in combustion systems. Advanced approaches include studies of photodissociation, laser spectroscopy methods, molecular-beam mass spectroscopy, and the use of unimolecular kinetics for the theoretical study of high-temperature reactions important to combustion. Another area of research is laser-material interactions for chemical analysis.

Research in structural biology is directed at a fundamental understanding of the chemistry of electronically excited molecules, with attention on features that relate to the conversion of photon energy and the photo-assisted synthesis of high-value compounds. Projects focus on the manganese catalytic function in artificial photosynthesis, the photoinduced reduction of $CO_2$ into organic products, and polyelectrolyte interfaces for increasing quantum efficiency in photosynthetic processes. Other work explores chemistry induced by red and near-infrared light, the most abundant form of energy available from the sun. The focus is on redox reactions in solution that may lead to new concepts for chemical storage and conversion of these long-wavelength quanta into electricity and on their use for controlled photochemical synthesis in a solid matrix. A major new effort is directed at monitoring elementary reaction steps in these environments by time-resolved Fourier-transform infrared spectroscopy.

## Engineering and Geosciences

The Geosciences Program at LBNL is strengthening its multidisciplinary effort to support the scientific basis of many energy-related technologies, including development of hydrocarbon and strategic-mineral resources, safe disposal of radioactive and toxic chemical wastes, and exploitation of geothermal energy. Earth sciences researchers at LBNL are among the leading experts in the areas of subsurface imaging of the structure and dynamics of the earth's crust, experimental investigation of the mechanisms by which lithospheric processes influence energy resources, and numerical modeling of geochemical and hydromechanical processes occurring in heterogeneous fractured rock formations.

Geohydrology research at LBNL includes experimental studies of the physical behavior of fluid-saturated rock, numerical modeling of coupled processes in subsurface reservoirs, and investigation of the mechanisms associated with chemical transport and multiphase fracture-flow phenomena. New algorithms are being developed to greatly increase the efficiency of the numerical solution of flow and transport equations.

Geophysicists, supported by LBNL's Geophysical Measurements Facility and the Center for Computational Seismology, are developing methodologies and instruments to define crustal structure over a range of scales, to monitor processes in subsurface reservoirs, and to track the movement of contaminated plumes in underground aquifers. Borehole seismic and electromagnetic source development, coupled with real-time signal processing, are keys to improved high-resolution imaging capabilities. On a laboratory scale, new approaches are being employed to understand fracture processes and wave propagation in fractured media. Other geophysical research uses new computational codes to measure fracture properties in subsurface reservoirs and to map hydrofractures at well sites.

Geochemical studies focus on the thermodynamic properties of electrolytes, the generation and migration of petroleum compounds, and the interactions between minerals and groundwaters. Analytical capabilities of the Center for Isotope Geochemistry provide a powerful means of characterizing natural systems. This center is an important element in many of the multidisciplinary geological and environmental investigations at LBNL. It provides a focus, in collaboration with geophysicists and geologists, for continued study of crustal processes as part of the multiagency Continental Scientific Drilling Program.

The thrust of LBNL research in environmental characterization will be in two different areas—the understanding of radionuclide chemistry and mixed organic radionuclides, and the effect of natural subsurface heterogeneity on microbed behavior. The goal of this research is to provide fundamental knowledge on the complexation behavior of neptunium, plutonium, and cobalt with synthetic organic-radionuclide wastes in the subsurface at DOE sites. Fundamental knowledge of the chemical processes that occur between radionuclides and synthetic organic chemicals present in DOE waste sites will allow more accurate predictions of the processes that control contaminant mobilization and transport in the subsurface environment. We are conducting experiments to determine the thermodynamic and kinetic solution phenomena such as complexation constants, speciation, solubility of complexes, and the nature of compounds that can form between constituents of mixed organic-radionuclide wastes.

The heterogeneity research is part of the Subsurface Science Program Heterogeneity Subprogram. It contributes to meeting the goals of the subprogram by improving the means of relating subsurface physical properties to the microbial heterogeneity of natural systems. A large number of field-scales of heterogeneity range from the pore scale to the bed scale and beyond. To relate the significant scales of variation of microbial and chemical behavior to the variation of physical properties, it is critical to know the scales at which various processes dominate. Without this knowledge, it would be impractical to attempt to relate a small-scale process (i.e., microbial behavior) to field-scale measurements.

The goal of the work is to use subsurface imaging to identify the fundamental scales of variation of physical parameters that control transport behavior relative to predicting subsurface microbial behavior. With this information, it may be possible to relate physical and chemical heterogeneity (i.e., those parameters that geoscientists have experience measuring *in situ*) to significant microbial heterogeneity and thus explain and predict their behavior in the subsurface. This approach uses controlled meter-scale field sites and supplementary laboratory and intermediate-scale information to characterize those physical properties that affect fluid flow and chemical transport and can be imaged with *in situ* methods. The work

must be tightly integrated with chemical and microbial characterization and process definition efforts that will be undertaken in the subprogram. At DOE sites where information has been gathered on the microbial and chemical properties, field work will be carried out to define and characterize the natural subsurface physical heterogeneity. This work is being done in close collaboration with Pacific Northwest Laboratory, Oak Ridge National Laboratory, and the University of Virginia as part of DOE's Subsurface Science Program for studying subsurface heterogeneity and bacterial transport.

The Geosciences program in the Office of Energy Research also supports the Advanced Computational Technologies Initiative (ACTI), which is reviewed in more detail under Fossil Energy.

## Energy Biosciences

LBNL's program continues to improve understanding of the unique features of photosynthetic organisms for collecting light energy and storing it as chemical energy. One project uses spectroscopic techniques to map the components and the kinetics of the light reactions. The genetics of the photosynthetic apparatus of single-celled organisms are studied to allow application of DNA-cloning techniques to elucidate photosynthetic mechanisms. The light regulation of gene-encoding components of the photosynthetic apparatus in plant protoplasts is also being investigated. The DOE Division of Energy Biosciences is also supporting research at LBNL's Center for Advanced Materials on the enzymatic synthesis of materials.

## Applied Mathematics and Computer Science

The program in mathematics at LBNL centers on the development of numerical and analytical methods and their application to the most challenging problems in physics and engineering. Investigations that were started within the LBNL Mathematics Department have been at the frontiers of such topics as vortex methods, random-choice techniques, high-resolution methods in gas dynamics, front-propagation techniques, and lattice and polymeric models in turbulence.

The five most active areas are: vortex and particle methods, interface techniques, the statistical mechanics of vortex systems, the parallel implementation of codes for large-scale scientific computing, and fast algorithms. In the first area, recent successes include the design and experimental validation of vortex codes for three-dimensional turbulent flow around complex bodies, rapid implementation of particle methods, and numerical studies of engineering flows and of suspensions. In the second area, we develop and apply state-of-the-art algorithms, such as the level set methodology and new surface integral techniques for following free surfaces. These techniques allow models of complex problems in crystal growth and dendrite solidification, minimal-surface and capillarity theory, two-phase flow, and flame propagation. In the third area, we are implementing renormalization schemes for vortex interactions, have undertaken a systematic analysis of vortex motion in constant temperature systems, and are applying it to problems in superfluidity. In the fourth area, we are one of the leaders in the practical implementation of highly sophisticated codes for realistic problems on massively parallel processors. In the fifth area, we are developing and implementing new fast algorithms for elliptic and parabolic, linear and nonlinear problems.

The Scientific Database Management Research Program will continue to investigate new data-management techniques suited to scientific and statistical applications. New requirements arise from the structure of some scientific data (e.g., sparse multidimensional tables, temporal data) and operation needs (e.g., transposition, aggregation, random sampling, proximity searches). Thus, new efficient techniques for data-storage organization, new algorithms for data manipulation, and new data-modeling methods to improve the semantics of scientific data are being developed.

The Supercomputing Access Tools Program addresses the problems of scientific computing in distributed environments, with the goal of developing techniques that will partition the computational requirement optimally across distributed resources. The research on a software bus system will result in an ability to generate interoperable, and therefore reusable and replaceable, software. This will greatly enhance the computing environment available to energy research scientists. Visualization and imaging tools compatible with this innovative architecture will be developed.

A new area of research, in collaboration with the Xerox Palo Alto Research Center, has been multimedia conferencing. New protocols have been developed to support high-quality audio and video conferencing. New protocols also have been developed to support high-quality audio and video transmission on ESnet and other parts of the Internet. In addition, work is being done to incorporate an interactive "whiteboard," or graphic display window, in which network users can make real-time modifications.

## *Nuclear Physics*

Nuclear physics research at LBNL will continue to focus on the experimental and theoretical investigation of the structure and properties of nuclei, emphasizing studies of nuclei under extreme conditions (e.g., temperature, isospin, angular momentum, and density). LBNL research programs are closely coupled with national priorities in nuclear science as defined in the Nuclear Science Advisory Committee 1995 Long Range Plan. LBNL research programs also play an important role in the education and training of young scientists. In addition, ongoing technology development efforts contribute to significant advances in detector design, construction, and operation.

LBNL has played a seminal role in defining the forefront of relativistic heavy-ion physics since the field's inception and intends to continue to maintain this leadership role. The main focus of the future high-energy heavy-ion research program at LBNL is the Relativistic Heavy-Ion Collider (RHIC), which is currently scheduled to be completed at Brookhaven National Laboratory (BNL) in 1999. Experiments studying the collision of heavy ions are being carried out in four energy regimes: (1) the Bevalac (now shut down, but data analysis continues), where nuclear matter is compressed sufficiently to study its equation of state; (2) the Alternating Gradient Synchrotron (AGS) at BNL, extending the studies of the Bevalac to an energy range where the maximum pressure from the baryons is likely to occur; (3) the Super Proton Sychrotron (SPS) at CERN, where the energy density of the nucleons in the collision of very heavy nuclei may be sufficient to produce a phase transition to a plasma of free quarks and gluons; and (4) RHIC, where the energy density of the produced particles will be sufficiently high that production of the quark–gluon plasma is expected to occur. Understanding the reaction dynamics and the nuclear matter equation of state is of fundamental interest, and necessary for a physical description of neutron stars and supernova explosions. It is believed that the quark–gluon plasma existed soon after the Big Bang and may exist now in the cores of neutron stars.

The broad and versatile Nuclear Structure and Reactions Research Program is centered at the LBNL 88-Inch Cyclotron. The Cyclotron is operated as a national user facility and is equipped with two state-of-the-art ECR ion sources capable of producing high-charge-state ions of most elements.

The Cyclotron is the site of the Gammasphere, a national gamma-ray facility consisting of a $4\pi$ array of 110 Compton-suppressed high-purity germanium detectors. Completion of this system is scheduled for October 1995; however, it was recognized several years ago that even a modest fraction of the full system would be very powerful. Thus, an Early Implementation phase of operation was begun in April 1993 and ended in January 1995. A total of 60 runs were completed, utilizing about 50% of the 88-Inch Cyclotron research time. A total of 176 users came from 24 U.S. and 14 foreign institutions to use this phase of the Gammasphere. These users have already discovered a large number of new superdeformed bands and have observed many new phenomena, including new nuclear symmetries, identical bands in different nuclei, and pairing correlations in superdeformed nuclei. Future experiments will seek to understand these new phenomena and also will focus on a search for hyperdeformed nuclei and the study of neutron-rich nuclei. An inner $4\pi$ particle detector system, MicroBall, extends the capabilities of the Gammasphere and enables studies of angular momentum transfer and alignment in deep-inelastic reactions with discrete gamma rays.

In order to pursue this physics in even more detail, the nuclear structure group is also developing a next-generation gamma-ray array, the Gamma-Ray Energy Tracking Array (GRETA), which will have a resolving power a thousand times that of the Gammasphere. This array would consist of a shell of highly segmented germanium detectors. The R&D required to establish feasibility is presently underway.

The nuclear structure of nuclei far from stability, including, for example, light proton-rich nuclei and heavy nuclei, is also being investigated at the 88-Inch Cyclotron. Several factors, including the availability of intense (microampere) beams and the technology for handling radioactive beams, have combined to make the Cyclotron facility one of the leading laboratories in the world for the production and study of

transuranic nuclei. Recent experiments at the Cyclotron by the heavy element group confirmed the original discovery of element 106 (at LBNL in 1974), enabling the discoverers to finally name the element. This research program will continue to use the Cyclotron to produce and characterize new elements and isotopes, to study nuclear reaction mechanisms, and to train students in modern nuclear and radiochemical techniques. The group is also undertaking a design study for a compound-nucleus separator with capabilities that surpass any of those currently in use.

The LBNL Institute for Nuclear and Particle Astrophysics (INPA) was founded in late 1993 to bring together LBNL research in astrophysics on such topics as solar neutrinos, cosmic rays, dark matter, supernovae, cosmic background radiation, and theoretical astrophysics. A major new project is the application of laser techniques for trapping atoms to study fundamental problems in nuclear physics. Recently, the first transport, cooling, trapping, and alignment of radioactive atoms using laser light were demonstrated in experiments at the 88-Inch Cyclotron. In collaboration with eleven other institutions from Canada, the U.S., and the United Kingdom, LBNL is participating in the Sudbury Neutrino Observatory (SNO), an experiment to detect neutrinos from the sun and supernovae. Earlier this year, the upper half of the stainless-steel geodesic structure, which will hold the phototubes, was installed 2070 m (6800 ft) underground at the SNO Laboratory at the INCO mine near Sudbury. Members of INPA are becoming involved in two possible initiatives that cut across group and division boundaries. One is the development of the next-generation high-energy neutrino detector, which may have an effective sensitive volume of one cubic kilometer. Another possible initiative is the compilation and evaluation of astrophysical data in collaboration with the Isotopes Project and the Particle Data Group.

The goal of the nuclear theory program at LBNL is to address important problems at the frontier of nuclear science by developing the theory and methods necessary for the analysis and interpretation of experiments involving nuclei and for the prediction of as yet unobserved phenomena. In addition, the program aims at adding breadth to the overall nuclear research program.

The Isotopes Project of the Nuclear Science Division provides evaluated nuclear structure and decay data for the world nuclear physics community. The group has an expanding leadership role within the U.S. Nuclear Data Network. This includes responsibility for the compilation and evaluation of data from the new gamma-ray detector arrays, and the development of electronic access to the extensive data files.

Another vital area to the nuclear science program is the study of accelerator improvements. Planned future improvements include modernization of the radiation safety interlock system and an upgrade of the Advanced Electron Cyclotron Resonance (AECR) ion source so that it can operate at higher magnetic fields and frequency, further increasing the Cyclotron's performance for the heavy ion beams (A>100). A subsequent project will improve the flexibility and precision of the beam-timing characteristics of the 88-Inch Cyclotron. The goal of this project is to develop a fast-beam chopping system that could chop out individual beam pulses and enable the study of short half-life nuclear states with lifetimes greater than 100 ns with the Gammasphere detector. In the longer term, construction of a new, third-generation ECR source to provide higher energy and higher intensity heavy-ion beams will open up additional new research opportunities.

## *High-Energy Physics*

In high-energy physics, the Laboratory continues its strong and diverse program of experimental and theoretical research, including the development and operation of innovative detectors and research on advanced accelerator components and concepts. LBNL is actively participating in the national effort to design future facilities, including an asymmetric B Factory at PEP.

The Laboratory's experimental programs in high-energy physics focus on the properties of quarks and leptons, the basic constituents of matter. Their interactions are mediated through the gauge bosons, namely, massless photons and gluons and massive W and Z particles. Efforts at studying these particles emphasize the development of sophisticated detectors and their operation at colliding-beam facilities. Major experiments are in progress or in active preparation at SLAC and Fermilab.

LBNL has a major role in both of the two large detectors at the Fermilab Tevatron Collider, the Collider Detector Facility and the D-Zero. In 1995, the two collaborations made simultaneous announcements of the discovery of the top quark. The effectiveness of the Collider Detector Facility has been enormously enhanced by the Silicon Vertex Detector, for which LBNL was the lead institution. This work involved close collaboration among the Physics Division, the Engineering Division, and industrial suppliers. The Silicon Vertex Detector has achieved approximately 10-μm resolution in the transverse plane. The result is that B physics has been opened up to an unprecedented and unexpected extent. This detector has played a crucial role in the CDF discovery of the top quark. LBNL groups with this experiment are involved in analysis of B decays, and the measurement of the W mass and top quark masses Meanwhile, the D-Zero detector has made important measurements of tri-gauge couplings, with LBNL playing a key role. LBNL groups are involved in analysis of W and Z events. LBNL is heavily committed to the design and fabrication of the SVX-2 chip for D-Zero and SVX-3 for CDF. These chips are being developed jointly with Fermilab.

LBNL is also a major participant in the B Factory at Stanford Linear Accelerator (SLAC). This project will examine B-meson decays. The studies of B-meson decays are limited today by the relatively low rate of events produced at $e^+e^-$ storage rings. To study the most interesting processes within the Standard Model, both rate decays and, even more important, to study the phenomenon of charge conjugation-parity (CP) violation, an effective increase in the event rate of at least a factor of 100 is required. In the B Factory, this will be accomplished by increasing the luminosity by a factor of 10 and by simultaneously increasing the event sensitivity through the use of asymmetric collisions (equivalent to another factor of 10 in luminosity).

Construction of the $177 million PEP-II accelerator began in January 1994 and will extend through the end of FY 1998. The project is being carried out as a collaboration of SLAC, LBNL, and LLNL. LBNL construction activities focus mainly on the Low-Energy Ring. In particular, LBNL is responsible for fabrication of the Low-Energy Ring arc magnets (roughly 200 dipoles, 300 quadrupoles, 150 sextupoles, and 200 corrector dipoles) and some of the key "special" magnets in the interaction region. We are also responsible for fabrication of the arc vacuum system (about 1500 m of vacuum chambers) and for a portion of the PEP-II power supplies (corrector supplies and high-power, nonchopper power supplies). Staging and fabrication space sufficient to serve the PEP-II project has been identified on site. LBNL has played a key role in the development and testing of the innovative multibunch feedback systems and will be responsible for providing the transverse feedback systems for both PEP-II rings. LBNL accelerator physicists and engineers continue to play key roles in the B Factory project, including serving as Deputy Project Director, and as System Manager and System Engineers for the entire Low-Energy Ring. In FY 1998, LBNL personnel will play a leading role in the commissioning of the Low-Energy Ring.

LBNL will have a major part in the design and construction of the silicon vertex tracker for the B Factory. This is an especially critical component of the detector because it is essential to determining the location of the B decay vertices. LBNL's effort builds on its extensive experience with the SVX in the Collider Detector at Fermilab (CDF), with the major effort accomplished for the Solenoidal Detector Collaboration (SDC), and with the design of the D-Zero upgrade planned at Fermilab. The silicon vertex tracker will require substantial contributions from the Engineering Division, as well as from the Physics Division itself.

LBNL will, in addition, assume responsibility for other components of the B Factory detector. Particle identification is a particularly important challenge since it is essential to determining the particular decay modes being observed. LBNL will continue its work on the DIRC (Detection of Internally Reflected Cerenkov light), which led to its selection as a particle I.D. device.

LBNL will also undertake a substantial role in electronics and computing for the B Factory detector. This effort will build on the tremendous capability established, in conjunction with the Engineering Division, to meet the daunting requirements of the SDC, which we were designing for the Superconducting Super Collider (SSC). Similarly, data-acquisition work, originally designed in part for the SSC, gives us a strong basis for tackling the problems of the B Factory detector. This detector will have enormous computing needs, and LBNL will be a leader in designing the overall architecture for this work, with leadership coming from the Information and Computing Sciences Division.

The Astrophysics Program of the Physics Division has three components: cosmic microwave background measurements, a search for dark matter, and a search for distant supernovas. The cosmic

microwave background program may be extended with new satellite-borne detectors. The dark matter search component has embarked on a several-year program of experimentation. The distant supernova search program has already discovered several very distant supernovas, including the most distant one ever observed. An expanded program should find a few dozen distant supernovas, enough to determine the mass density of the universe.

The Laboratory also has a strong theoretical particle physics group, whose work ranges from highly theoretical topics to others closely related to current experiments. A substantial effort is being devoted to theoretical studies in support of physics in the multi-TeV energy range.

The Particle Data Group performs a service for the world's high-energy physics community through its compilations of particle properties. This includes the recent enhancing of database accessibility through computer links.

Advanced detector development is aimed at long-range research in detector problems relevant to proposed hadron colliders. The program emphasizes the development of radiation-hardened devices, pixel devices, monolithic amplifier arrays, and data-acquisition electronics.

Accelerator physics and engineering for the design and application of particle beams is an LBNL core competency that has long played a leading role in research and development for high-energy physics facilities. In the recent past, for example, LBNL experience with beam cooling resulted in successful systems at the Tevatron I. Most recently, LBNL has turned its attention to high-luminosity lepton colliders such as B-meson factories and has been using its combination of analytical and practical expertise to solve a variety of problems such as beam–beam instabilities and damping of higher-order modes.

A comprehensive, integrated approach to superconducting magnet R&D is a part of the competency that LBNL applies to high-energy physics. The program emphasizes two major aspects of building higher-field and higher-quality magnets. An ongoing effort to make wire for greater current density explores small filament diameters (2–3 μm) and brittle superconductors such as niobium–tin. Improved cable designs are also a major focus of activity. These achievements come together in the development of stronger and more efficient accelerator-type magnets, one of which set a field-strength record of slightly more than 10 tesla in 1992 testing. Other highlights include efforts to make better magnets and to find better ways of designing magnets.

In a futuristic program aimed at a next-generation, high-energy electron collider, LBNL scientists, collaborating with LLNL and SLAC colleagues, are working on the Two-Beam Accelerator. This concept, pioneered at LBNL, uses either a free-electron laser or a relativistic klystron to generate extreme levels of microwave power, which is then applied to a high-gradient linac structure.

## *Health and Environmental Research*

Life-sciences-related research activities include six research program areas: gene expression and genome mapping; structural biology; nuclear medicine and functional imaging; carcinogenesis, mutagenesis, and radiation biology; environmental and health-effects research; and measurement technology. These programs form a core of research conducted for DOE's national programs supported by the Office of Health and Environmental Research (OHER). Program expansions are anticipated in human genome research, structural biology, gene expression, growth regulation, molecular medicine, and environmental science.

### Gene Expression and Genome Mapping

Important research growth areas for LBNL are studies on human genome structure and regulation of gene expression. Research at the Human Genome Center includes generation of physical and genetic maps, identification and localization of expressed genes on human chromosome 21, and development of techniques for efficient sequencing of human DNA and automation of these techniques. Analysis of the biologically relevant signals culled from sequence information is under way. A physical map of the *Drosophila* genome, along with the identification of expressed genes, is being developed in collaboration with UC Berkeley and Harvard University. The biological function of the human DNA sequences identified

by the Human Genome Center will be determined using genetically engineered mice developed by researchers at LBNL.

LBNL's Life Sciences Division conducts several related research programs on gene expression within mammary-gland and blood-forming systems. The highly secretory mammary epithelial cells provide excellent models for gene expression and chemical- and radiation-induced carcinogenesis and are now also providing vehicles for production of genetically engineered foreign genes. LBNL has identified hematopoietic research for expansion. Blood-forming cells are important targets of radiation-induced damage and are versatile models of stem-cell differentiation and regulation of gene expression.

Molecular cytogenetics describes a set of pioneering diagnostic methodologies for biomedical applications—many of which have already made a significant contribution to the megabase sequencing effort in the Human Genome Project. The research program centers in particular on refinements in hybridization technology to increase the speed, sensitivity, and specificity of hybridization to allow rapid identification and mapping of genetic aberrations.

## Structural Biology

One thrust of LBNL's structural biology program is directed toward x-ray-based research at the ALS (see the Structural Biology Initiative, p. 4-12), although the program has other facets as well. X-ray crystallography, electron crystallography, and NMR spectroscopy focus on protein and nucleic acid structures. Several studies are aimed at determining how proteins regulate the expression of genes by examining the structure of the protein-nucleic acid complexes. These latter studies will use advanced techniques, such as x-ray diffraction, that are made possible by the ALS.

Studies based on high-resolution electron crystallographic structure analysis and x-ray diffraction are also elucidating the structure of specific membrane proteins involved in transmembrane signaling and ion channels. Using unique techniques for electron diffraction and imaging of crystalline sheets of membrane proteins, structural studies will focus on such membrane-bound proteins and integral membrane proteins as growth-factor receptors, chemotaxis receptors, and receptors for extracellular matrices. LBNL's new intermediate-voltage electron microscope, which allows viewing of much thicker specimens than can be examined with conventional electron microscopes, is enabling researchers to study complex structures, including that of the isolated mitotic spindle, which can be prepared as a frozen, hydrated specimen. Related work will exploit circular-dichroism microscopy, electron microscopy, and novel microscopic-imaging capabilities from the ultraviolet and soft-x-ray beams of the ALS.

Hard-x-ray radiation from a wiggler will make it possible to develop technical capabilities in synchrotron-based protein crystallography that have never been attempted before. One such advance is specialized x-ray optical devices that will provide multiplexing and time-sharing capabilities leading to order-of-magnitude more efficient use of the available beams. Another is x-ray microfocus technology to extend data-collection capabilities to protein microcrystals as small as 20 μm or less.

Current research is exploring new concepts in the realm of soft-x-ray microscopy of biological specimens. The goal is to test ideas such as high-resolution fluorescence microscopy (using lanthanide chelate labels) and the mapping of elemental distribution within subcellular compartments. A scanning x-ray microscope designed to exploit these techniques would use a specially designed undulator, optimized for light output in the "water window" range of x-ray wavelengths.

LBNL has also established a unique center of excellence, the Program for Biomolecular Design, that will bridge the chemical, biological, and computer sciences by combining the expertise at LBNL and UC Berkeley. The program will catalyze an understanding of biological systems with the ability to analyze and manipulate chemical structure. The aim is to redesign the natural biological molecules to create new classes of novel biomolecular structures with applications to major problems in the medical, biological, and environmental sciences relevant to DOE missions.

## Nuclear Medicine and Functional Imaging

Research in nuclear medicine will include new studies in molecular biology and continuing studies of improved radiopharmaceuticals and advanced instrumentation for applications to medical science. A systematic search for new, ultrafast heavy-atom scintillators will continue, as well as the development of solid-state photodetectors for multilayer, high-resolution, positron-emission tomography. A new multilayer, high-resolution tomograph is planned for use in medical studies of the human and animal brain and heart.

Methods for the production of radioisotopes and for the labeling of biochemical substrates to be used in noninvasive imaging have contributed to the effective use of these diagnostic-imaging tools. Newly developed radioisotope generators give greater flexibility to the application of short-lived, positron-emitting isotopes by using long-lived parent radioisotopes, and automated elution techniques for the delivery of short-lived radionuclides.

Based on LBNL's tradition of radiobiology and isotope chemistry, the Laboratory is supporting DOE's Health and Environmental Research program to conduct isotope-based research and to provide tracer isotope resources for the nation's biomedical research community. LBNL is a consultant in studies for a national biomedical tracer facility, the purpose of which is to maintain a U.S. research infrastructure for stable and radioactive tracers that are vital in biomedical research, including metabolic studies, diagnostic imaging, and other applications.

In parallel with an emerging national trend in molecular nuclear medicine, studies in four new areas have been initiated at LBNL: (1) use of modern instrumentation and dosimetry, along with human genetic studies and transgenic animal models, to pursue the relationship among variations in the genome, low-density lipoprotein receptors, and the occurrence of atherosclerosis; (2) use of advanced noninvasive methods of nuclear medicine and NMR to study the relationships among ion-channel protein aberrations, brain physiology associated with mental disorders, and the genome; (3) development of labeled DNA probes of specific proteins associated with inflammatory diseases, autoimmune conditions, atherosclerosis, and cancer; and (4) use of nuclear medicine methods to monitor gene therapy.

## Carcinogenesis, Mutagenesis, and Radiation Biology

LBNL has a number of strong research programs in carcinogenic mutagenesis and radiation biology:

**Control of Growth, Differentiation, and Genomic Stability.** LBNL has strong programs in the elucidation of mechanisms that control cell proliferation, differentiation, and genomic stability, and the abnormalities that occur in each of these processes during tumorigenesis.

**Hormones and Extracellular Matrix.** Research is directed toward identifying the intracellular molecules that mediate cells' responses to hormones, particularly the sex steroids, and the extracellular matrix (ECM). Investigators have demonstrated the importance of hormones and ECM in maintaining the balance between growth, differentiation, and death in normal tissue; mediating the tissue response to radiation; and initiating neoplasia. Researchers are now working towards understanding the molecular bases for the actions of hormones and ECM and developing methods to modulate their activities.

**Hematopoiesis.** Using rodent and human cells in culture and *in vivo,* investigators are examining how differentiation and malignant transformation are controlled in blood-forming cells. In particular, there is a substantial effort to understand how tissue-specific gene expression is regulated, to identify chromosomal changes that occur in these cells after exposure to carcinogenic stimuli, and to characterize and isolate hematopoietic stem cells.

**Mammary Biology.** A large, multi-investigator program in mammary gland biology aims to understand the extracellular signals and intracellular mediators that control mammary epithelial cell growth, development, functional differentiation, and death, particularly as it relates to various stages of tumorigenesis. Investigators are studying epithelial-stromal interactions, ECM–cell and cell–cell interactions, growth factor and ECM receptors and the intracellular signaling pathways, and transcription factors that are key regulators of growth and differentiation.

**Oncogenes and Tumor Suppressor Genes.** In another area of research, investigators are learning how protooncogenes (which, through mutation, become oncogenes) and tumor suppressor genes function in normal and neoplastic cells. Using both viral and cellular genes, investigators are determining the role of protooncogenes and tumor suppressor genes in the cell phenotype resulting from environmental signals, such as growth factors and ECM and DNA damaging agents, as well as genetic programs, such as replicative senescence and terminal differentiation.

**Radiation and Chemical Carcinogenesis.** LBNL researchers are studying the biological responses of cells and organisms to environmental hazards such as ionizing radiation. These studies will enable an understanding of the consequences of low-dose exposure, which is important in assessing the risk associated with space exploration, certain occupational hazards, and medical diagnostic techniques. These studies also are providing a molecular understanding of how DNA lesions are acquired and repaired.

**DNA Repair.** Activities in the area of DNA repair include the cloning of human genes by complementation of repair defects in lower organisms, studies on how the structural constraints and genomic organization affect damage and repair, and the inducible responses to DNA damage.

Excellence in measurement technology is key to the success of OHER programs. Refinements in sensors and analytical techniques have been developed at LBNL for a number of years. New detector configuration and the discovery of new scintillation will significantly benefit the positron-emission tomography program of OHER. Research and development of the associated electronic signal-processing techniques complement this work. OHER support for x-ray detectors at the ALS and other synchrotron sources will utilize LBNL expertise and provide significant advances in image resolution and chemical characterization of biological materials.

### Environmental and Health-Effects Research

Environmental research at LBNL is comprised of multidisciplinary efforts on global, regional, and local environmental problems such as epidemiological factors, subsurface contamination, indoor air quality, and high-magnetic-field environments, all conducted for OHER.

The Laboratory is advancing programs in support of DOE's research initiatives on the subsurface environment. The Laboratory's proposed programs encompass the biological and hydrogeochemical control and remediation of toxic waste. Specific projects include characterization of contaminants, subsurface heterogeneity, transport processes, and enhancement of restoration methods. Improved risk-estimation methods will enable the deployment of cost-effective remediation technologies.

LBNL is developing an interdisciplinary program to investigate the processes that lead to changes in the physical and chemical characteristics of the atmosphere and other potential changes in the ecosystem. Initial research subjects include atmospheric processes that are involved in the generation of nucleating particles from artificial and natural sources; heterogeneous chemical processes; the role of particulates in the formation of clouds, and the resulting chemical and physical changes in the atmosphere; and atmosphere–ecosystem interactions.

The LBNL program on radon migration includes unique experimental facilities for studying radon movement in soil and into buildings under controlled conditions. These studies will allow comparisons with detailed numerical simulation models. In addition, the radon research program examines the effects of other parameters, including other indoor air pollutants, building construction and operation, and climate conditions, on the resulting indoor radon concentrations and, ultimately, on the radiation doses to the building occupants from these indoor exposures.

## *Fusion Energy*

Fusion energy research at LBNL focuses on accelerator systems supporting the nation's inertial-confinement and magnetic-fusion energy programs. Materials, superconducting magnets, and magnetic fusion energy theory are important parts of the program. LBNL's heavy-ion fusion accelerator research has

focused on the physics and technology of induction acceleration as the means for producing high-current, heavy-ion beams as drivers for inertial-confinement fusion systems. In comparison with other possible inertial-fusion drivers (e.g., lasers), beams of heavy ions offer important advantages for practical applications, including high efficiency from the "wall plug" to the beam, good potential for beam-to-pellet energy focusing and coupling, and high pulse-repetition rates. LBNL's current efforts have resulted in successful completion of the multiple-beam experiment to examine the initial accelerator components for space-charge-dominated beams undergoing current amplification. Current efforts are directed toward design and development of the next set of studies, the Elise accelerator and experiments. The Elise accelerator would constitute a significant step toward realizing induction-accelerator technology that could be used to produce intense sources of spallation neutrons. An induction accelerator that uses 5-MW beams of protons at 1 GeV to generate spallation neutrons in 100-ns bursts at a rep-rate of 10 Hz would be quite similar to, but one-tenth the size and cost of, an inertial fusion driver. At higher average power levels (i.e., rep-rate), induction accelerators are candidates for accelerator-based pulsed reactors for waste transmutation, for tritium production, and for a fusion material test facility.

LBNL has contributed to the magnetic fusion energy program through the development of neutral beams for heating, refueling, and drive current in reactor plasmas. LBNL's work on positive-ion-based neutral beams has been coupled with the research efforts at the Tokamak Fusion Test Reactor at Princeton and the DIII-D at General Atomics in La Jolla. The most prominent achievement thus far has been the design, development, and transfer to industry of the Common Long-Pulse Source, which has been incorporated into all major U.S. fusion experiments.

Many proposals for future magnetic-fusion projects involve injection of dc neutral beams at high currents and at high kinetic energy. The beams play a significant role in heating the plasma and in driving the toroidal current noninductively in the steady state. LBNL has traditionally been a leading center for design and development of these neutral-beam injection systems, including the standardized Common Long-Pulse Source. Future work is likely to be carried out under the aegis of the Japan Atomic Energy Research Institute (JAERI).

An additional contribution to the magnetic fusion program in the Materials Sciences Division is research on alloys and weldments for low-temperature superconducting magnets for magnetic-confinement fusion systems. The alloys must withstand extremely high magnetic fields at the cryogenic temperatures needed for superconductivity.

# Energy Efficiency and Renewables

The LBNL program in Energy Efficiency and Renewable Energy comprises a broad set of related activities that provide research support and technology development in the furtherance of national goals to reduce energy demand and cost to consumers, balance environmental concerns with economic development, and enhance energy security. LBNL's programs are principally in electrical-energy storage and distribution, buildings, industry, transportation, utility systems, and geothermal systems.

## *Utility Technologies*

LBNL's programs provide assistance to utility planning and renewable energy supply and research that will yield long-term options for utilities. An expanding effort in Integrated Resource Planning is directed toward providing information and analytic methods for incorporating conservation and renewable options in utility planning on an equivalent basis to conventional supply options. This effort is carried out in close collaboration with the National Association of Regulated Utility Commissioners.

The work on electrochemical energy storage, described below under Transportation Technologies, will provide stationary energy-storage options for load-leveling applications. In another effort, work is ongoing to understand the effects of electromagnetic fields on biological systems.

A multidisciplinary program addresses the characterization and development of geothermal energy resources. The current program consists of field, laboratory, and theoretical studies covering four principal

technical areas: delineation and evaluation of geothermal systems, definition of reservoir processes, modeling of reservoir dynamics and exploitation effects, and optimization of field-management practices.

Reservoir technology work will lead to more accurate predictions of the responses of a geothermal reservoir to exploitation for optimum management through carefully designed fluid-production and injection operations. Joint field projects with U.S. geothermal developers and utilities continue to be highly productive, as do collaborations with organizations in Mexico, Iceland, and Italy.

Currently, LBNL is investigating The Geysers, the largest geothermal field in the world, as well as several other systems in California and Nevada. This investigation is part of a DOE-industry multi-institutional collaboration. More generally, the U.S. geothermal industry, including utilities, continues to be assisted by LBNL's geothermal program in its effort to develop hydrothermal (hot water and steam) resources in the U.S. and abroad. Instrumentation, field techniques, data interpretation methods, and computer codes developed at LBNL, which are used in locating, evaluating, and optimizing the exploitation of geothermal systems, are being transferred to the private sector. The assistance to industry also includes the collection and release of information on geothermal prospects throughout the world.

LBNL is performing extensive analysis of energy demand in China: historical studies of determinants of energy intensity, case studies of energy-efficiency decision making in industrial facilities, analysis of possible energy-efficiency investments, and assessments of energy-efficiency business opportunities in China.

Magnetic-field interactions are being evaluated in experimental animal systems and in tissue and cellular systems potentially sensitive to this nonionizing radiation. This program will develop theoretical models of magnetic-field interactions with biological systems and provide essential data for assessing the potential effects of magnetic fields.

## *Industry Technologies*

This effort focuses on advanced industrial concepts, including energy-efficient chemical separations, the opacification of aerogels for high-performance insulation in nonview applications (e.g., refrigeration), and other industrial applications. Work is under way on two projects on catalysts for industry: theory-assisted design of metal and zeolite catalysts; and chemistry, immunology, and modeling as tools for the rational design of stable, active enzymes.

## *Transportation Technologies*

LBNL manages the Exploratory Technology Research Program, which is the electrochemical research arm of DOE's Office of Propulsion Systems. The primary goal of this program is to advance the development of high-performance rechargeable batteries and fuel cells for use in electric vehicles. The battery performance goals for this program have been established by the U.S. Advanced Battery Consortium. LBNL research areas include exploratory R&D on new electrochemical systems, supporting research for advanced rechargeable batteries currently under development, materials science research for improved battery components, fundamental electrochemical research to improve electrochemical energy-conversion efficiency, and characterization of advanced electrodes and electrolytes for use in fuel cells.

Based on its work in building technologies, LBNL is developing switchable glazings for automobiles and other vehicles. Optical control to reduce solar heat gain will permit downsized air conditioners and thus reduce use of chlorofluorocarbon (CFC) refrigerants as well as increase mileage.

LBNL is working in conjunction with the other DOE multiprogram Laboratories to assist DOE in its role in the federal-industry Partnership for a New Generation of Vehicles (PNGV). LBNL expertise that is available to the PNGV includes the above areas, as well as combustion and emissions, lightweight materials, and improved manufacturing techniques.

## *Building Technologies*

LBNL will continue activities related to residential and commercial buildings in a program of laboratory and field research, modeling, data analysis, and partnerships with industry to accelerate market impact of our research. This work is a coordinated systems approach to designing building components and whole buildings with improved energy efficiency and better conditions for human health, comfort, and productivity. Modeling and field measurements verify results on economic costs and benefits of using energy efficiently. Important aspects of the work include measurements of indoor air quality and possible health effects of proposed efficiency measures.

The Laboratory has a leading role in applied research in four areas related to energy efficiency in buildings: windows and daylighting, artificial lighting, computer modeling of building energy use, and infiltration/ventilation and indoor air quality. The general objective of these programs is to develop advanced energy-efficient technologies, computational tools, and experimental facilities. This will allow evaluation of technologies showing the greatest promise for significant energy savings in buildings while maintaining levels of illumination and air quality adequate for human comfort and health. Specific projects focus on energy-savings opportunities in fluorescent lamps, advanced windows, novel building insulation, analysis of federally assisted housing, residential and commercial building analysis and performance studies, analysis of appliance energy efficiency, and site-planning studies to minimize summer heat-island effects. Increased effort is focused on providing more "user friendly" access to the technologies and methodologies developed at LBNL. Examples include a graphic user interface to computer codes such as DOE-2, expert systems to aid energy-efficient building design, and electronic kiosks for information transfer. Another growing effort involves providing technical assistance to the Federal Energy Management Program (FEMP) as that program seeks to increase the energy efficiency of federal buildings. A third new focus is an emphasis on the development and understanding of integrated building systems, and on assuring their performance (energy, and occupant health and productivity) throughout the life cycle of the building. These projects are undertaken in close collaboration with the building industry and utilities. There is an additional emphasis on supporting the U.S. government's commitment to reducing green-house gas emissions to 1990 levels by the year 2000, by accelerating implementation of new energy-efficient technologies and processes.

Both domestic and international studies of economic impacts of alternative energy policies are expected to grow. The purpose of surveying the conservation policies of other developed countries is to enable the U.S. to compare progress in this area and perhaps adopt some of their effective efficiency measures.

## *Federal Energy Management Program*

LBNL's In-House Energy Management Program, supported by FEMP, pursues opportunities to significantly reduce energy costs at LBNL. It is estimated that the program will result in $1 million in annual savings by the end of FY 1995. The program involves surveys and studies of existing conditions, retrofit projects, new construction support, and utility-cost management. Retrofit projects have improved the efficiency of mechanical systems, lighting, and utility systems.

# Office of Fossil Energy

LBNL conducts research directed toward making coal more usable, including studies on conversion to gaseous and liquid fuels and reduction of emissions. One current effort focuses on the low-temperature catalytic gasification of graphite and other forms of carbon. A flue-gas chemistry project is directed toward methods of simultaneous removal of $SO_2$ and $NO_x$, and other new processes are being developed to remove $H_2S$ from gas streams, such as those produced during coal gasification. Another project is studying the erosion and corrosion of materials used in systems developed for coal conversion and use.

In the oil and gas area, LBNL is completing a study directed to the development of methods for characterizing heterogeneous and fractured reservoirs through a combination of geological, geophysical, and hydraulic studies. Heuristic methods are used to determine the systematic patterns of conductive features that result from the geologic processes. Improved seismic and electromagnetic methods are being

developed for imaging these features from boreholes. Both of these types of information are used to obtain an improved model of reservoir performance to enhance our ability to manage reservoir production. LBNL is continuing development of advanced inversion codes and interpretation methods. This work has active industrial support.

The Earth Sciences Division of LBNL has taken the lead in developing DOE-Industry cost-shared research alliances with California-based oil and gas producers, mainly those facing difficult and costly production problems from the Diatomite reservoirs in Kern County. Although these reservoirs contain about 10 billion barrels of light oil in place, recoveries are low (2.5 to 6.0%) due to the very impermeable nature of the rock. Production is impeded by the chemical/mechanical nature of the rock, which leads to a high rate of production-induced rock deformation and well failures. LBNL has started four new projects under the DOE/FE Oil Recovery Technology Program (ORTP), each with cost-sharing from industry. ORTP is one of several technology programs under FE's Natural Gas and Oil Technology Partnership, a partnership program started by SNL and LANL in 1989 and expanded to include LBNL and LLNL in 1994.

The partnership program was significantly expanded by the Offices of Fossil Energy and of Energy Research in FY 1995 through the Advanced Computational Technologies Initiative (ACTI), a major 1995 thrust under the Domestic Natural Gas and Oil Initiative. ACTI was designed as a major technology development program to assist the domestic oil and gas industry in finding and producing more oil and gas at lower cost and with lower financial and environmental risks. ACTI focuses on the vast, state-of-the-art computational capabilities—including hardware, software, and the array of other enabling technologies—at the national laboratories. The main rationale for ACTI is to reduce the nation's increasing dependence on imported oil, now the largest contributor to the U.S. foreign trade deficit. Working with major and independent producers, oil-field service companies, and universities, LBNL received DOE approval for five projects. These ER-LTA funded projects cover advanced geophysical exploration for subsalt imaging in the Gulf of Mexico, drill-site analysis of drill cuttings for rock properties, visualization and virtual reality techniques for the reservoir engineer, control of production-related ground subsidence, and optimizing fluid injection for better production from low-permeability reservoirs. In addition, the Geosciences program in the Office of Energy Research is supporting three continuing projects.

LBNL is exploring the major factors that will affect the economic and technical success of cogeneration in China, with the object of promoting the cost-effective application of that technology in China. LBNL is also exploring selenium's presence in San Francisco Bay and its effects on the Bay's water quality, as well as assessing whether oils refined in the region are sources of selenium contaminants.

# Environmental Management

The Laboratory is implementing site projects for restoration and waste management consistent with DOE's National Environmental Management Program. Through direct involvement at LBNL and other DOE and DOD sites, LBNL intends to identify major technology gaps in environmental restoration. These gaps will then be addressed and resolved in close cooperation with industry. In addition, and as described in greater detail in Section V, the existing and budgeted site projects address specific conditions at the Laboratory, including facilities and operating programs for corrective actions, environmental restoration, and waste management.

In support of the Office of Technology Development in DOE's Environmental Management Program, and to facilitate the development of underlying science conducted in the Offices of Basic Energy Sciences and Health and Environmental Research, LBNL is developing a multidisciplinary research and development program directed at improving the effectiveness and cost/risk benefits of environmental restoration technologies. The program has four components:

- Improved characterization of subsurface environments, including better measurement of their biological, chemical, and physical properties and better definition of the associated contaminant transport processes.
- Development of methods for assured containment and control of subsurface biological, chemical, and radiological contaminations.

- Development of advanced remediation technologies, including instrumentation for cost-effective measurements and treatment methods appropriate to complex and heterogeneous subsurface environments.
- Improved risk assessment and prioritization systems to allow better allocation of remediation funds.

The methodologies used in the program will include field testing and tracking contaminant fronts; developing descriptive and predictive mathematical models; characterizing heterogeneous underground systems; designing, demonstrating, and testing containment and cleanup systems at specific contaminant sites; and determining the underlying chemical, biological, and thermodynamic properties involved in mixed contamination. As program plans are developed, they will be reviewed for NEPA and CEQA documentation requirements.

In a specific direction, LBNL has joined with LLNL and SNL to form a joint project called the California Environmental Enterprise. Formed in FY 1994 with initial funding from the Office of Technology Development, the project is seeking to help facilitate the cleanup of the many contaminated properties in California by utilizing the environmental remediation expertise developed at the DOE laboratories. LBNL's role in the California Environmental Enterprise project will be to use the special expertise within its Earth Sciences, EH&S, Engineering, and Information and Computing Sciences Divisions for the following activities: (1) to assist small environmental technologies businesses gain access to information about technologies being developed within LBNL and other federal laboratories; (2) to broker technologies developed within the DOE programs to companies in California; and (3) to help design and develop a better information system that will give businesses, regulators, and laboratories access to a wider range of information than is currently available from a single source.

# Environment, Safety, and Health

LBNL is continuing its strong programs in analytical methods development and statistical studies of environmental and epidemiological factors supported by the Office of Epidemiology and Health Surveillance. The Population at Risk to Environmental Pollution Project focuses on the collection, analysis, and interpretation of data pertaining to relationships between human health and environmental pollution. Computational techniques are developed for the analysis of ecologic data, especially small-area geographic data, to investigate alleged departures from expected disease rates, to generate etiologic hypotheses, and to plan clinical trials or cohort studies. The role of the Comprehensive Epidemiologic Data Resource (CEDR) Project is to provide exposure and health data on DOE workers to research epidemiologists both within and outside DOE. CEDR includes work on past and current epidemiologic studies by DOE and the Department of Health and Human Services, and is being expanded to include current epidemiologic monitoring data on DOE employees. Other data sets of interest, such as Radiation Effects Research Foundation summary tables and dose reconstruction data from the Nevada Test Site, are included. The goal of the program is to encourage independent review and augmentation of existing findings on DOE worker health effects, in response to criticism that DOE research has not been viewed as impartial by the public. The availability of CEDR data has been increased by posting the data on the World Wide Web and providing access through Gopher and various interfaces.

# Other DOE Programs

## *Civilian Radioactive Waste Management*

LBNL continues a strong multidisciplinary program of interrelated geoscience and geological engineering research important to the safe long-term underground storage of high-level nuclear wastes. This research includes characterization of deep geologic formations, determination of the physical and chemical processes occurring in the repository rocks, analysis of hydrologic and chemical transport mechanisms, and development of predictive techniques for repository performance. Coupled with ongoing basic research,

LBNL is contributing to technology and applied development research at DOE's Yucca Mountain Project as well as to international projects in cooperation with Sweden, Switzerland, Canada, and Japan.

Experimental work involves testing rock samples to determine fundamental chemical, mechanical, and hydrologic parameters under a suite of anticipated repository conditions. Complementary research is conducted on the solubilities of actinides and the characteristics and processes that control radionuclide transport in host rocks. Related efforts involve the understanding of processes and the development of methods for predicting the response of geologic systems to repository development and the performance of geologic environments for various repository containment designs. These expanding research activities draw upon LBNL's expertise in chemistry, earth science, computing, and numerous engineering fields.

## *Policy, Planning, and Analysis*

LBNL undertakes analysis activities in support of policy issues of concern to DOE. Recent efforts include analysis of "feebates" (an imposition of fees and concomitant offering of tax incentives to encourage energy-efficient technologies) as a policy approach to increase auto fuel economy, combustion pollution exposure that takes place indoors, the development of data and models for developing projections of energy demand under a variety of policy cases, and assessment of a variety of policies as an input to DOE's assessment of U.S. energy strategies.

LBNL is supporting (along with Battelle/Pacific Northwest Laboratory) the creation of the Beijing Energy Efficiency Center. This center has the mandate to influence Chinese policy to promote energy efficiency, to carry out training and educational programs, and to promote trade and joint ventures in energy-efficiency products.

In 1994, the U.S. government initiated a program to provide technical assistance to developing countries in their efforts to find ways to reduce the growth of greenhouse gas emissions. While the program is government-wide, the Policy Office is playing a leading role in organizing this enterprise. LBNL has been selected as the organization that will organize the technical assistance effort, using our own expertise and that of other organizations. This will begin with assistance to 14 countries and is expected to expand to about as many more countries over time.

## *Other DOE Contractors*

LBNL contributes to the research programs at other DOE national laboratories and facilities through such activities as management and design for the STAR project at Brookhaven National Laboratory (see the Relativistic Heavy-Ion Collider Initiative, above), laser-material interactions for Lawrence Livermore National Laboratory, development of specialized object scanning CCD cameras, the investigation of advanced windows and energy-conservation strategies for the Bonneville Power Administration, and environmental research and technology development at DOE sites.

# Work for Others

## *National Institutes of Health*

The success of the DOE biosciences and environmental sciences programs at LBNL has depended not only on DOE support but also on complementary NIH-supported research that is closely coupled to these programs. Several critical technologies recently identified as being of high priority for advancement by NIH—specifically molecular medicine, biotechnology, and structural biology—are all major components of the life sciences program at LBNL. These technologies build on the unique facilities and expertise available at LBNL and point toward a growing interaction of DOE- and NIH-funded research in pursuing new goals in biology and medicine.

NIH supports programs on radionuclides, NMR, diagnostic image reconstruction, and radiopharmaceuticals related to advanced instrumentation and disease treatment. Other major NIH-funded

programs involve lipoproteins and their relationship to cardiovascular disease, biological structure analysis by electron crystallography to characterize cell-membrane proteins and viruses, and the intracellular molecular structure of DNA and sickle hemoglobin.

NIH applies LBNL's unique resources to investigations of the human genome and in carcinogenesis and mutagenesis. Repair and recombination in yeast and the genetic effect of carcinogens will continue to be major foci. Cell nuclei are studied by circular dichroism and related techniques. The Laboratory's capability in culturing human mammary epithelial cells is used to study breast cancer.

The National Tritium Labeling Facility conducts research into the labeling of compounds with tritium. LBNL also conducts a program on intermediate-voltage biological electron microscopy under NIH sponsorship. NIH also supports research on oxygen radicals and aging, environmental tobacco smoke, soil transport of gas pollutants, and ecotoxicology assays.

In the life sciences, research on human lipoprotein function and genetics is supported by the National Dairy Board through Children's Hospital in Oakland. The UC California Tobacco Research Institute supports research on carcinogenesis. The National Cancer Institute supports basic research on how carcinogenesis is initiated by chemicals and radiation. Additional studies are funded to investigate how normal growth and cancer cells are controlled by their microenvironments.

## *Department of Defense*

The Advanced Research Projects Agency (ARPA) is expanding its support of research in x-ray lithography at the CXRO. The projects supported by ARPA are on the critical path for the development of EUV pattern-transfer technology. The research is in response to unique opportunities for science and technology at the ALS. Funding for the design of an undulator beamline was received in FY 1991 through LBNL's CXRO. The CXRO is also acquiring an advanced direct-write electron beam lithography system with ARPA funding. This e-beam writer, or "nanowriter," will be used to support x-ray lithography research through the fabrication of zone plates and x-ray masks. LBNL may also receive increased ARPA support for dual-use R&D for magnetic materials microscopy and for molecular design.

ARPA funds the MAGIC gigabit testbed, a project to combine high-speed, wide-area-network technology, distributed image-storage systems, and high-speed graphics with aerial and satellite images, to present a user with a virtual reality that corresponds to what a real observer would see while traveling through the real terrain. LBNL is doing the research and development for the high-speed distributed-image server system that will supply the imagery to the terrain-visualization application providing the real-time view of the landscape.

## *National Aeronautics and Space Administration*

The space radiation environment and what it means to continued human presence in space, is one of the most unique of NASA's problems. In order to address the health hazard aspect of this problem, LBNL investigators are conducting multidisciplinary research at the molecular, cellular, and tissue levels. In consortium with Colorado State University, Fort Collins, LBNL is now the recognized NASA Specialized Center for Research and Training in the area of human health. The purpose of the training is to produce the next generation of space radiation scientists.

The LBNL Astrophysics Group has been instrumental in the development of the Differential Microwave Radiometer installed on the Cosmic Background Explorer (COBE), which has detected anisotropies in the cosmic microwave background. These anisotropies show the primordial seeds of modern structures such as galaxies, clusters of galaxies, and larger-scale patterns. These seeds were produced by particle interactions at the creation of spacetime. Data analysis is continuing, to improve statistics and to refine our understanding of the early universe.

Other NASA projects at LBNL include studies on gravitational effects on combustion and low-noise electronics for detectors These studies have applications in atmospheric and astrophysics research.

## *Environmental Protection Agency*

LBNL conducts research on the hydrogeological transport of contaminant plumes from deep underground injection disposal. In the area of global environmental effects, LBNL is characterizing the emissions of energy technologies, improving global energy projections, fostering international awareness of global trends, studying effects of tropical deforestation, and gathering information on the potential effect of global climate change on U.S. natural resources. LBNL, along with other national laboratories, is working to develop new programs in partnership with the Environmental Protection Agency (EPA) that advance national environmental goals, including the more efficient use of energy to reduce greenhouse gas emissions.

## *Department of the Interior*

Laboratory scientists are investigating the geochemistry of selenium and other trace elements at Kesterson Reservoir, which has been a terminus of agricultural drainage water in California's San Joaquin Valley. Continuing collaborative investigations are under way to evaluate remediation techniques for the area's soil. Related research is being conducted at Stillwater Marsh, Nevada.

## *Agency for International Development*

The Agency for International Development is supporting a multiyear effort in which LBNL will perform research in support of improving the efficiency of energy use in developing countries.

## *Other Agencies/State and Private*

The Laboratory conducts research for the Electric Power Research Institute (EPRI). Chemistry-related research includes studies on reducing oxidation and scale formation, and on oxygen depletion in compressed-air storage. Another EPRI project is the study of surface modification with metal plasma techniques.

The Gas Research Institute supports databases on the influence of clays on seismic-wave attenuation in reservoir rocks. The California Air Resources Board is sponsoring an analysis of polycyclic aromatic hydrocarbons in indoor air.

LBNL's expertise in buildings is recognized by the California Energy Commission and the energy utilities. Much of the support is through the California Institute for Energy Efficiency (CIEE), a joint effort among the California energy utilities, LBNL, the University of California, and the California Energy Commission and Public Utilities Commission. CIEE manages a focused research program, with the research being carried out by California universities and DOE national laboratories located in the state. CIEE's overall research framework is determined by a research board consisting of high-level executives from the utilities, the University, the commissions, DOE, the Gas Research Institute, and EPRI. A planning committee with members from these same institutions approves individual research projects within this framework. CIEE serves in effect as a Work-for-Others (WFO) agency that evaluates and funds proposals from LBNL, along with those from other California research institutions. Particular LBNL projects funded by CIEE include the study of efficient systems for thermal distribution in buildings, integrated envelope and lighting technologies, end-use technology performance data, urban landscape modifications to reduce energy use and air pollution, and advanced combustion devices to reduce nitrogen oxide emissions.

Additional utility support is as follows: Southern California Edison supports window studies; Pacific Gas and Electric Company supports a study of end-use energy intensifiers in commercial and residential buildings; and the Sacramento Municipal Utilities District supports energy-savings studies of shade trees and other surfaces.

# Laboratory-Directed Research and Development

This program contributes to scientific staff capability and vitality through the support of new research programs of merit and potential. Examples of project areas eligible for support include:

- Work in forefront areas of science and technology that enrich Laboratory research and development capabilities
- Advanced study of new hypotheses, new experiments, and innovative approaches to development of new concepts or knowledge
- Experiments directed toward proof of principle for initial hypothesis testing or verification
- New-device studies to explore possible application to instrumentation or experimental facilities

Recent achievements sponsored by the Laboratory Directed Research and Development (LDRD) program in the energy sciences include research in interface and nanostructure materials, blue-light-emitting diodes and lasers, novel displacement detectors for seismology, time-of-flight spectroscopy of rare gases, x-ray reduction lithography, novel chemical dynamics studies, studies of fullerenes, new high-pressure semiconductor processing, and advanced techniques for electron microscopy. Research achievements in the general sciences were directed towards prototype tracking and timing detectors, ultraviolet free-electron lasers, new types of silicon-tracking systems, and new data-acquisition systems. Achievements in the biosciences area include analysis of a cell-cycle regulatory gene, single DNA molecule chemistry, testing of novel mismatch repair enzymes, x-ray crystallographic studies of ribonucleic acid (RNA), and environmental air pollutants and oxidative stress. Achievements in the resources and operations areas included studies on neutron detectors for future applications and studies in high-density packaging of high-frequency integrated circuits. The annual *Report on Lawrence Berkeley Laboratory, Laboratory Directed Research and Development Program* is available from the Office for Planning and Communications. Planning documents that indicate program directions and projected resources are prepared annually.

Laboratory Directed Research and Development Program

| Category | FY 1993 Actual | FY 1994 Actual | FY 1995 Authorized | FY 1996 Projected |
|---|---|---|---|---|
| Funding ($M) | 5.1 | 5.2 | 7.6 | 7.9 |
| Projects Approved | 48 | 52 | 48 | — |

# Science and Technology Partnerships

To support DOE's mission to increase the nation's technological competitiveness, LBNL continues to redefine and enhance its programs to develop science and technology partnerships. LBNL recently created Industry and Government Partnerships (IGP), a new group that combines the technology transfer department with government and community relations efforts. The new group strives to fortify ties to federal and state government and to make technology applications and transfer an integral part of all LBNL programs. The thrust of IGP's mission will be to accelerate the process by which the knowledge gained from LBNL's scientific research is converted into technological goods and services. IGP will build new partnerships with industrial and nontraditional government partners; provide stewardship of technology and intellectual property; strengthen business relationships and establish LBNL as a preferred business partner; increase business volume to create income; and fortify ties with our many constituents.

## *Technology Transfer Program Direction*

The group has comprehensive responsibility for providing technology transfer services, including work for others and user facilities agreements. For DOE's Energy Research Laboratory Technology Transfer Program, it manages the selection of projects using an extensive peer review process and is implementing a project management program for all key projects.

Members of the IGP group work closely with the research divisions to select and promote technologies available for licensing and collaboration with industry. It negotiates intellectual property agreements and

Cooperative Research and Development Agreements (CRADAs); manages the interface with licensees and CRADA participants; and oversees submission, approval, and tracking of sponsored research projects. IGP keeps researchers apprised of new funding or partnership opportunities and acts as an interface for DOE small-business partnerships.

## *Work for Others*

LBNL annually receives in excess of $40 million in sponsored research funding from non-DOE sponsors. The National Institutes of Health (NIH) have sponsored the most non-DOE funded research at LBNL over the past ten years. Their annual support to LBNL exceeds $15 million for a variety of research projects in the biomedical field. Other sponsors supporting large research projects at LBNL include the office of Naval Research, which is expected to fund the Molecular Design Institute for research on the synthesis of novel materials at the molecular lithographic level. Large industrial sponsors include Amgen, who continues to fund a large project in automated sorting of cDNA libraries.

Technology Transfer Program

| Category | FY 1994 | FY 1995[a] | FY 1996[a] | FY 1997[a] | FY 1998[a] | FY 1999[a] | FY 2000[a] | FY 2001[a] |
|---|---|---|---|---|---|---|---|---|
| Activity | | | | | | | | |
| Industry Cooperative Agreements | 28 | 50 | 50 | 55 | 60 | 60 | 60 | 60 |
| Agreement Value ($M)[b] | 7 | 20 | 29 | 30 | 37 | 37 | 37 | 37 |
| Personnel Exchanges | 6 | 14 | 15 | 15 | 15 | 15 | 15 | 15 |
| Staffing | | | | | | | | |
| Technology Transfer Department[c] | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

[a]Estimated approved (CRADAs only).
[b]This represents total dollars awarded by calendar year (vs. funding received annually).
[c]Excludes Work for Others (WFO).

## *Partnerships with Industry*

### Marketing/Outreach

LBNL's outreach objective is to increase the recognition of LBNL as a major resource for new technologies and partnerships. To promote LBNL's technologies, the Technology Transfer Program uses a broad range of communication tools, from press releases and brochures to exhibiting at trade shows. As a result of successful marketing efforts, LBNL received over 600 inquires from the private sector in FY 1994. Each inquiry receives personal, one-on-one contact by letter, by phone, or by visiting LBNL facilities. An LBNL inquiry database is maintained to track interactions. One example of a successful communications effort is the "New Technology Announcement." The attributes of a new invention available for licensing or collaborative partnership are summarized using attractive layouts that highlight potential product applications. The package is sent to the corporate executive in charge of company development, who is targeted through a high-technology corporate database. LBNL also distributes the announcements to emerging technology newsletters and releases them to trade journals and the general press.

As part of its marketing mix, LBNL also attends several trade shows and conferences each year. Conferences are targeted to match the Laboratory's scientific and technical areas of expertise. Shows have included the Society of Automotive Engineers' (SAE) yearly congress and exposition, BIO, the Western Universities Technology Transfer Conference, NASA's technology transfer 2000 series, 3M's Technology Fair, and the Industrial Energy Efficiency Conference sponsored by DOE's Office of Industrial Technology.

Attending trade shows is an excellent means of gaining exposure for LBNL. For example, LBNL's attendance at Technology 2003 in Anaheim, California, resulted in over 250 corporate contacts.

LBNL has instituted several effective outreach innovations. The Laboratory is on the information superhighway with a variety of documents that describe LBNL, including LBNL's Catalog of Research Abstracts and a listing of technologies available for licensing and collaboration. The information is available to users of the global Internet via Gopher and the World Wide Web. LBNL is also one of several DOE laboratories participating in a pilot program to put its technologies, expertise, and partnership information on a new nationwide DOE database aimed at making partnership information available to the broadest possible business audience. The database, known as the DOE Technology Information Network (DTIN), will be accessible via the World Wide Web, and will contain information from 13 DOE national laboratories.

Because outreach involves Laboratory networking, internal programs will focus on the important opportunities to perform collaborative research with U.S. industry. One way in which this is being accomplished is through a technology transfer liaison, a senior division manager or technology transfer specialist who acts as a single point of contact within each of the 12 research divisions to help disseminate technology transfer opportunities, new funding sources, updates, technology inquiries, and requests.

## ER-LTA Program

LBNL's Energy Research Laboratory Technology Applications (ER-LTA) Program has been established to support DOE's overall Technology Transfer Program, which aims to enhance U.S. industrial competitiveness through beneficial collaborations between the national ER laboratories and industry. The program goal is to derive maximum value for the American public from technology developed at LBNL. Funding mechanisms include Cooperative Research and Development Agreements (CRADAs), maturation projects, technical assistance, and personnel exchanges. Partnerships include major projects like the AMTEX collaboration and the Advanced Computational Technology Initiative. Over 80 ER-LTA projects have been funded with industrial partners such as Rockwell, Amgen, Motorola, Seagate, Chiron, AccSys Technology, Octree Corporation, Advanced Photonics, Mas Par, and Intel. Other partners include IBM, Siemens, Rhone Poulenc, Kaiser Foundation Hospital, Motorola, and Bay Technical Products. DOE funding to date totals over $25 million, and combined industry and DOE commitments exceed $40 million. Overall, the ER-LTA Program is an important funding source, supporting the Laboratory's key core competencies at a $10–15 million per year level.

## Industrial Development Program

The Industrial Development Program is an outreach of the Technology Transfer Department, staffed with personnel who have scientific and industrial backgrounds. Internally, LBNL's evaluation of new scientific and technological results is coupled to markets and specific industrial candidates. Expertise and strategies for presentation of LBNL capabilities, including technology transfer mechanisms, are then presented to industry and/or local institutions jointly with the scientific team.

To maximize the effectiveness of the LBNL/ industry efforts, the resources of LBNL should be focused where the greatest leverage is gained from a match between Laboratory talent and infrastructure, and industry needs. The Laboratory would benefit most from a focus on local industries.

For example, biotechnology is a well-matched industry. The biotechnology industry was born out of UC San Francisco, UC Berkeley, Stanford, and LBNL. The greatest concentration of biotechnology companies in the U.S. is located in the Bay Area and in California. This high-growth industry is expected to create one-third of the new jobs in California (200,000) over the next five years. The industry is already closely tied to existing scientific programs with LBNL, including the Human Genome Center, the Materials Sciences Division, the Structural Biology Division, the Life Sciences Division, and the Advanced Light Source. These divisions and centers employ a substantial fraction of the scientific and technical staff of the Laboratory. This synergy of human resources, a unique physical infrastructure, and an industry with positive growth potential can keep the U.S. at the top of the international biotechnology industry. LBNL intends to contribute to the success of this exciting field.

## Opportunities for Small Business

LBNL's Technology Transfer Department is the designated contact for small business outreach. Small businesses are a major source of job creation, economic growth, and technological innovation in our economy. Current technology policies create both an opportunity and an obligation for all federal agencies to sharpen their strategic focus on American industrial competitiveness and job creation. One of DOE's highest priorities is to work with existing public- and private-sector networks for reaching small and historically underutilized businesses. In the last round of approved LBNL/ER-LTA CRADAs, 100% were with small companies. LBNL is committed to helping small businesses leverage their R&D resources.

## Intellectual Property

In addition to increasing its outreach training efforts and encouraging its scientists to become involved in technology transfer opportunities, LBNL has developed a "Technology and Invention Inventory," which lists LBNL technologies (including patentable inventions, public domain technologies, mask works, and copyrightable works) in database form. The database yields information regarding subject area, patent and licensing status, and scientists. Portfolio categories of technologies that interest U.S. companies include transportation technology, chemical processes, new materials, sensors and detectors, energy-efficiency technology, ion sources, new instrumentation, medical applications, software, biotechnology, and environmental technology. The Laboratory is taking steps to identify potential intellectual property early in the creation process, to encourage its development, and to ensure its protection through appropriate means. The technology transfer staff works closely with the LBNL Patent Department to ensure the early identification of commercializable ideas.

## Patents and Licensing

LBNL seeks to patent and license its intellectual property to strengthen the value of its inventions, both for use and application by industry and to promote the research and technology transfer interests of the Laboratory and its research staff. LBNL filed 31 patent applications in FY 1994, and 15 patents were issued. The number of licensing agreements in FY 1995 to date already exceeds FY 1994's total, and LBNL expects the rate of licensing to increase significantly as additional licensing staff join the Technology Transfer Department in the last quarter of FY 1995.

Licensing income typically arises from three terms in the license agreement: an up-front, one-time license issue fee; minimum annual royalties; and sales royalties. Intellectual property from a research laboratory may require considerable development effort. Thus, sales royalties are not expected to begin until several years after the license is signed. Licensing and royalty income is distributed according to University of California policy and is consistent with patent law. Patent prosecution costs are first deducted, and University policy allows the Laboratory to assign 15% for administrative costs for licensing effort and in maintaining the license. After the inventor receives a share, the remainder is available for laboratory research. Consistent with patent law, 75% of the royalty income that exceeds 5% of LBNL's annual budget will be paid to the U.S. Treasury.

Intellectual Property Management

| Category | FY 1994 | FY 1995 (est.) | FY 1996 (est.) | FY 1997 (est.) | FY 1998 (est.) |
|---|---|---|---|---|---|
| New Licenses (No.)[a] | 14 | 25 | 30 | 30 | 32 |
| License Income ($K)[b] | 66 | 150 | 180 | 280 | 300 |
| U.S. Patent Applications | 31 | 30 | 33 | 34 | 35 |
| U.S. Patents Issued | 15 | 21 | 23 | 23 | 24 |
| Patent Staffing | 3 | 3 | 4 | 4 | 4 |
| Intellectual Property Use of Income[c] Management | | | | | |

[a]Includes options.

[b]Cash in only (i.e., not including fair market value of noncash income).

[c]Invention & ORTA Administration: 15% of gross income plus patenting costs.
Scientific or Applied R&D: 50% of net income.
Awards & Inventor Payments: 50% of net income.
Education/Training: 0.
Other (Specify): 0.

## Industry–Laboratory Cooperative Projects

LBNL has approximately 50 CRADAs with private industry. CRADAs and private industry-sponsored WFO brought approximately $17 million into LBNL in the last fiscal year. In addition to participating in a number of CRADAs with small business partners, LBNL is a participant in many large partnership CRADAs, including ones with AMTEX, USABC, and ACTI.

Examples of some current ER-LTA funded industry–LBNL cooperative projects are:

- **Neurochemical Imaging of Gene Therapy.** LBNL is putting its medical imaging technology to work in the fight against Parkinson's disease through a $2.5 million partnership with Somatix Therapy Corporation of Alameda, California. The collaboration will test a method for restoring levels of important brain chemicals in animals, with hopes of eventually developing a similar treatment for human Parkinson's patients. Parkinson's afflicts almost a million people in the United States. Somatix will use genetic engineering to create fibroblast skin cells that produce the neurochemical dopamine, which is depleted in patients with Parkinson's. The altered cells will be implanted in brains of animals with the disease. The Life Sciences Division's Center for Functional Imaging at LBNL will use scanning techniques to study to what extent dopamine levels are restored by fibroblasts. Positron emission tomography (PET) and single photon computed tomography (SPECT) scans will detect radiolabelled compounds that are specifically taken up by dopamine-producing cells in the injected animals. Somatix plans to develop a way to insert genes into human cells that will allow the cells to produce specific chemicals. Such cells could then be implanted into the brains of patients to restore deficiencies related to brain diseases such as Parkinson's and, possibly, Alzheimer's.
- **Blue-Emitting GaN LEDs and Lasers.** LBNL has a $340,000 CRADA with Hewlett-Packard of Palo Alto, California, to develop blue-emitting GaN LEDs. This partnership combines LBNL's advanced materials expertise with HP's market-leading electronics know-how to produce the next generation of photonic products such as high-density optical data storage, flat-screen color television and displays, and energy-efficient lighting. The flat-panel display market alone is potentially huge, and already hotly contested by foreign competitors. The development of blue LEDs and lasers will complement red and green LEDs and lasers, which are already common, and be the enabling technology for the production of high-resolution-color, flat-panel displays. LBNL is assisting HP to develop a GaN LED that will allow them to retain their lead in this field.

- **Development of a Light-Rail Object-Avoidance Prototype.** LBNL is involved in a personnel exchange with Spacek Labs , Inc., and MM Wave Technology that will address the issues of wavelength, angular resolution, and range determination (sensitivity) to develop a high-technology sensor system suitable for fast-moving light rail systems and other applications. The proposed system will be similar to anticollision systems for aircraft but will be smaller and more locally operated. The technology could also be used in the larger, developing market of anticollision systems for automobiles.

## AMTEX: The AMerican TEXtile Partnership Program

The AMTEX Program is a partnership of the integrated U.S. textile industry and its suppliers (the Industry), the nation's textile research universities, the DOE, and the DOE national laboratories. The Industry encompasses fiber producers, textile and fabric manufacturers, apparel and home furnishings manufacturers, industrial products manufacturers, and retailers of such products. It is among the largest contributors to the national economy, is the largest employer in the U.S. manufacturing sector, and has a long history of excellence in product development. However, today the Industry is being seriously threatened by offshore competition. The rise of imports has accounted for a loss of over 400,000 jobs in the last 10 years. Unless trends are reversed, it is predicted that another 500,000 jobs will be lost over the next 10 years and the Industry may eventually be lost.

AMTEX is a program to fuel the national economy through technological improvements. The program is composed of a large variety of R&D efforts. Lawrence Berkeley National Laboratory provides research excellence in many of these areas. One of the first priorities is the Demand Activated Manufacturing Architecture (DAMA) Project, which seeks to facilitate step-change improvements in the competitiveness of the Industry by designing information systems and business practices that will enable more effective and responsive business decision-making strategies. LBNL's participation in the DAMA project is in the leadership of the Enterprise Understanding Task. The purpose of the Enterprise Understanding Task is to understand the Industry as a whole—its structure, its dynamics, its limitations, and the future structures that will make it more effective—and to introduce communication technology, where appropriate, to improve the timeliness of response and enhance industrial linkage.

LBNL is also leading the Rapid Cutting Project, the objectives of which are to develop a new generation of cutting systems and improve the technology in current systems as to cutting quality and efficiency. Such systems will make true on-demand manufacturing of apparel available to large and small manufacturers. New cutting systems involve such innovative technologies as ultra-high-speed laser cutting, photochemical cutting, advanced materials for knife blades, and new types of mechanical actuators. Government investment in advanced ceramics, high-power lasers, and control systems form the technological basis for this work.

LBNL is also participating in the Computer-Aided Fabric Evaluation, Textile Resource Conservation, and Cotton Biotechnology Projects. The Computer-Aided Fabric Evaluation Project will develop inspection systems to assure high-quality, consistent textiles, using advanced computer vision systems to detect and classify defects in greige (undyed, unfinished fabrics) as well as solids, prints and woven patterns. The objective of the Textile Resource Conservation Project is to develop processes that will meet the needs of the Industry for recovery and reuse of chemical and solid wastes, reduction of waste sources, and new environmentally benign processes. The Cotton Biotechnology Project hopes to revolutionize advancements in the qualities and performance of cotton fiber, such as strength, length and uniformity.

A novel and important aspect of this initiative is the linking of the DOE and its resources with an entire industrial network. The partnership involves all of the national laboratories and an industry represented by industrially supported technology centers that provide a focal point for technology developments and university involvement. This powerful synergy can be a role model for revitalizing entire sectors of the U.S. economy. The DOE stands to reap benefits from this collaboration as well. Thanks to the AMTEX partnership, DOE is gaining mature, industry-tested technologies and field-experienced staff able to solve problems more rapidly and at a lower cost in DOE's core mission areas, including energy, environment, materials sciences, and national defense.

# University and Science Education

The Center for Science and Engineering Education (CSEE) develops and implements programs that utilize the resources of LBNL to improve the quality of mathematics, science, and technology education in the United States. On an annual basis, CSEE educational activities reach thousands of students and faculty from kindergarten through postgraduate school. With a total annual budget of $2.8 million, CSEE programs are funded primarily by the Department of Energy, with additional funding from the National Science Foundation and the National Institutes of Health.

## *Ongoing Initiatives*

Since its inception in 1987, CSEE has developed programs in six areas. These areas represent target audiences in the educational continuum from precollege to post graduate and include the professional development of high-school and university science faculty. The programs and activities in each of these areas are matched to the needs of the target audiences and to the resources of the Laboratory.

**Precollege Programs.** Encompass eight subprograms that focus on systematic reform and student and faculty development. Especially noteworthy is the Bay Area Science and Education Collaboration (BASTEC), which provides a broad range of educational activities and curriculum support for the Oakland Unified School District, a large urban school district with over 55,000 students and 2000 teachers. The Teacher Research Associate Program has been instrumental in creating leadership opportunities for teachers and continues to lead in the development of new programs and activities at LBNL, such as Hands-On Universe, and in classrooms across the country. In addition to BASTEC and the Teacher Research Associate Program, the precollege programs support sponsorships and provide institutes for the professional development of science teachers. Student programs include the National Science Bowl Competition and a four-week life sciences institute for outstanding high-school students from across the country.

**College and University Programs.** Provide students and faculty from across the country with research experience in LBNL scientific and engineering programs. Both summer and academic-year programs are characterized by long-term, close mentor relationships that provide participants with in-depth exposure to the world of scientific research and development.

**Educational Outreach Programs.** Focus on supporting the educational needs of students and teachers in the San Francisco Bay Area. The programs are noted for their cadre of LBNL employees who volunteer to work in individual classrooms and for summer research programs for high-school students from groups that are underrepresented in the sciences.

**The Science Consortium.** Is a collaboration of three entities—LBNL, Jackson State University in Mississippi, and the Ana G. Méndez University System in Puerto Rico. These three organizations work together to promote computer and science education in the academic institutions through collaboration with LBNL scientists.

**Hands-On Universe.** Provides students with an opportunity to participate in the ongoing automated supernova search at LBNL. The project is carried out collaboratively with the LBNL Physics Division and the Institute for Nuclear and Particle Astrophysics. Currently in the development, testing, and early evaluation phase, Hands-On Universe is an international partnership with over 10 museums, 30 teachers, 1000 students, and leading science education specialists across the country. The project links students to automated telescopes through the Internet.

**The Community College Connection.** Provides educational services to students and faculty in community college career education programs. Program components include a Cooperative Work Education Program, a Speakers' Bureau, LBNL tours designed to augment course curricula, and a summer faculty research associate program. Future plans include a school-to-work component for community college vocational students.

## *New Initiative*

**The Educational Technology Program.** Coordinates the educational efforts of various research divisions at LBNL to promote and deliver materials for the nation's classrooms through the World Wide Web. Examples of programs under development include: Microworlds, based on the work at the ALS, with its imbedded assessment tools and curriculum materials; the Human Genome Project Ethical Legal and Social Issues; and the Whole Frog Project, with its Frog Dissection Kit. LBNL will extend its outreach to the nation's classrooms through the use of the World Wide Web. As an extension of this area, partnerships are being developed with Far West Laboratory for Educational Research and Development, the California Math and Science State Systemic Initiative, and other state-wide mathematics and science education programs organized under the UC Office of the President.

Science/Math Educational Program Participation

| Programs | FY 1994 Totals | FY 1994 Minorities[a] | FY 1994 Women | FY 1995 Totals | FY 1995 Minorities[a] | FY 1995 Women |
|---|---|---|---|---|---|---|
| *Precollege Programs* | | | | | | |
| Bay Area Science and Technology Collaboration (Teachers) | 902 | 450 | 675 | 1,272 | 579 | 890 |
| Bay Area Science and Technology Collaboration (Students) | 4,672 | 3,928 | 2,216 | 17,464 | 12,790 | 8,557 |
| Teacher Research Associates Program (Teachers) | 40 | 9 | 22 | 30 | 3 | 12 |
| High School Honors (Students) | 64 | 8 | 36 | 68 | 10 | 41 |
| Updating Science Knowledge for Instruction (Teachers) | 420 | 95 | 257 | 429 | 97 | 256 |
| Science Bowl (Students) | 96 | 10 | 15 | 96 | 9 | 14 |
| Education Outreach[b] | 20,000 | 8,000 | 10,000 | 25,000 | 10,000 | 9,000 |
| Student Research Program | 5 | 25 | 19 | 25 | 24 | 19 |
| Student Work Experience Program | 15 | 15 | 8 | 15 | 15 | 8 |
| National Teacher Enhancement (NTEP) | 19 | 10 | 13 | 28 | 12 | 16 |
| Oakland Science Explorers Program | 10 | 3 | 7 | 10 | 3 | 7 |
| *Undergraduate Programs* | | | | | | |
| Community College Connection (Faculty Development) | 236 | 43 | 84 | 234 | 29 | 123 |
| Community College Transfer[c] | 5 | 4 | 2 | 2 | 2 | 1 |
| Laboratory Co-op Program | 18 | 2 | 6 | 36 | 10 | 17 |
| Environmental Management Career Opportunities for Minorities | 1 | 1 | 1 | 0 | 0 | 0 |
| Minority Access to Energy-Related Careers | 8 | 8 | 2 | 10 | 10 | 3 |
| LBNL/JSU/AGMUS Consortium | 19 | 19 | 17 | 20 | 20 | 9 |
| Science and Engineering Research Semester | 24 | 3 | 9 | 38 | 5 | 16 |
| Faculty/Student Teams (Faculty)[c] | 5 | 3 | 1 | 2 | 2 | 0 |
| Community College Co-op (Students) | 0 | 0 | 0 | 2 | 1 | 2 |

[a]Minority numbers are for underserved groups only.
[b]This program covers Northern California.
[c]Estimate includes summer programs.

# V. CRITICAL SUCCESS FACTORS

LBNL's strategic planning focuses on aligning the Laboratory's management and operational systems so as to support DOE national research programs and achieve Vision 2000. A number of organizational systems have been identified as critical factors for measuring the Laboratory's performance. The previous section addressed the programmatic initiatives and research directions whose performance is essential for meeting the needs of LBNL's customers—principally DOE, other federal agencies, industrial partners, and state and local agencies. This section describes the management and operational systems that support LBNL's programs and are a key to successful research management and institutional planning.

## HUMAN RESOURCES

LBNL's strategic plan supports a major human resources initiative in clearly communicating performance expectations and empowering the staff to pursue these goals in an atmosphere of mutual trust and respect. This endeavor undergirds DOE's efforts for aligning human resources with agency priorities. We are seeking an increase in the diversification of workforce organizations—with streamlined management, the utilization of continuous process improvement tools in systems review, and empowered employees—all of this occurring with less regulatory oversight so that LBNL and the Department can respond to today's technology-demanding economy.

An LBNL human resources strategic planning effort involving Division Directors, LBNL Center Heads, and Senior Administrative and Human Resources staff has resulted in the formation of a vision and mission for the Human Resources Department at Lawrence Berkeley National Laboratory. This mission is to positively influence the organization's culture by offering quality programs and services to our customers and proactively supporting all organization members in establishing, maintaining, and promoting a team-oriented work environment within an atmosphere of mutual respect and trust.

Each individual is provided opportunities and is challenged to reach his or her highest potential, resulting in maximum productivity, creativity, and job satisfaction.

Our ultimate goal is a motivated, committed, and educated work team, ready to serve our partners, peers, and the community to achieve the objectives of the Laboratory.

The Human Resources Strategic Plan has resulted in the creation of a set of operating principles and expected outcomes concerning the delivery of services in the areas of compensation, employee relations, labor relations, benefits, training, reception center, and staffing. In each of these areas, we are challenged to deliver valuable services to our customers.

The principles that guide our performance require us to establish a consultative partnership with our clients. Our efforts will support institutional goals and directives that are situationally rather than structurally based. We need to be flexible and offer a market-based compensation program focusing on duties and responsibilities. We will deliver training that is skilled and behavioral and value based, and that incorporates the "Laboratory culture." We expect a bipartisan employee relations climate that balances management's perspective with the employee's perspective, where our Employee Relations staff is valued for its objectivity and quality consulting.

LBNL's initiative directly addresses the barriers to achieving human resources goals that DOE has identified within many departmental elements. These barriers include resource constraints, complex personnel systems, competition for diversity talent, and historic cultures that impede trust and delegation of responsibility. The principal components of LBNL's human resources planning effort are discussed below and are also summarized in Section III, "Laboratory Strategic Plan."

# Laboratory Personnel and Programs

LBNL's most valuable resource is its people—the scientists, engineers, and support staff who contribute their many diverse skills to advance the Laboratory's research programs. The Laboratory's scientific and engineering staff are known for a wide range of accomplishments and honors. Nine LBNL scientists have become Nobel laureates, sixteen have won Lawrence Awards, and four have won Fermi Awards. Of its present staff, 55 have been elected to the National Academies of Sciences and Engineering. Much of this success is founded on the Laboratory's ability to create highly effective teams of scientists, engineers, technicians, and students—then to orchestrate their efforts to produce a rich yield of basic knowledge and applied technology. From scientific leadership to technical expertise to administrative support, all parts of the team are necessary if we are to succeed.

To reinforce our successes, the Outstanding Performance Award (OPA) Program has been developed to recognize and reward individuals and teams that support the Laboratory's strategic plan. Examples of areas of achievement include technology transfer, total quality management, and workforce diversity.

A large part of the Laboratory's success is also due to the many graduate and undergraduate students who contribute their efforts each year, as well as the many senior staff scientists jointly appointed as faculty on the UC campuses, primarily at UC Berkeley. This relationship with UC provides a unique ability to interact with the broader university community, and helps to attract and retain a professional staff of high caliber. All of these factors contribute to LBNL's mission to promote excellence in education and training, both for its own employees and for the greater scientific community. Our ultimate goal is to offer exceptional opportunities for professional growth, in an environment where achievement is recognized and rewarded at every level.

The Laboratory's Human Resources programs are administered in a manner consistent with the Prime Contract with the University of California and the Department of Energy. The Laboratory has adopted a compensation philosophy with the following objectives:

- To provide a level of compensation that, within available funds, attracts, motivates, and retains the quality work force necessary for the achievement of Laboratory goals.
- To recognize and reward performance and productivity while maintaining a competitive market position and providing internal Laboratory equity.

In its administering of the Human Resources programs, the Laboratory strives to deliver Human Resources systems in a cost-effective manner; develop and maintain work force excellence; strengthen the Laboratory's commitment to achieving work force diversity; and guide Human Resources programs and operations in accordance with the Laboratory's quality strategies and initiatives.

The LBNL Reception Center provides all the services one needs to get started at LBNL: check-in for casual visitors (such as meeting participants) and participating visitors (those who will engage in standard activities at LBNL such as scientific research); new employee identification badges, parking permits, and card keys; safety orientation for those who will work on site; and a help desk to answer questions before, during, or after visits. The Reception Center also provides coordination of all conferences hosted by LBNL, housing lists for temporary guests, and oversight of organized employee activities such as recreational clubs, buying services, and special events.

Human Resources programs and initiatives that are planned for the next fiscal year include:

- Developing and maintaining an applicant pool that is diverse, current, and highly qualified.
- Streamlining the hiring and recruitment process, with more scientific and engineering activity occurring in the research divisions and more administrative hiring occurring centrally.
- Providing affirmative action guidelines and resources.
- Implementing a career development program and an integrated management program with defined skill sets for each management level.
- Implementing supervisory training programs that reinforce and support Laboratory quality initiatives.

- Developing a proactive role for Employee Relations and Labor Relations staff that balances employee concerns with management needs.
- Developing programs that effectively coordinate the Laboratory's employee resources.
- Developing and implementing alternative rewards programs, including nonmonetary rewards, spot awards, and employee-initiated awards.

Laboratory Staff Composition (Full- and Part-Time Personnel—FY 1994)

| Group | Doctoral | Master's | Bachelor | Other | *Total* |
|---|---|---|---|---|---|
| Professional Staff | | | | | |
| Staff Scientists | 825 | 53 | 49 | 6 | 933 |
| | (24.0) | (1.5) | (1.4) | (0.3) | (27.2) |
| Engineers | 74 | 125 | 143 | 34 | 376 |
| | (2.2) | (3.6) | (4.2) | (1.0) | (11.0) |
| Management/Administrative | 33 | 100 | 193 | 282 | 608 |
| | (1.0) | (2.9) | (5.6) | (8.2) | (17.7) |
| Support Staff | | | | | |
| Technicians | 9 | 104 | 211 | 627 | 951 |
| | (0.3) | (3.0) | (6.1) | (18.3) | (27.7) |
| All Other | 0 | 111 | 330 | 124 | 565 |
| | (0.0) | (3.2) | (9.6) | (3.6) | (16.5) |
| *Total* | *941* | *493* | *926* | *1073* | *3433* |
| | *(27.4)* | *(14.4)* | *(27.0)* | *(31.3)* | *(100.0)* |

## *Training and Development Programs*

Through a combination of on-the-job training, in-house training programs, and attendance at programs/courses provided by non-Laboratory institutions, the technical skills of the Laboratory's employees are constantly upgraded to keep current with rapid technological advances.

The development of training in leadership skills continues. The pilot program now includes approximately 200 managers, supervisors, Laboratory Heads, and Division Directors. We have now moved beyond the pilot and are developing a program for the scientific organizations. Ultimately, this training will be integrated into the Laboratory's required training program.

In addition, the Human Resources Department offers a range of management and supervisory development courses. One of these is the ongoing training program to assist managers and supervisors of disabled employees. Special events have been held to heighten the awareness of the Laboratory community regarding employment of the disabled, including workshops and demonstrations of equipment to assist disabled employees. The Vocational Rehabilitation Service is available to assist supervisors in making accommodations for employees and potential employees with disabilities. Other important Human Resources Department programs and activities include on-site and off-site programs to assist employees in developing their skills. Several of these courses emphasize communications, including *The Pronounced Difference: Speech Evaluation Workshop for Non-native Speakers of English.* In addition, the Laboratory has an education assistance and tuition reimbursement program to assist employees in obtaining advanced training and education through approved employee development plans.

In addition to providing training, the Laboratory maintains an Employee Assistance Program (EAP), which offers counseling to employees with problems that often impact job retention, personal well-being,

and effective job performance. These resources and programs are available through the Human Resources Department's Employee Relations and Labor Relations offices and the Health Services Department. The long-range goal is to outsource this program, thereby offering comprehensive services for employees through a competent external organization.

More than 30 development courses and seminars are offered on site each year. The Laboratory also provides support for off-site training and education, including baccalaureate and advanced degrees as well as other professional training credentials. Scheduled on-site training and programs are conducted in environmental safety and health and in management, personnel, computer, and workstation skills.

# Work Force Diversity

As we move into the next century, one of the more dramatic changes affecting employers is the increasing diversity of both the state of California and the nation at large. The challenge for LBNL will be to continue and expand our efforts to create a climate in which diversity is valued. This means actively seeking diversity and fully supporting the contributions and changes brought about by diversity in our workplace. By recognizing, creating, and celebrating a diverse culture, LBNL aims to provide an environment that is accessible, equitable, and hospitable to all its employees and guests. Creating a workplace where diversity can thrive will also enable us to attract the qualified staff that we need to continue to conduct world-class science. In more recent years, the term "work force diversity" has been used at LBNL to recognize that there is a broader set of issues than the traditional focus on affirmative-action compliance. In effect, there is a new emphasis on harnessing diversity to the cause of scientific excellence. The term, then, is used to describe an environment, essentially a new workplace culture, in which a fundamental set of guiding principles and values form the community context in which diversity is practiced. Five key principles form the basis of the definition of diversity at LBNL:

- Differences in ethnicity, culture, gender, age, and lifestyle are valued for the variety of the perspectives they bring to the workplace. New perspectives and old perspectives are equally important.
- Differences are not only welcomed but actively sought.
- Management takes these differences into account in setting policies, motivating people, and giving rewards.
- The sense of being valued motivates all employees to put forth their best efforts and therefore leads to higher productivity.
- The spirit of mutual regard and cooperation leads to synergism—the state in which working together yields results greater than the sum of individual efforts.

In addition to these key principles, the Laboratory's Work Force Diversity Office, in partnership with senior management, will undertake the following specific programmatic initiatives as well as a wide range of programs that will enhance our ability to attract and retain qualified individuals:

- Aggressively seek women, people of color, and individuals from other protected classes who have the potential to achieve excellence at LBNL. Initiate new recruitment methods that identify potential candidates early in their educational careers.
- Mentor employees so that they can achieve excellence.
- Ensure a working atmosphere that is supportive and gives a sense of belonging to employees from all cultures.
- Provide resources to help managers and supervisors implement the Laboratory's affirmative action program.
- Develop new capabilities for the Laboratory as a whole and for each division to review their performance with regard to affirmative action issues.

## *Accomplishments in 1994-1995*

The following is a representation of several programmatic achievements that occurred in FY 1994:

**Mentor Program.** On a recommendation by the Laboratory's Committee on Diversity, LBNL implemented a pilot Mentor Program in the Engineering Division. The program pairs a skilled and experienced employee (mentor) with someone less skilled and experienced (protégé) so that the mentor can share his or her knowledge and experience with the protégé. The goals of the formal Mentor Program for the Engineering Division are to provide Engineering Division employees with a mentoring resource to develop and sustain skills and capabilities critical to current and future programmatic needs and opportunities; increase exposure to diverse skills, knowledge, and abilities; and collaborate with other LBNL staff to access their knowledge and experience. Discussions are underway with others in the Laboratory who are interested in establishing a mentor program in their areas.

**UC President's Postdoctoral Fellowship Program.** The Regents established this program in 1984 in order to improve the quality and diversity of UC faculty and to enhance the competitiveness of outstanding people of color and female Ph.D. degree holders for appointments at UC campuses and the DOE laboratories. The Laboratory hosts two fellows annually, and each fellowship is for a 12-month period, renewable for a second year pending evidence of satisfactory progress. The Laboratory has appointed six fellows in the last three years, three of whom are still in the UC President's Program. The program, which has been well received, has resulted in the development of a Lawrence Berkeley Laboratory Postdoctoral Fellowship Program. The Laboratory will continue to participate in the UC President's Program.

**Lawrence Berkeley Laboratory Postdoctoral Fellowship Program.** The Laboratory is developing its own year-round Postdoctoral Program aimed at improving diversity and developing promising scientists and engineers for career employment opportunities. The program has been implemented in 1995.

**Diversity Training.** The Laboratory has implemented a pilot Diversity Training Program for Environment, Health and Safety Division's (EH&S) supervisors and managers. This program represents a second generation of diversity training at LBNL within the last four years. The training program focuses on increasing one's awareness so as to create a work environment that is inclusive and welcoming to all employees and to enhance and develop skills for effectively managing differences. The program is being piloted for more than 30 managers and supervisors in EH&S before it is offered Laboratory-wide as a part of the ongoing Employee Development and Training Unit's on-site program.

**Employment Law Training.** Employment law training was offered to the Laboratory in Operations and Administration as a one-day workshop for supervisors and managers and as a half-day workshop for employees. It is expected that the employment law training program will be expanded to the Laboratory's scientific divisions in 1995. These training efforts demonstrate the Laboratory's renewed commitment to strengthening supervisory skills in managing diversity and addressing supervisor and employee expectations and responsibilities in the workplace.

**Child Care Center Working Group.** In late 1993, the Child Care Center Working Group (CCCWG), chaired by Deputy Director Pier Oddone, conducted a survey to gauge employees' interest in an on-site child care center. The survey was distributed to Laboratory employees in December 1993 and the results were compiled by the UC Survey Research Center. Based on the positive response of Laboratory employees, in June 1994 the CCCWG developed a business plan for an on-site child care center. The business plan was subject to a peer review in September 1994 by representatives from Argonne National Laboratory, Brookhaven National Laboratory, and Lawrence Livermore National Laboratory. Following the review, the Laboratory Director identified the on-site child care center as a high priority for the Laboratory. The Laboratory is in the process of identifying funding sources for the center.

## *Affirmative Action Program*

The Laboratory's Affirmative Action Program outlines activities, such as special recruitment, training, and employee development programs, aimed at improving access to the workplace for people in

underrepresented groups. It also serves as a working document that describes current policies, practices, and results in the area of affirmative action. It represents the Laboratory's framework for an affirmative approach to increasing the representation of people of color and women in segments of our work force where they have been underrepresented and increasing the employment of persons with disabilities and special-disabled and Vietnam-era veterans. The program describes the hierarchy of responsibility for Laboratory affirmative action, the mechanisms that exist for full Laboratory participation in the Affirmative Action Program, the policies and procedures governing recruitment at all levels, the Laboratory's plan for monitoring, reporting, and evaluating affirmative action progress, and a description of special affirmative action programs and plans the Laboratory has used and will use in its efforts to increase the representation and retention of groups historically underrepresented in our work force.

The Laboratory also has established measures to ensure that basic equal opportunity/affirmative action efforts have been incorporated into standard division procedures, such as the inclusion of AA/EEO responsibilities in supervisors' performance reviews, development of recruitment plans when vacancies exist, equity review of salary actions, and participation in related training programs. The following activities are part of the Laboratory's good-faith efforts that have expanded steadily over the last four years.

## Short-Range Plans

LBNL is committed to pursuing the following goals:

- Utilizing women and people of color in underrepresented job groups.
- Ensuring that the composition and vitality of candidate pools reflect the relevant labor market ethnic and gender composition.
- Assessing supervisors' AA/EEO contributions in their annual performance reviews.
- As vacancies appear during 1995, LBNL continues to target openings so as to obtain equitable access by diverse ethnic groups and women throughout the Laboratory. A special emphasis is placed on all professional and technical positions so that career opportunities are available for members of groups historically underrepresented in the science and engineering fields.
- Giving special attention to recruitment/outreach efforts in key underrepresented areas.
- Enhancing employment opportunities for individuals with disabilities and for covered veterans.
- Continuing efforts to educate the work force as to diversity awareness, goals, and objectives.
- The Work Force Diversity Office will continue to implement the recommendations contained in the Laboratory Diversity Committee Report, as approved by the Laboratory Director.
- Encouraging and obtaining active top management support of diversity considerations, including affirmative action and educational outreach efforts.
- The Work Force Diversity Office will continue to develop affirmative action reports for Division Directors to assist them in managing their affirmative action responsibilities and will assess how well divisions are using available opportunities to improve and meet their work force affirmative action goals.
- Line management will be targeted for greater participation in affirmative action recruitment for vacancies as they occur in the divisions. Managers will attend job fairs and related events and speak directly with qualified individuals interested in their specific areas.

## Long-Range Plans

Our goal is to increase the representation of women and people of color in our mid- and senior-management-level job groups. Community outreach activities, university and college relations initiatives, and refined and selective recruitment efforts will be utilized for this purpose.

With the help of the new Human Resources Information System database, which will be on line in FY 1996, trending analysis will be expanded and/or refined to include:

- Merit increases
- Upward mobility
- Promotions
- Transfers
- Special recruitment
- Reorganization
- Training and staff development
- Retention

By attaining all work-force statistical goals through the use of training programs, employment pools, and targeting of management-level positions, the Laboratory will be able to reduce or eliminate underrepresentation in job groups and/or classifications.

The following two tables are compiled from the Laboratory's 1990 and 1995 Affirmative Action Programs. The data source for each report is based on the preceding fiscal year (October 1 through September 30). The two tables show the Laboratory population for the 1989 and 1994 fiscal years and provide breakdowns by federal occupation category and by race and gender. Population figures are based on career-status employees. Representation of women has increased 11.2% in the Officials and Managers category and 26.1% for the Scientific and Engineering Professionals. Representation of people of color has increased 36.7% in the Officials and Managers category and 26.6% for the Scientific and Engineering Professionals.

Overall, the Laboratory's work force has increased with respect to the representation of women (13.6%) and people of color (8.0%).

## Lawrence Berkeley National Laboratory 1989

| Federal Occupational Category | Total | | Total | Minority | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Total | Black | Hispanic | Asian | Nat. Am. |
| Gender | Male | Female | Caucasian | M&F | M&F | M&F | M&F | M&F |
| OFFICIALS & MANAGERS | 90 | 22 | 97 | 15 | 7 | 3 | 5 | 0 |
| | 80.36% | 19.64% | 86.61% | 13.39% | 6.25% | 2.68% | 4.46% | 0.00% |
| PROFESSIONALS | | | | | | | | |
| Scientists & Engineers | 705 | 134 | 697 | 142 | 12 | 13 | 116 | 1 |
| | 84.03% | 15.97% | 83.08% | 16.92% | 1.43% | 1.55% | 13.83% | 0.12% |
| Management & Administrative | 63 | 132 | 141 | 54 | 18 | 12 | 24 | 0 |
| | 32.31% | 67.69% | 72.31% | 27.69% | 9.23% | 6.15% | 12.31% | 0.00% |
| TECHNICIANS | 451 | 70 | 400 | 121 | 33 | 28 | 59 | 1 |
| | 86.56% | 13.44% | 76.78% | 23.22% | 6.33% | 5.37% | 11.32% | 0.19% |
| All Other (Crafts, Laborers, Service Workers, Office, and Clericals) | 322 | 266 | 355 | 233 | 124 | 63 | 40 | 6 |
| | 54.76% | 45.24% | 60.37% | 39.63% | 21.09% | 10.71% | 6.80% | 1.02% |
| Total All Categories | 1631 | 624 | 1690 | 565 | 194 | 119 | 244 | 8 |
| | 72.33% | 27.67% | 74.94% | 25.06% | 8.60% | 5.28% | 10.82% | 0.35% |

Source: LBNL's 1990 Affirmative Action Plan. Figures are based on fiscal year 1989 (10/1/88–9/30/89).

## Lawrence Berkeley National Laboratory 1994

| Federal Occupational Category | | | | | Minority | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | Caucasian | | Total | | Black | | Hispanic | | Asian | | Nat. Am. | |
| Gender | Male | Female | M | F | M | F | M | F | M | F | M | F | M | F |
| OFFICIALS & MANAGERS | 111 | 31 | 89 | 27 | 22 | 4 | 8 | 1 | 4 | 0 | 9 | 3 | 1 | 0 |
| | 78.17% | 21.83% | 62.68% | 19.01% | 15.49% | 2.82% | 5.63% | 0.70% | 2.82% | 0.00% | 6.34% | 2.11% | 0.70% | 0.00% |
| Total Male & Female | 142 | | 116 | | 26 | | 9 | | 4 | | 12 | | 1 | |
| | 100% | | 81.69% | | 18.31% | | 6.34% | | 2.82% | | 8.45% | | 0.70% | |
| PROFESSIONALS | | | | | | | | | | | | | | |
| Scientists & Engineers | 742 | 187 | 590 | 140 | 152 | 47 | 12 | 4 | 15 | 1 | 124 | 42 | 1 | 0 |
| | 79.87% | 20.13% | 63.51% | 15.07% | 16.36% | 5.06% | 1.29% | 0.43% | 1.61% | 0.11% | 13.35% | 4.52% | 0.11% | 0.00% |
| Total Male & Female | 929 | | 730 | | 199 | | 16 | | 16 | | 166 | | 1 | |
| | 100% | | 78.58% | | 21.42% | | 1.72% | | 1.72% | | 17.87% | | 0.11% | |
| Management & Administrative | 71 | 158 | 48 | 115 | 23 | 43 | 5 | 16 | 6 | 7 | 12 | 19 | 0 | 1 |
| | 31.00% | 69.00% | 20.96% | 50.22% | 10.04% | 18.78% | 2.18% | 6.99% | 2.62% | 3.06% | 5.24% | 8.30% | 0.00% | 0.44% |
| Total Male & Female | 229 | | 163 | | 66 | | 21 | | 13 | | 31 | | 1 | |
| | 100% | | 71.18% | | 28.82% | | 9.17% | | 5.68% | | 13.54% | | 0.44% | |
| TECHNICIANS | 347 | 56 | 274 | 36 | 73 | 20 | 18 | 7 | 22 | 2 | 33 | 10 | 0 | 1 |
| | 86.10% | 13.90% | 67.99% | 8.93% | 18.11% | 4.96% | 4.47% | 1.74% | 5.46% | 0.50% | 8.19% | 2.48% | 0.00% | 0.25% |
| Total Male & Female | 403 | | 310 | | 93 | | 25 | | 24 | | 43 | | 1 | |
| | 100% | | 76.92% | | 23.08% | | 6.20% | | 5.96% | | 10.67% | | 0.25% | |
| All Other (Crafts, Laborers, Service | 252 | 266 | 161 | 140 | 91 | 126 | 38 | 76 | 34 | 26 | 15 | 23 | 4 | 1 |
| Workers, Office, and Clericals) | 48.65% | 51.35% | 31.08% | 27.03% | 17.57% | 24.32% | 7.34% | 14.67% | 6.56% | 5.02% | 2.90% | 4.44% | 0.77% | 0.19% |
| Total Male & Female | 518 | | 301 | | 217 | | 114 | | 60 | | 38 | | 5 | |
| | 100% | | 58.11% | | 41.89% | | 22.01% | | 11.58% | | 7.34% | | 0.97% | |
| Total All Categories | 1523 | 698 | 1162 | 458 | 361 | 240 | 81 | 104 | 81 | 36 | 193 | 97 | 6 | 3 |
| | 68.57% | 31.43% | 52.32% | 20.62% | 16.25% | 10.81% | 3.65% | 4.68% | 3.65% | 1.62% | 8.69% | 4.37% | 0.27% | 0.14% |
| Total Male & Female | 2221 | | 1620 | | 601 | | 185 | | 117 | | 290 | | 9 | |
| | 100% | | 72.94% | | 27.06% | | 8.33% | | 5.27% | | 13.06% | | 0.41% | |

Source: LBNL's 1995 Affirmative Action Plan. Figures are based on fiscal year 1994 (10/1/93–9/30/94).

### Future Efforts

The initiatives and programs mentioned here are by no means an all-inclusive list. They merely illustrate the direction and support of affirmative action and equal employment opportunity at Lawrence Berkeley National Laboratory. The Laboratory is committed to the idea and intent of equal employment opportunity for all people and will support the principles of EEO within the Laboratory at all times. The Laboratory will continue to implement new initiatives to further affirmative action and equal employment opportunity throughout the year. One such initiative is the College Relations Program. The Laboratory is developing a college relations program aimed at addressing underrepresentation that occurs among the Laboratory's Research Associates classification series. It is expected that this program will be implemented in 1995.

While the Laboratory is strongly committed to recruiting women and people of color into its work force, equally important is the retention of its current employees. In an effort to retain staff as well as to recruit promising scientists to the Laboratory, LBNL has restructured its scientist and engineer classification and pay program. This new structure, along with the recent establishment of scientist and engineer leadership positions, provides more clearly defined career paths in the areas of both scientific accomplishment and scientific management, formalizes accountabilities, and improves succession-planning capabilities. The Laboratory is directing its recruitment program toward three goals: (1) ensuring a breadth of experience, (2) maintaining a strong scientific and technical base in the work force, and (3) committing to its diversity goals. LBNL is active in recruiting promising scientists and engineers through its divisional fellow and postdoctoral associate programs, and each division is accountable for affirmative action/equal employment opportunity action-oriented programs aimed at achieving a diverse work force. LBNL has taken the following specific steps to achieve these goals:

- Strengthened the Laboratory's competitiveness in the recruitment marketplace, including an active advertising campaign, strong representation at job fairs, and training programs.
- Created outreach recruitment programs, including a widely distributed job listing, professional seminars, and search committees, with extensive participation of managers and supervisors.
- Created special employment and internship programs, including summer student and youth employment programs, as well as education programs for members of groups historically underrepresented in the science and engineering fields.

Additionally, since its beginning, the Laboratory has had a strong commitment to train the next generation of scientists and engineers. The education programs of the Center for Science and Engineering Education are instrumental in encouraging young people, especially women and people of color, to enter careers in science and engineering disciplines, better positioning them to attain their career goals. LBNL is now exploring ways to maintain contact with these students after they have completed a Laboratory program and as they progress through the educational system. In this way, the Laboratory can continue to encourage and assist them in achieving their goals and address its own future human resource needs.

# ENVIRONMENT, SAFETY, AND HEALTH

LBNL's environment, safety, and health programs, which are integral to program performance, fully support DOE's Critical Success Factor Strategies for ensuring the safety and health of workers and the protection and restoration of the environment. Excellence and timely implementation of environmental, safety, and health activities are critical to the success of each of LBNL's—and DOE's—core business areas. LBNL strongly endorses DOE's vision that the hallmark and highest priority of all our activities is daily excellence in the protection of the worker, the public, and the environment. LBNL's EH&S programs correspond to and cooperate with all four of the DOE goals in support of this vision. Our entire program overlaps DOE's Goal 1. Performance measures corresponding to Goal 2 are incorporated into the DOE-UC contract for the management of LBNL. EH&S priorities are set and followed in accordance with DOE's EH&S Management Plan and the DOE Environmental Restoration and Waste Management Five-Year Plan to

satisfy the requirements of Goal 3. Also, LBNL is striving diligently to demonstrate respectable performance related to environmental protection and worker/public safety, as envisioned by Goal 4. The programs described below are fundamental to the attainment of this vision and represent the performance commitment of LBNL employees to trust, communications, and continuous improvement in all LBNL activities.

# ES&H Goals and Objectives

It is the policy of the Lawrence Berkeley National Laboratory to integrate environment, safety, and health (ES&H) performance into all of its operations to ensure employee and public safety and the protection of the environment. The Laboratory has developed institutional ES&H goals to guide its integrated ES&H program. The ES&H goals are the following:

- LBNL will provide employees with a safe workplace.
- LBNL will design and operate facilities and research activities to minimize adverse impact on public health and the environment.
- LBNL will produce and use only materials that can be disposed of safely and will minimize waste.
- LBNL will promptly communicate the known hazards of our activities and the related methods necessary for safety and health protection.
- LBNL will use available technology, engineered safeguards, and responsible science to mitigate all significant risks arising from its research and related activities.

The objectives of ES&H in the conduct of research activities are to ensure the integrity of human health and safety and the environment in which we operate, to manage resources with a value-added perspective, to maintain a capability that is not currently supported by other Laboratory programs, to provide opportunities for staff development, to build new competencies that could prove useful to future Laboratory and DOE ES&H programs, and to support the Laboratory's technology transfer mission.

Underlying these goals is a commitment to ES&H performance through quality management of the Laboratory's programs and in its conduct of operations. LBNL's current efforts respond to the management initiatives of the DOE Office of Energy Research (ER), and directly to the Corrective Action Plan for the Tiger Team Assessment and ER review. The Laboratory has also developed ES&H management and is developing implementation programs for a DOE Environmental Restoration and Waste Management Five-Year Plan. These efforts include a renewed commitment to ES&H through self-assessment and an effective Corrective Action Plan.

The Laboratory's ES&H Performance Measures are utilized to improve performance and institute a more quantitative framework for LBNL's ES&H trends and activities. For employee health and safety, representative measures include those that document occupational radiation doses and accidental frequency and severity rates (expressed as cases or days lost per 200,000 hours worked). In accordance with the requirements of Contract 98, LBNL has embarked on a course of continuous improvement in ES&H performance over prior years.

Environmental Performance Measures include monitoring public radiation doses from LBNL operations, waste minimization, and the Toxics Release Inventory. The goal of waste minimization is to manage waste disposal more effectively and efficiently, including significantly reducing the total amount of hazardous wastes generated when compared to prior years. Waste minimization indicators include the percent of Laboratory office waste recycled, and the total number of waste streams recycled. Performance Measures include those that count the number of waste pick-up requisitions rejected because waste is nonhazardous (waste minimization), the number of complaints received by a group leader (waste management operations), and the number of requisitions received and processed with average turn-around time for each requisition (waste management operations). In addition, the Laboratory is establishing procedures to assure that there will be no excess discharge of heavy metals and toxic chemicals into the sewer system. The goal is to keep all discharges below established standards.

# Current Conditions

## *Programmatic Directions and Potential Hazards*

As indicated in Section IV, LBNL's scientific and technical programs primarily support DOE's Office of Energy Research (64%). The multiprogram charter includes programs in Basic Energy Sciences, Nuclear Physics, High Energy Physics, and Health and Environmental Research. Energy Efficiency and Renewable Energy (7%) supports studies in building energy conservation, energy storage, and solar and geothermal energy. Other DOE-sponsored programs (13%) include research supported by Civilian Radioactive Waste Management, and Fossil Energy. Work for Other Agencies and Institutions (16%) is primarily for the National Institutes of Health (NIH), Department of Defense (DOD), states, and private industry.

LBNL's potential ES&H risks are characteristic of accelerator operations, shops, and a diversity of laboratories for chemical, biological, materials science, and technology development, as well as other facility support operations. Hazards arise from both radiological and nonradiological activities. Radiation protection for workers and the public is required for accelerators, x-ray units, sealed sources, and radioisotope use. The nonradiological hazards include electrical systems, sources of ignition and combustible materials, rotating and reciprocating machinery, hoisting and rigging operations, lasers, chemicals, biohazards, moving vehicles, construction activities, and natural phenomena such as storms and earthquakes.

LBNL monitors the levels of chemicals, biohazards, and radioactivity discharged from operations at the Laboratory, and evaluates their impact on the environment and to the public health. Radiological operations include particle accelerators, gamma irradiators, laboratories conducting research using radionuclides and radiopharmaceuticals, and the National Tritium Labeling Facility. Nonradiological sources and discharges include chemicals from research operations, fabrication shops, automotive shops, paint shops, water treatment facilities, and the Hazardous Waste Handling Facility. Current trends in Laboratory activity indicate the following environmental and safety hazards that must be mitigated:

- **Chemistry and Materials Research.** Programs in materials and chemical research, including new hazardous materials management requirements, create demands on many ES&H programs. Examples include managing chemical acquisition and inventories, chemical monitoring systems, fume hood monitoring, laser safety training, respiratory protection programs, and hazards communications. The ALS, a controlled facility, expands the use of x-rays on site, and is operated with complete ES&H systems and management protocols in place.
- **Biological Research.** LBNL biological research programs have grown recently. LBNL's biological hazards control program continues to be expanded. Biological research programs often utilize radiolabeled materials, and the delivery of low-level radioisotopes has increased in the last few years. The radioactive and mixed wastes derived from these operations present a special challenge because of the restrictions on their disposal.
- **Radiobiology Experimental Programs.** LBNL radiological research at the Bevalac has ended, but the use of isotopes is expected to continue in many applications, including at the new Biomedical Isotope Facility.
- **Construction.** LBNL's construction activity has increased during the past decade, resulting in potential additional accident risk. ES&H oversight for construction contractors and tradespersons has become increasingly important, including, but not limited to, the need to ensure the stability of excavations and management of drainage systems.
- **Nuclear Physics and Nuclear Chemistry.** The nuclear physics experimental programs at the Bevalac were curtailed in FY 1993. However, the 88-Inch Cyclotron has expanded research with the Gammasphere detector and supports a more diversified scientific program. In addition, planning is under way for an IsoSpin Laboratory that would utilize radioactive isotopes.

Increased resources have been provided to serve research program areas that have potential hazards, such as those employing toxic chemicals, lasers, new x-ray sources and beamlines, and radiolabeled compounds. Space for staff and equipment must be provided to meet service demands and logistics needs. Reporting functions have been formalized to optimize use of staff. Automated systems to track chemicals from procurement to disposal and to automate all monitoring and analytical activities are under development. LBNL is committed to meeting all regulatory requirements in a cost-effective, risk-based fashion that deals with real risks and environmental concerns as the top priority.

## *Activities and Accomplishments*

### Environment Department

During the past year, LBNL's Hazardous Waste Handling Facility (HWHF) received full authorization to ship all kinds of waste (hazardous, radioactive, and mixed radioactive and hazardous) from the HWHF to off-site hazardous-waste facilities, including the Westinghouse Hanford Company's Hanford, Washington, radioactive-waste site. This authorization ended a two-year moratorium on shipments of these wastes from LBNL, established as a result of an audit by the Westinghouse Hanford Corporation and the DOE "Tiger Team" visit of January 1991. The moratorium was declared on shipment of waste from LBNL until the waste management work methods and documentation could be upgraded to ensure that all LBNL waste was characterized and packaged correctly. EH&S undertook a major upgrading of waste management documentation, procedures, and work methods, as well as a major upgrade of the HWHF itself. Waste shipments have now resumed, and the backlog of "legacy" waste (including mixed waste) built up during the moratorium has been eliminated.

### Health Department

EH&S's Radiation Assessment Group undertook a major program upgrade this past year. The group completed and issued the *Radiological Control Manual*, which was required by both federal law and DOE orders. The group also began documenting Laboratory-wide radioisotope use via a newly developed Project Review and Radioisotope Permitting Program. Under this program, all LBNL radioisotope users must complete a Radioisotope Project Review Form, which looks at all health and safety aspects of the proposed project related to radioisotope usage.

### Safety Department

The LBNL Emergency Command Center (ECC) was upgraded significantly during the past year. This was a long-needed project that received a boost after the disastrous 1991 Oakland Hills fire, which came within a few miles of LBNL. The upgraded ECC features a dedicated line to the Fire Department Dispatch Center, located in the same building. Additional telephones were installed, and new maps, checklists, and administrative supplies were also provided. LBNL also formed an Automatic Aid Agreement with the City of Berkeley Fire Department. The agreement allows the LBNL Fire Department to respond to fires in the adjoining Oakland and Berkeley hill areas. The agreement should improve fire safety greatly in the hill areas adjoining LBNL.

# ES&H Plans and Initiatives

To promote integration of strategic and program planning, the Laboratory maintains a Comprehensive Planning Calendar that defines annual planning requirements and provides a schedule that identifies necessary information exchange and preparation responsibilities. This process defines the responsibilities and information requirements that will incorporate environmental, safety, and health concerns into institutional and program planning elements. Examples of planning products include those for program plans and for ES&H support functions:

- **ES&H planning and initiatives.** The EH&S Division has realigned its mission in sync with the broader mission of the Laboratory. To this end, the Division effectively manages environment, health, and safety in a way that minimizes interference with new or ongoing scientific research. Creating value for the economy and contributing to the community through partnerships with industry is another part of the Laboratory's mission. The EH&S Division is developing creative solutions for environment, safety, and health problems that can be transferred into the private sector for broader application.
- **ES&H management and operations planning.** LBNL manages and coordinates its ES&H programs through strategic plans that define activities, source needs, staffing, and regulating responsibilities. These plans include, as examples, the Tiger Team Assessment Corrective Action Plan, the ES&H Management Plan, the Self-Assessment Implementation Plan, NEPA programs planning, and waste minimization plans (see below). Other examples are the Environmental Protection Implementation Plan, the Environmental Monitoring Plan, and the Groundwater Protection Management Plan.
- **LBNL emergency preparedness and response planning.** This includes maintaining and updating a Master Emergency Plan, building and facility emergency plans, and individual equipment emergency plans. LBNL is revising and strengthening these plans and implementing programs to ensure that resources and trained staff are available to address all credible emergencies.
- **Research program planning.** As an example of this program planning, early in the formulation of the Induction Linac Systems Experiments (see Section IV), the underlying ES&H criteria for this facility were established, as documented in a Conceptual Design Report. The safety systems and procedures for this facility are being designed to meet all standards for the expected occupancy. Safety management operations have been integrated with program plans and are included in cost estimates. The National Environmental Policy Act (NEPA) document preparation schedule and the requirements for Operational Safety Procedures were also planned from the outset. The Human Genome Laboratory underwent a similar review and documentation process.
- **Site development planning.** The Site Development Plan integrates ES&H objectives and needs in all facilities-related programmatic building support projects. Site-planning goals, existing conditions, and planning analysis integrate ES&H planning information, including NEPA and CEQA requirements. Specific references are made to environmental monitoring, environmental impact studies, and the health and safety of facilities. To provide adequate ES&H support facilities, two general-purpose building initiatives are proposed within the period covered by this plan. Current Laboratory support service facilities are inadequate and inefficient because of obsolete design and substandard construction.
- **Strategic and Environmental Planning.** LBNL's Environment, Safety and Health Division, with the Office for Planning and Communications, has incorporated a comprehensive planning mechanism to integrate strategic and environmental planning. In support of this integration, an environmental compliance calendar and a Comprehensive Planning Calendar have been created.

## *Corrective Action Plan*

LBNL's Tiger Team Assessment Corrective Action Plan, completed in September 1991, addresses the findings and concerns of the Tiger Team as well as the 1989 Technical Safety Appraisal. The Laboratory and DOE/OAK developed 409 tasks with subsidiary milestones to correct the findings and concerns and eliminate the underlying root causes. These root causes addressed the need for:

- Greater formality of operations and effective verification of the meeting of environmental, safety, and health requirements.
- More effectively addressing the demands of environment, safety, and health requirements and the urgency of incorporating these demands into LBNL operations.
- Providing DOE program direction and oversight that place adequate emphasis on environmental, safety, and health requirements.

LBNL has implemented all tasks from the Corrective Action Plan.

## *Environment, Safety, and Health Management Plan*

The Laboratory has developed and utilizes a prioritized Management Plan for Environment, Safety & Health Activities that includes the existing core program of environment, safety, and health activities, additional basic support, and specific projects to fully meet all LBNL and DOE environmental, safety, and health goals. LBNL contributed to the development of the ER prioritization system to rank activities based on quantitative risk reduction criteria for the purpose of allocating funds.

In response to the requirements of the Corrective Action Plan, and to emphasize safety and health issues, LBNL has significantly increased its spending on core environment, health, and safety programs since 1991. Conscientious application of prioritization methodology to these issues will allow the Laboratory and DOE to allocate appropriate funding each year, and to assure that serious and urgent issues are addressed appropriately in light of resource limitations.

Management Plan Projections

| Category | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| Operating | | | | | | | |
| Core | 19.7 | 21.2 | 21.9 | 22.4 | 23.2 | 24.0 | 15.4 |
| Improvements | 0.0 | 0.1 | 1.1 | 0.6 | 0.6 | 0.3 | 0.3 |
| Total Op. | 19.7 | 21.3 | 23.0 | 23.0 | 23.8 | 24.3 | 15.7 |
| Gap. Equipm't | 0.0 | 0.1 | 1.4 | 0.1 | 0.0 | 0.0 | 0.0 |
| GPP | 2.1 | 2.1 | 1.4 | 1.2 | 0.0 | 0.0 | 0.0 |
| Line Item | 0.0 | 0.0 | 0.5 | 3.4 | 8.7 | 6.3 | 5.5 |

## *Waste Minimization Plan*

LBNL's waste minimization program is an organized, comprehensive, and continual effort to systematically reduce hazardous, radioactive, and mixed waste generation. The DOE Waste Minimization and Pollution Prevention Awareness Program and California Senate Bill 14 (HazWaste Source Reduction and Management Review) are designed to eliminate or minimize pollutant releases to all environmental media from all areas of the site's operations. These efforts offer increased protection of public health and the environment. They will yield the following additional benefits:

- Reduction of waste management and compliance costs.
- Reduction of resource usage.
- Reduction or elimination of inventories and releases of hazardous chemicals.
- Reduction or elimination of civil and criminal liabilities under environmental laws.

The program reflects the goals and policies for waste minimization for LBNL and represents an ongoing effort to make waste minimization/pollution prevention part of the site's operating philosophy. LBNL's overall efforts include assessment of waste minimization opportunities and the development of source reduction plans. The projected budget authority goals of the waste minimization program as included in the Environmental Restoration and Waste Management Program are indicated in the following table for LBNL's unconstrained funding case.

Waste Minimization Management Program
Resource Requirements (FY BA $M)[a]

| Category | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| Operating | 0.2 | 0.5 | 0.4 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

[a]Estimated ERWM (EX) Budget Authority for unconstrained funding case.

## *National Environmental Policy Act Plan*

The Laboratory has undertaken a program to achieve full compliance with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Consistent with the Office of Energy Research's goals for adherence to the principles of the National Environmental Policy Act, LBNL's NEPA Program, in concert with other LBNL Environment, Health and Safety programs, strives to: (1) prevent and eliminate damage to the environment from LBNL activities; (2) attain beneficial uses of the LBNL environment and site without degradation; (3) reduce the risk of undesirable or unintended environmental consequences of LBNL activities; and (4) thus, achieve productive harmony between LBNL's mission and the environment. The Laboratory has prepared Guidelines for Compliance with the National Environmental Policy Act and the California Environmental Quality Act that describe processes and procedures for LBNL scientists and managers to ensure compliance and to prepare documents and recommendations for DOE and for the University of California, Office of the President (UCOP).

LBNL's general plan of action for projects includes preparation of checklists specifying NEPA and CEQA documentation recommendations for Field Task Proposals and capital projects one to two years prior to funding, and for Work for Others and Cooperative Research and Development agreements, and research grant proposals at the time of proposal preparation. The checklists are prepared by Division NEPA/CEQA Coordinators, in consultation with principal investigators, and are submitted to DOE in budget documents and to the LBNL Office for Planning and Communications for preparation and submittal of formal NEPA and CEQA documentation to DOE and UCOP.

During 1994, the following NEPA Environmental Assessments were under development: the proposed Human Genome Laboratory, Recycling Surplus Copper, and the construction and operation of a Genome Sequencing Facility in Building 64.

# Environmental Restoration and Waste Management

LBNL environmental management site projects supported through the DOE Office of Environmental Restoration and Waste Management (EM) are essential to correct and restore environmental conditions at the Laboratory and to improve the management of waste handling operations in support of DOE's national environmental objectives. The corrective actions achieve and maintain required low exposure and risk levels. The environmental restoration program includes the assessment and characterization of contamination and the closure of the existing Hazardous Waste Handling Facility. Increased support for the waste management program is necessary for the proper management of radioactive and hazardous waste. The waste management program supports the construction of a new Hazardous Waste Handling Facility. These two programs meet regularly to ensure compliance with DOE and other federal regulations, as well as requirements established by state and local agencies.

The Laboratory's systematic and prioritized input to the EM Five-Year Plan supports DOE's national environmental restoration and waste management goals. The plan responds to specific environmental conditions at the Laboratory and includes facilities and operating programs for managing those conditions to maintain air quality, surface water quality, and groundwater quality. The plan focuses on three Environmental Management programs for restoration and management activities:

- **Environmental Restoration.** Assessment, characterization, and remediation of chemical contamination of soils and groundwater, closing of the existing LBNL Hazardous Waste Handling Facility, and decommissioning of the Bevalac facility.
- **Corrective Activities.** The more significant corrective-action projects are associated with an EPA Finding of Violation for noncompliance with Clean Air Act requirements regarding the evaluation of potential radioactive air releases. Subsequently, a Federal Facility Compliance Agreement was established between EPA and DOE. These projects will bring LBNL into full compliance by February 1, 1995.
- **Waste Management.** Waste management program for hazardous and radioactive waste handling, disposal, waste minimization, planning, and the construction of a new Hazardous Waste Handling Facility. Current funding projections as shown in the following table, are adequate for meeting regulatory requirements. However, increased funding of waste management operations will be necessary to meet additional program requirements.

EM's Five-Year Plan is vital for compliance with DOE and other federal regulations and for meeting requirements established by state and local agencies. The program has been developed in conjunction with DOE, state, and federal reviews. The resource projections below and in Section VI reflect existing guidance in Activity Data Sheets. These resources do not include additional corrective action planning requirements, maintenance projects, and other upgrades funded through LBNL institutional resources. The resources also do not include the cost for decommissioning the Bevalac, following acceptance by EM.

Environmental Restoration and Waste Management Resource Requirements ($M)[a]

| Category | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| Environmental Restoration | | | | | | | |
| Operating | 3.9 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 |
| Capital Equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| GPP | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Line Items | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 3.9 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 |
| Waste Management | | | | | | | |
| Operating | 8.5 | 6.0 | 6.8 | 7.9 | 8.3 | 8.6 | 8.7 |
| Capital Equipment | 0.4 | 0.0 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 |
| GPP | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Line Items | 0.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 8.9 | 6.0 | 7.0 | 8.2 | 8.6 | 8.9 | 9.0 |
| Total EM Funding | 12.8 | 10.2 | 11.2 | 12.4 | 12.8 | 13.1 | 13.2 |

[a]Actual-year LBNL Budget Authority as provided in the EM Five-Year Plan. The funding level shown for FY 1995 reflects the actual approved budget, for FY 1996 reflects the President's budget request to Congress, and for FY 1997 reflects the target (EM requested) budget level.

# Landlord Funded ES&H

ES&H (other than Waste Management and Site Restoration) is currently funded mostly through Laboratory overhead. Proposals for replacing overhead have been submitted through the ES&H Management Plan. The ES&H Management Plan makes the distinction between core activities and additional funding necessary to fully implement an ES&H program that will address needed improvements facing the Laboratory. This year's Activity Data Sheet submissions are summarized in the table "Management Plan Projections" on page 5-15.

# MANAGEMENT PRACTICES

A key element of LBNL's strategic plan addresses the need for efficient and effective management practices that focus on performance and accountability. LBNL is working with DOE and the UCOP to fully implement performance-based contracting and to streamline management systems. LBNL fully supports DOE's Strategic Plan, which addresses the numerous separate systems for managing its operations and improving the Department's flexibility. LBNL is working with DOE through Process Improvement Teams and through other management and communications systems to achieve DOE goals to become a more streamlined and agile organization. LBNL is taking specific steps to address DOE's defined need for change in information systems, procurement and contracting, planning and budgeting, financial management, and site and facilities management.

## Quality Assurance and Self-Assessment Programs

LBNL has a strong tradition of research productivity and quality, maintaining a commitment to the success of DOE's mission and its research program. The Laboratory is committed to continuous improvement in program performance and environment and safety management, and to the execution of best business practices. LBNL has developed a strategy for programs to improve performance based on nationally recognized criteria and Total Quality Management principles, and is working with DOE on implementation of these programs.

The Laboratory is responsible for maintaining the infrastructure for effective financial and administrative performance. LBNL is committed to best business practices and continuous improvements in all areas of administration, including human resource development and training, finance and contractual relations, materials management and procurement, and facilities maintenance and engineering. The University and the Laboratory emphasize the application of performance measures in key functional areas, and are committed to working in partnership with DOE for continuous performance improvement for national research institutions.

LBNL's Operating and Assurance Program (OAP) Plan, developed and administered by the Office of Assessment and Assurance, is the institutional document that specifies the Quality Assurance requirements for the Laboratory. LBNL's OAP was developed using the guidance provided in the *Implementation Guide for QA Programs for Basic and Applied Research* (DOE-ER-STD 6000-92) and is intended to optimize the long tradition of LBNL excellence in science by applying required management controls to both performance of research and to research support activities in an integrated and cost-effective way. In both cases, the extent and detail of the management systems are commensurate with the scale, cost, complexity, and hazards of the work being performed. The requirements specified by the OAP are intended to meet the requirements of DOE Order 5700.6C, Quality Assurance. The Plan describes a management system and set of activities designed to:

- Maintain the level of performance necessary to achieve LBNL's programmatic and administrative objectives effectively and safely through the application of Quality Assurance principles.
- Implement an LBNL management philosophy that supports and encourages continuous improvement in performance and quality at the Laboratory.
- Provide a management system that permits an integrated approach to compliance with applicable and related regulatory requirements and DOE orders.

LBNL has also instituted a program for self-assessment as a systematic way to identify LBNL's strengths and weaknesses, and to develop corrective actions if needed. Each LBNL Division develops its own program to evaluate itself against performance objectives established by the Laboratory. This continuous process of information gathering enables LBNL to assess performance in a systematic and uniform manner, and to target areas that may need improvement. Targeted areas of improvement are the subject of formal root-cause analysis performed by teams of management representatives and technical specialists. Areas of improvement in the past included waste management practices and hazard communication (training).

Corrective actions that address root causes are identified and tracked on the Laboratory's tracking database to ensure accountability and timely implementation. The Office of Assessment and Assurance documents the Laboratory's self-assessment activities in an annual report.

The Office of Assessment and Assurance also performs independent assessments of selected LBNL functions and processes within specific organizational units, as well as across organizational boundaries. These cross-functional appraisals assess LBNL's management systems, operational performance, and quality systems, and review the effectiveness of institutional programs.

# Administrative Management

## *Financial Management*

The LBNL Chief Financial Officer (CFO) is responsible for the financial and purchasing functions of the Laboratory. These functions include planning, utilization, and accounting for the funds provided to LBNL to carry out its research and development programs and the acquisition of supplies, services, and construction necessary to support the Laboratory. Under the CFO there are three major areas: CFO/Finance, CFO/Budget, and CFO/Business Services. CFO/Finance is responsible for conducting and overseeing financial operations in a manner that is responsive to the Laboratory's research mission, and complies with UC and DOE regulations, Generally Accepted Accounting Principles, and Federal Cost Accounting Standards. CFO/Budget is responsible for budget formulation and execution, budget planning and analysis, and indirect budget planning and monitoring. CFO/Business Services is responsible for procurement, property, and travel services. These three areas continue to improve and enhance the Laboratory's information systems, budget formulation, execution processes, and procurement activities.

The Laboratory's financial systems are being continuously improved through the streamlining of data-handling processes. We have moved from laborious, time-consuming, multistage hard-copy inputs to the use of interactive electronic computer workstations. Results are reflected in the amount of time it takes to complete actions—e.g., the time to complete some 20,000 annual general ledger account changes was reduced from as long as six weeks to overnight. The Laboratory is currently developing a means to convert the handling of over 100,000 annual employee time cards to instantaneous, electronic transactions. Improved networking systems provide for the transfer of timely information to external locations as well.

An Accounts Payable system has been implemented utilizing electronic data handling. Further improvements in data processing are a result of electronic interfacing of the Accounts Payable system with the newly implemented Purchasing-Receiving system. Other ongoing Laboratory projects include developing a general ledger system to process its 750,000 ledger transactions; conversion activities to prepare for the handling of approximately 5,600 transactions a year now processed by the DOE's Financial Information System; a new Work for Others Financial Tracking System; and a new UNIX/Oracle-based system to replace the existing Payroll and Personnel system.

As part of the Laboratory's budget formulation and execution processes, the CFO conducts an annual budget workshop for research divisions that is supplemented with a budget preparation handbook; validates the budget proposals for adequate justification; and coordinates the Laboratory Director's formal review-discussion process.

The Laboratory's indirect cost structure and indirect rates have undergone a full review, resulting in enhancements in the methods for estimating, accumulating, allocating, and reporting practices. The changes have been reviewed and approved by the cognizant DOE Contracting Office for compliance with federal Cost Accounting Standards.

The CFO faces major challenges in the areas of both procurement and property services. Inefficient and outdated processes and systems need to be replaced with a modern electronic data system that will interface with vendors, provide bar coding, and house just-in-time contracting systems to reduce the time between identification and fulfillment of need.

The CFO is also in the process of restructuring how LBNL employees make their travel arrangements. This includes encouraging travelers to take more responsibility for their individual travel planning and voucher preparation.

## *Internal Auditing*

The LBNL Internal Audit Services Department, established during FY 1993, provides independent, objective reviews and analyses to assist management in achieving internal control objectives. Audit efforts are proactive, and the independent appraisal process determines if management has established and maintained adequate systems of accounting and management controls over programs and administrative functions to provide assurance that: (1) programs and operational objectives are conducted efficiently and effectively in accordance with program direction and funding requirements, (2) costs and obligations are in compliance with applicable laws, and (3) funds, property, and other assets are safeguarded against waste, loss, mismanagement, unauthorized use or misappropriation. Topics considered for evaluation encompass all facets of the Laboratory, including: Financial Management; Procurement Management; Human Resources Management; Construction and Facilities Management; Information Management; Environmental Health and Safety; Data Processing Systems; Property Management; Planning and Budget Management; and Support Services and various research programs.

In past years, the LBNL Internal Audit Services Department initiated the development and implementation of an Internal Audit Peer Review Program for DOE management and operating contractors. This program provides assurance that professional auditing standards are complied with and acts as a forum for the exchange of Best Practices to assist in meeting the challenges imposed by changes in strategic direction, increased public scrutiny, and limited DOE resources. During the current year, the LBNL Internal Audit Services Department developed a uniform risk assessment model in conjunction with the University of California Office of the President to quantify high-risk areas of financial exposure and liability to the institution. The formal assessment of institutional risks will ensure that LBNL Internal Audit effort and resources are allocated appropriately. LBNL is a participant in the DOE Cooperative Audit Strategy, emphasizing improved communication and coordination among the DOE Offices of Inspector General, DOE Field Offices, and internal audit staffs. This quality initiative should result in greater reliance on the work of internal audit staffs, and in reduced DOE audit effort and oversight.

# Information Resources Management Program

LBNL's Information Resources Management (IRM) program includes both research and operational activities. Research is discussed in the Applied Mathematics and Computer Science program description (pp. 4-25 and 4-26). Operational activities involve the integration of these new technologies into a seamless information technology infrastructure that supports the research and administrative requirements of the Laboratory.

All scientific programs at LBNL make essential use of LBNL information resources for the collection and analysis of data and the modeling and visualization of physical process; for numerous administrative support functions; and for communication with colleagues—both on an individual basis through e-mail, fax, and telephone services and through hardcopy and electronic (e.g., World Wide Web) publications, conferences, and video conferences.

This section identifies the major objectives of LBNL's IRM efforts and the principal strategies for achieving those objectives.

## *Major Objectives*

The Laboratory has developed IRM objectives that will support the National Information Infrastructure (NII), encourage the development of usable tools for all LBNL employees, foster a corporate approach to information management, encourage the transition from a paper-based information society to one based on

electronic media, and promote the development and maintenance of a comprehensive records management program. In somewhat more detail, these goals are:

- **For corporate data:** Define and implement a corporate information management architecture that includes interoperable electronic mail, makes corporate databases fully accessible, implements file portability, and strengthens institutional standards for database systems and utilities (Infrastructure).
- **For Industrial Partnership (AMTEX):** Develop a set of operating principles and enterprise interactions in the Integrated Textile Industry that will enable the system to achieve a sustainable market share (Programmatic).
- **For the management of scientific and technical information:** Expand and extend our current lifecycle information management program to accommodate the increasing shift from a paper-based to a network-based environment (Infrastructure).
- **For the NII:** Conduct an advanced research and development program in support of the nation's High Performance Computing and Communications Initiative and the most effective development and utilization of national information highways (Programmatic).
- **For on-line information:** Encourage the development of on-line access to information located both locally and at other sites; assist in the development of DOE policy governing electronic information; create a library "without walls"; promote the introduction of digital technology into the preparation and presentation of technical material; and contribute to the development of the World Wide Web (Infrastructure).
- **For records management:** Maintain a secure records management program that identifies and protects the essential scientific and administrative records of the Laboratory and administers appropriate retention schedules for all LBNL records (Infrastructure).
- **For the staff:** Provide state-of-the-art and transparent computing and communications resources for DOE programs and services to every scientific, engineering, or administrative employee; these services include advanced network communications technology that keeps pace with demand, workstation support services and technical support for telecommuting and telework, transparent access to computing resources, upgraded central computing facilities, and proper control of access to sensitive files (Infrastructure).

These goals underpin LBNL's mission for research and development, design and operation of user facilities, education and training, and technology transfer. Together with the human and facilities resources of the Laboratory, the information resources enable a flexible and responsive operating environment for the implementation of DOE programs. Effective information management is vital to the success of this mission, and will require the allocation of adequate DOE resources for effective implementation.

Information Resources Management Program Resource Requirements (FY BA, $M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|
| Recharge | 19.01 | 19.96 | 20.96 | 22.00 | 23.10 | 24.00 |
| Overhead– | 3.30 | 3.40 | 3.60 | 3.80 | 3.96 | 4.11 |

For those activities identified above as "Infrastructure."

## *Strategies*

LBNL's IRM strategy includes focused support for improving the nation's computing and communications infrastructure, assistance to DOE in the development of IRM policies and plans, and development of LBNL's computing and communications infrastructure to support the LBNL DOE multiprogram energy research Laboratory mission. LBNL's strategies directly support IRM goals and objectives described above to provide state-of-the-art, transparent computing and communications

resources; accessible corporate information management systems; effective scientific and technical information services; and a secure records management program. These strategies are:

**Improve National Computing Infrastructure.** LBNL has provided continuing support to the Office of IRM Policy to develop DOE's Information Resources Management strategies. This includes review of existing strategies and policies and the development of new policies to cope with the changing IRM environment. LBNL is an active participant in DOE's effort to streamline the directives that apply to Information Management. LBNL strongly supports DOE's efforts to develop a planning process that is driven by programmatic need rather than by report requirements.

LBNL is active in several branches of the standards-development process that are of particular interest to DOE. These include participation in technical committees dealing with network issues, the planning and development of ESnet, and the Internet Engineering Task Force.

LBNL also supports the development of the national communications infrastructure by providing the chairperson of the ESnet Steering Committee, which assists in the prioritization of DOE developments in high-speed data transfer, video conferencing, and other network-based communications media.

**Enhance International Collaborations and Information Environment.** In support of DOE and Laboratory goals to increase the benefits of international cooperation in basic science, LBNL engages in many activities that involve foreign collaborations. Among those that are IRM-intensive are activities involving LBNL's expertise in the numerical modeling of geophysical and geochemical processes. For example, there are joint projects on nuclear or chemical waste with Russia, Sweden, Switzerland, and Canada, and formal agreements with both Mexico and Italy on geothermal development. LBNL is the site of the International Geothermal Association. LBNL is also a contributor to the extensive international electronic information exchange known as the World Wide Web.

**Enhance the LBNL Work Environment and Corporate Information.** A new institutional strategic change to achieve the LBNL Vision 2000 has been an increase in activity directed toward the definition and management of corporate and institutional data. LBNL's site strategy encourages the integration of appropriate information technology into the individual work environments. The process of creating an integrated Laboratory approach to information management has begun. This effort will extend over several years.

Many of LBNL's computing and communications facilities and planning requirements are institutional, and we believe that DOE should provide more vigorous support for institutional technology resources at the multiprogram energy laboratories. This strategy strongly supports the goals of DOE's Strategic Plan 2000 because it reinforces the notion of institutionalization of IRM Planning, which is obscured by a reporting process that requires the partitioning of institutional requirements into a welter of small, fictitious, "programmatic" tabulations.

**Convert to a Primarily Electronic Information Environment.** LBNL has made a number of preliminary steps towards creating an information environment that is primarily online rather than paper-based. Over the next several years, we shall bring these efforts together so that all LBNL staff have convenient on-line access to essentially all the information they need, whether it is located at LBNL or at other institutions. This effort will include administrative applications (such as electronic time reporting), digital photography, the exchange of scientific and general-interest information through the World Wide Web, access to remotely located computational resources through ESnet, the expansion of online library services, and video conferencing, both desktop and studio-based. It is expected that this new online environment will materially change the way in which intellectual and administrative work is accomplished in the years ahead.

**Demonstrate the Educational Possibilities of Distributed Electronic Media.** Two LBNL initiatives, the Virtual Frog and Microworlds, have demonstrated the ability of distributed electronic media to reach a worldwide audience with relatively little local effort. These initiatives have been two of the most heavily accessed segments of the World Wide Web, despite the absence of any effort by LBNL at international advertising. The metaphor of "If you build it, they will come," is a very real phenomenon in the presence of global accessibility.

## *Resources and Initiatives*

LBNL IRM initiatives encompass a range of significant new programs that will expand DOE computing and communications resources. The Center for Energy Research Networking and Advanced Computation Initiative is described in Section IV. The following initiatives are directed at improving DOE and Laboratory infrastructure and management and towards meeting the resource and management needs of the DOE and its Office of Energy Research.

### Advanced High-Speed Networking

To meet projected traffic and demand, LBNL anticipates that expanded communications and networking infrastructures will be required. The Laboratory's High Speed Networking Initiative seeks to extend high-speed (100 Mbs and beyond) network access to the majority of LBNL workstations. In addition, network backbones and server systems will need to be upgraded or replaced.

Advanced High-Speed Networking Resource Requirements ($M)[a]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.8 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 5.5[b] |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual year Budget Authority (B&R code KC07, tentative).
[b]Includes $1.3 M in equipment costs.

### Visualization, Video Conferencing, and Technical Information

LBNL is playing a lead role in organizing a testbed that will bring together most of the major workstation vendors, several universities and laboratories, and the telecommunications industry to develop and test the hardware and software technology needed to support workstation-based video teleconferencing in a metropolitan area network. The project will also develop prototype technologies for teleseminars.

LBNL is also playing a lead role in the development of packet-based computing and communication environments to support collaborative work. This includes a multimedia environment incorporating audio, video, and a distributed electronic whiteboard operating over the Internet/ESnet, as well as a packet-based video-conferencing multicast environment that will greatly enhance ER-wide video conferencing.

LBNL is continuing to introduce new technology into the operations of the Library and the Technical and Electronic Information Department. The Digital Darkroom, which began full operation at the end of FY 1994, has replaced on-site, wet-chemistry photography.

LBNL regularly participates in video conferences with collaborators, the UCOP, and DOE Headquarters. We have introduced the World Wide Web and its associated navigational tools (e.g., Mosaic) into the review of DOE directives, and expect to participate in the initial trials of the World Wide Web as a vehicle for distribution of IRM planning information. LBNL also expects to provide production access to desktop video conferencing tools, beginning with limited availability in FY 1995, and becoming generally available by FY 1998.

Visualization, Video Conferencing, and Technical Information Resource Requirements ($M)[a,b]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 1.5 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual year Budget Authority (B&R code KC07).
[b]Does not include infrastructure activities.

### Other Initiatives and Infrastructure Investments

As a separate initiative, and in common with other federal facilities, LBNL has begun an examination of options to satisfy the impending narrowed bandwidth requirements for radio systems. Conversion to narrow bandwidth telecommunications using a trunk-based system will require expenditures over the next several years, beginning in FY 1996. This program is to be coordinated among the DOE laboratories in response to the DOE requirements.

In FY 1996, LBNL will begin a formal program of support for development of the information infrastructure. Some of the initial activities are described above. Other possibilities include the development of a cadre of experts skilled in preparation of multimedia presentations and documents, the introduction of virtual reality concepts into the analysis of complex data, and a sophisticated mechanism for the indexing, storage, and retrieval of visual information using visual and textual search techniques.

Other Initiatives and Infrastructure Investments Resource Requirements ($M)[a, b]

| Category | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| Operating | 0.5 | 1.0 | 1.5 | 1.5 | 1.5 | 1.6 | 7.6 |
| Construction | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[a]Preliminary estimate of LBNL actual year Budget Authority (B&R code KC07).
[b]Does not include infrastructure activities.

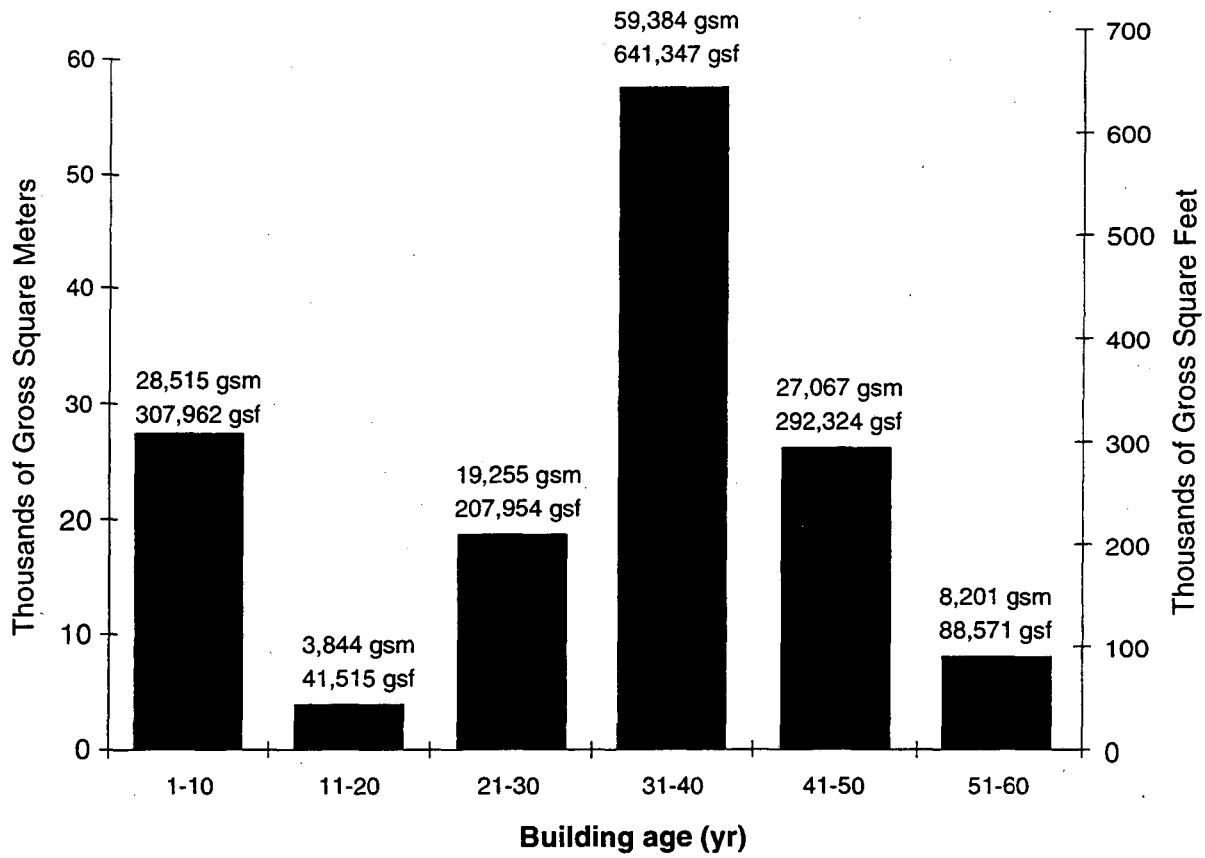
# Site and Facilities

Lawrence Berkeley National Laboratory is located in the hills above the UC Berkeley campus, on a 54-hectare (134-acre) site overlooking the San Francisco Bay. Founded in 1931 by Ernest O. Lawrence, the Laboratory was moved to its present site in 1940. It is the oldest of the DOE national laboratories, and the only one located adjacent to a major university.

Over the past decades, LBNL has continued on a course of diversification that has brought it wide recognition in high-energy and nuclear physics, materials sciences, chemistry, life sciences, and energy conservation research. For LBNL to continue its mission as a multidisciplinary national laboratory, it must address some critical issues and opportunities concerning site and facility improvement. The Laboratory strongly supports strategic planning activities that are now taking place as part of a national effort to restore and maintain the nation's scientific infrastructure, and has made these activities an integral part of its own site development process. In addition, LBNL is continually vigilant about creating conditions that protect the LBNL staff, the public, and the environment.

## *Site Description and Status*

The first building on the LBNL site was constructed in 1940. In FY 1995 the main site included 77 permanent buildings and 120 trailers and temporary structures. A significant number of the permanent buildings (61%), and the associated infrastructure, are over 25 years old. The existing facilities and the currently funded construction at LBNL constitute 182,000 gsm (1.95 Mgsf) located on the main site, the UC campus, and leased off-site locations. The space distribution upon completion of current projects in FY 1995 is shown below.

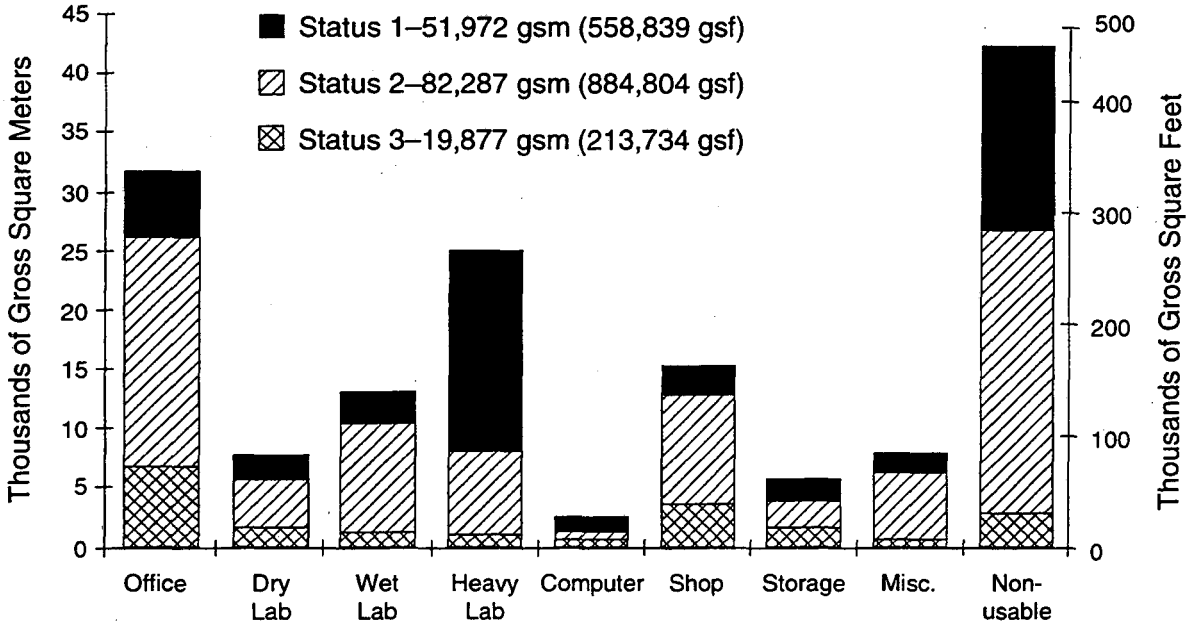



*Age distribution of permanent main-site buildings.*

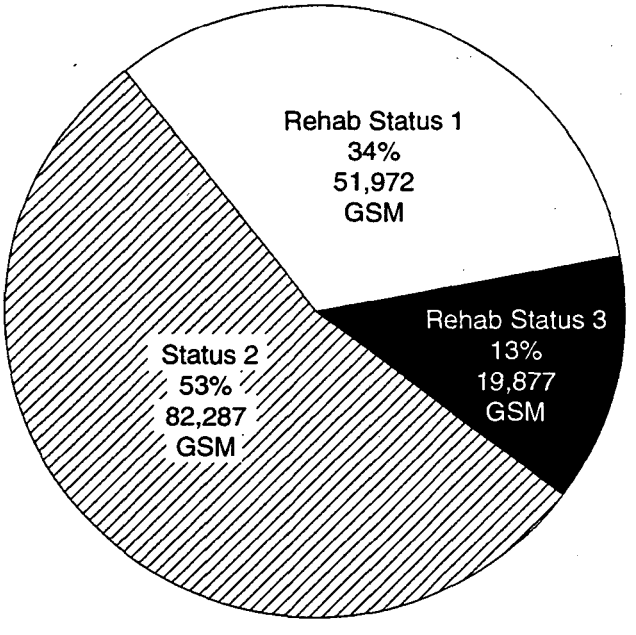
The vast majority of space utilized by LBNL research and support staff is located in DOE-owned buildings on the main site. LBNL space in UC Berkeley campus buildings is available to DOE by a long-term arrangement. This space, located at the adjacent campus of a major university, facilitates a continuing free flow of scientific thought and allows for productive interactions between the DOE Laboratory and university communities. The off-site leased buildings provide space for essential research and support functions.

Building condition and usability are recorded and monitored in accordance with categories developed from the former Strategic Facilities Initiative (SFI) building condition categories: Status 1 (Adequate); Status 2 (Functional, Can Be Economically Upgraded, to avoid approaching technological or functional obsolescence); Status 3 (Substandard, Cannot Be Made Adequate, includes temporary trailers that have aged beyond their useful lives). The following graph illustrates LBNL's inventory of building space. The Condition of Main-Site Space tables on page 5-27 give the specific amounts for each space type in square meters and square feet.

At LBNL, Status 3 buildings (the substandard buildings that cannot be made adequate) are primarily offices located in aged "temporary" trailers and older shop spaces. Of the 154,000 gsm (1.66 Mgsf) on the main site, about 8,000 gsm (86,000 gsf) are in trailers and other temporary structures. When these functions can




*Condition of Laboratory space (excluding proposed FY 1994 construction).*




*Condition of main-site buildings, including existing construction projects (classified as adequate space).*

LBNL Space Distribution[a]

| Location | Area (Ksm) | Area (Mgsf) | % of Total |
|---|---|---|---|
| Main site | 154 | 1.66 | 85 |
| UC Berkeley campus and Richmond Field Station | 10 | 0.10 | 5 |
| Off-site leased | 18 | 0.19 | 10 |
| Total | 182 | 1.95 | 100 |

[a]Includes funded projects.

be transferred to permanent buildings, the trailers and most of the Status 3 space will be eliminated. Status 2 space is the focus of ongoing planning and construction efforts aimed at retaining full use of these facilities.

The replacement value of the buildings at the main site, as determined by DOE's Real Property Inventory System for 1994, is more than $745 million. Replacement values for utilities and other site improvements continue to be developed.

Facilities Replacement Value[a]

| Type | Value ($M) | % of Total |
|---|---|---|
| Buildings | 272.5[b] | 64 |
| Utilities | 123.9 | 29 |
| Miscellaneous | 28.8 | 7 |
| Total | 425.2 | 100 |

[a]Estimated in 1986.
[b]Replacement value for buildings (1994) is $745M. Replacement value for utilities and other site improvements are under revision.

## *Facilities Plans and Options*

### Site Development Plans

Each year LBNL prepares site-development plans to provide analysis and policy guidance for the effective use and orderly development of land and facilities at LBNL. This planning effort is critical to all of the Laboratory's programs. First, it is critical because facilities require rehabilitation to avert safety hazards, shutdowns, and failures. Second, it is critical to optimize use of the Laboratory's limited land and building resources. In addition to the site development plan, department-wide planning efforts such as the Capital Asset Management Process (CAMP) are integrated into the total site-planning effort. The objectives of the site-planning effort are as follows:

- Evaluate future mission projections and anticipate DOE national research facility needs.
- Ensure a safe and healthy workplace in full compliance with building and fire codes.
- Protect the environment and buffer activities to enhance adjacent land uses.
- Protect the national investment in government-owned research and support assets.
- Consolidate research and support services through proper siting of new buildings and maintenance of functional units.
- Work with UC to identify projects with synergistic benefits.

- Make efficient use of unique Laboratory assets and the adaptive reuse of similar facilities with potential to support Laboratory missions.
- Improve access and communications within and to the Laboratory.
- Promote cost reductions and energy conversion through efficiencies in building design and location, operation and maintenance, and parking and transportation.

Resources to improve the Laboratory's facilities are provided through Multiprogram Energy Laboratory Facilities Support (MEL-FS), General Plant Projects (GPP), In-House Energy Management, and General Purpose Equipment (GPE). Adequate funding from these resources is a critical element of LBNL's ability to provide DOE with an effective multiprogram Laboratory that can meet environmental and safety standards. A major effort is under way to provide conditions that meet accepted standards for LBNL's environment, health, and safety programs, including providing adequate monitoring and sample processing laboratories, emergency command and response facilities, and sufficient space for on-site offices for industrial hygiene, environment, and other essential EH&S staff discussed above.

LBNL's facilities planning is coordinated through specific Laboratory management activities and DOE initiatives. The Site Development Plan (SDP) has been updated for FY 1995 and will continue to be updated as requested by the Office of Laboratory Management in the Office of Energy Research (ER-80). LBNL has established a prioritization framework for its multiprogram capital projects and incorporates a safety and environmental program. Operating funds have been provided through the MEL-FS General Purpose Facilities KG01 subprogram to support infrastructure, the Condition Assessment Survey, and other site-planning activities. The Laboratory's ten-year In-House Energy Management Plan represents significant opportunities for cost savings. All proposed projects undergo NEPA and CEQA review procedures for full compliance with DOE and UC guidelines. Institutional planning acts to couple site-management planning activities to program planning and other strategic management processes. For FY 1995, a complete 20-year infrastructure program has been developed consistent with DOE guidelines and the Laboratory's Vision 2000 strategic planning.

The SDP is based on five LBNL-site master-plan concepts. These concepts accommodate the facilities improvement needs within existing geophysical, environmental, and operational conditions. They provide a basis for understanding and evaluating the more detailed elements of specific projects, planned locations, and other site-improvement projections. These site-planning concepts are:

- Consolidation of activities within seven functional planning areas to enhance efficiency and effectiveness and to provide specialized research facilities.
- Redevelopment of obsolete buildings and deteriorated infrastructure, elimination of temporary structures used for permanent functions, and improvement of building arrangements to increase safety and energy efficiency.
- Concentration of development along the east–west circulation and utilities axis to enhance transportation and service systems, e.g., development of off-road parking and improvement of pedestrian pathways.
- Improvement and maintenance of perimeter and internal buffer zones to screen noise-generating activities and minimize potential incompatibility between adjacent operations.
- Providing of off-site facilities for receiving, warehousing, and other support and research activities suitable for decentralization.

Facilities planning includes exploring such options as the potential interim uses of off-site facilities for administrative and other support functions. Over the past three decades administrative requirements have been increasing as safety, accounting, environmental, and other requirements are addressed. LBNL is exploring long-term options, such as reconfiguration of some existing space, new additions to office and support buildings, and removal of temporary office structures. These temporary office structures proliferated during the past several decades as a result of limited construction for offices and support buildings.

If the full programmatic capability of the site is developed to meet anticipated national needs in energy technology and supporting research, per the Twenty-Year Plan, the sites and new buildings would result in a net increase of 37,000 gsm (0.4 Mgsf) to the existing main site, for a total of approximately 186,000 gsm (2.0 Mgsf). For comparison, the 1993 total, including current construction, consists of 153,000 gsm (1.65 Mgsf) at the main site. The Laboratory's on-site space is at an approximate 70% net-to-gross area efficiency. The usable on-site space is approximately 112,000 gsm (1.2M net square feet). The building utilization efficiency is not projected to change significantly, although the efficiency of land use is expected to improve with the replacement of obsolete single- and two-story buildings with three- to five-story structures.

## General Purpose Facilities Plans

**Multiprogram Energy Laboratory Facilities Support.** The total proposed twenty-year MEL-FS program represents an investment need of over $180 million. This modernization program addresses needs primarily related to the many buildings and utilities that are 30 to 50 years old. Individual projects are evaluated against generic Laboratory site-development priorities such as safety, environmental protection, reliability, maintainability, design standards and obsolescence, and delivery of research and support services.

**Safety and Health Improvements.** Health and safety improvements are needed in safety services, health services, building illumination, radiation protection and monitoring, and in other safety systems (see the "Environment, Safety and Health" subsection in this section). Many of these projects were initiated as MEL-FS projects. Examples of important funded projects include the Building 90 Seismic Rehabilitation, a Fire and Life Safety Systems Upgrade Project (Phase I), and the Hazardous Materials Safeguards Program.

**Mechanical Utilities/Safety.** The Laboratory's mechanical/utility systems are up to 40 years old. Mechanical utilities consist of domestic- and cooling-water; storm-drain and waste; natural-gas, compressed-air, and vacuum systems. Full implementation of LBNL's Six-Phase Plan would minimize the possibility of accidents or program disruption by loss of essential utilities and equipment.

**Electrical Utilities/Safety.** LBNL's power-distribution system consists of 24 substations and 32 km (20 miles) of 12-kV primary distribution cable. Much of the distribution equipment and cables are obsolete, resulting in reduced reliability and increased maintenance. The electrical rehabilitation projects have been prioritized into several phases based on the expected failure rates of equipment and the importance to site-wide facilities demands. Phases one and two, the Grizzly Peak Substation and Original Labsite Substation, are being completed. Phase three, the East Canyon Electrical Safety Project, was funded in FY 1992. The remaining phase is proposed in the Twenty-Year MEL-FS Plan. The upgraded switching and distribution system will provide the reliability, flexibility, and expandability necessary for efficient Laboratory operation and future growth.

**Building Replacement and Modernization.** The MEL-FS building replacement and modernization plan responds to the needs for safety, support, and research infrastructures, and for general-purpose engineering facilities. Improvements in substandard space conditions, as part of a long-term modernization program, would enhance the achievement of the Laboratory's mission. Included in the long-range plan is the removal of substandard facilities that cannot be made adequate. Projects include upgrades and additions for facilities, engineering and maintenance services, administrative services, applied sciences, science education, and visitor facilities.

## General Plant Projects

GPP funds are required to address a number of the essential strategic and site-planning objectives of the Department and the Laboratory. Realization of strategic and planning objectives requires capital funds as facility improvements are accomplished. GPP funds are the sole appropriate choice when the cost of these capital projects is below the MEL-FS threshold. The Laboratory applies GPP funds to important environmental, health, safety, and building modernization project needs in an expeditious and cost-efficient manner. GPP funds support achievement of objectives in many areas, including projects to upgrade high

efficiency particulate air (HEPA) filtration systems on glove-box exhaust stacks and to upgrade environmental monitoring equipment capable of documenting the care taken to preserve and protect the environment, to improve slope stability, and to correct existing noncompliance problems in order to conform with fire and life safety codes. Additional GPP projects include those to modernize and enhance utility infrastructure, to maintain and advance facility utilization through adaptive reuse of existing assets, and to modernize buildings in order to realize the benefits of automation and technological advances.

The Laboratory has a significant backlog of projects, in the amount of approximately $30 million. This backlog is not being reduced, as approximately $3 million of new project needs are identified annually whereas the Laboratory's GPP funding has remained at a similar level for a number of years. In addition, the recent application of overhead burdens further reduces available funds. The Laboratory reviews all candidates on an annual basis, and projects are ranked and reviewed using the DOE-developed CAMP and RPM criteria. Increasing GPP funding to $6 million annually would ensure achievement of critical strategic and site-planning objectives and reduce the backlog of projects.

## General-Purpose Equipment

Essential support equipment has been funded through DOE. LBNL's Five-Year GPE Plan identifies needs based on a range of criteria, including environment, safety, and health; legal requirements; failed, worn, inefficient, or obsolete equipment; substandard performance; or increased workload and demand. The current funding level of $1.7 million/year is inadequate to meet the Laboratory's needs. As noted in the new DOE/UC contract, "a continuing, active and affirmative program of supplementing and replacing such equipment is essential to scientific progress." Currently, there is a $19 million equipment backlog for environmental monitoring, transportation, data processing, and communications.

## Maintenance Plans

Maintenance plans and budgets are developed annually within an overall five-year planning and safety management strategy. The Laboratory has improved its current maintenance scheduling system and backlog of maintenance projects through its site-wide Plant Inspection Program and condition assessment program. Requirements are identified by periodic reviews and inspections, and new priorities are developed during the fiscal year.

The operating expenses for maintenance include physical-plant maintenance, mobile-equipment maintenance, and noncapital alternatives related to maintenance. In addition, specialized maintenance related to shop, computer, and telecommunications facilities is also performed.

The current strategy for improving maintenance relies on strengthening the capital outlays, continuing the operating-cost efforts, and implementing the maintenance-planning system. This allows the Laboratory to sustain DOE facilities while planning for maintenance cost economies. These economies can be achieved through the replacement of existing obsolete and high-maintenance-cost facilities with modern facilities and equipment supported by increased MEL-FS, operating, and GPP funds. GPP funds to replace infrastructure equipment are a particularly pressing need because recent revisions to the GPE criteria have eliminated the GPE funding option in this area.

## Programmatic Facilities Plans

The new programmatic research buildings and facilities in the plan serve the national interest in several research areas where LBNL has established programs. Several major scientific facilities form the core of LBNL's plans to contribute to DOE's research capabilities. The Human Genome Laboratory, ALS Structural Biology Support Facilities, and the Elise accelerator are recently funded projects. Proposed are the Chemical Dynamics Research Laboratory, the ALS Beamline Initiative, and expansion of the National Center for Electron Microscopy–Electron Beam Microcharacterization Facility. Completion of the second floor of the ALS building for users is essential to meet ALS program requirements. The Laboratory is also in the initial stages of planning for an Energy Efficiency and Renewables Facility and a Molecular Design Institute.

## Facilities Decommissioning Plan

The development of new national program directions for nuclear physics resulted in the shutdown of LBNL's Bevalac nuclear physics program during FY 1993. We completed a Nuclear Physics stand-down-and-secure of the facility in FY 1993 and FY 1994. LBNL is currently working with DOE/ER and DOE/EM to obtain a cost-effective and timely recovery of the space previously required for Bevalac operations and experimental programs.

The key element of LBNL's plan is a waste minimization initiative for reuse of the Bevalac shielding blocks at the Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory. This proposal leads to significant cost savings to DOE as it averts the disposal as low-level waste of 480,000 cubic feet of shielding block. Thus, use of valuable burial space is avoided, valuable shielding blocks can be reused, and over $100 million in burial costs at Hanford are eliminated. A demonstration project to ship 33 roof blocks (400 tons) to Brookhaven was undertaken and successfully completed in FY 1994. DOE has approved shipment of approximately one-third of the total Bevatron shielding inventory, to be carried out in FY 1995–1998.

LBNL has developed and submitted several proposals to the Inactive and Surplus Facilities Program (I&SFP; ER-80). These proposals are for the cleanup and cleanout for eventual reuse of nonactivated Bevalac equipment and peripheral spaces, permitting a gradual return of these spaces to productive Laboratory and programmatic use. Pending funding of the facility cleanup proposals, the Bevalac is in a surveillance-and-maintenance-only mode, presently funded by the Nuclear Physics Program in OER.

Aside from the Bevalac, the Laboratory conducts periodic reviews of facilities that may become inactive. Other facilities to be decommissioned include gamma irradiators.

Facilities Decommissioning Plan ($M)

| Category | FY 1996 | FY 1997 | FY 1998 | FY 1999 | FY 2000 | FY 2001 |
|---|---|---|---|---|---|---|
| Bevalac: | | | | | | |
| Surveillance and Maintenance (OER) | 0.14 | 0.15 | 0.15 | 0.16 | 0.16 | 0.17 |
| Block Reuse at BNL (OER/OEM) | 2.10 | 1.08 | 0.36 | — | — | — |
| Inactive & Surplus Facilities Program (ER-80) | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| D&D Base Program (OER) | 0.60 | 0.60 | — | — | — | — |
| *Total* | 3.00 | 1.99 | 0.67 | 0.32 | 0.32 | 0.33 |

## *Facilities Resources Requirements*

A five-year construction plan for programmatic and general purpose facilities is provided in the Lawrence Berkeley National Laboratory Construction Plan Table for FY 1996 to FY 2001 (following page). MEL-FS proposed projects are listed in a prioritized order of sequence in accordance with CAMP criteria. All budget information as indicated is actual-year authority.

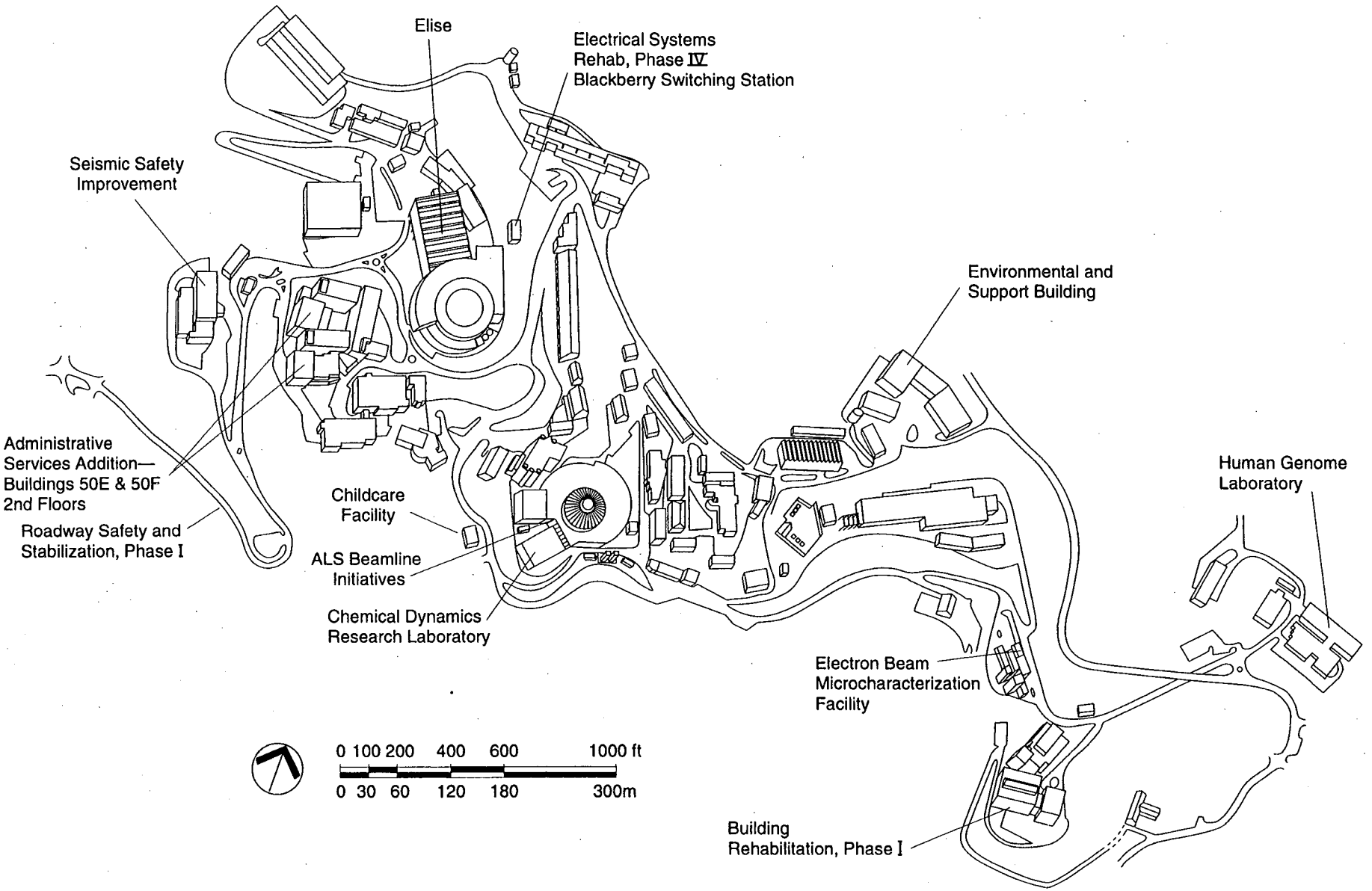
## Lawrence Berkeley National Laboratory Construction Plan

## FY 1996–FY 2001

**Plan for programmatic and general purpose facilities, including funded, budgeted, and proposed construction (FY BA, $M)**

| Project | Scope | TEC | Prior* | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **FUNDED PROGRAM RELATED PROJECTS:** | | | | | | | | | | | |
| Human Genome Laboratory (KP) | 3,809 gsm (41,000 gsf) | 24.700 | 17.934 | 5.766 | 1.000 | | | | | | |
| ALS Structural Biology Support Facilities | 1,031 gsm (11,100 gsf) | 7.900 | 5.282 | 2.618 | | | | | | | |
| Elise | 595 gsm (6,400 gsf) | 20.200 | | 3.200 | 4.500 | 4.700 | 4.400 | 3.400 | | | |
| **SUBTOTAL - FUNDED PROGRAM RELATED** | | **52.800** | **23.216** | **11.584** | **5.500** | **4.700** | **4.400** | **3.400** | | | |
| **FUNDED MEL-FS PROJECTS (KG):** | | | | | | | | | | | |
| Fire & Safety Systems Upgrade Proj. Ph I | | 4.600 | 3.470 | 1.130 | | | | | | | |
| Hazardous Materials Safeguards, Ph. I | | 4.720 | 3.432 | 1.288 | | | | | | | |
| **SUBTOTAL - FUNDED MEL-FS PROJECTS** | | **9.320** | **6.902** | **2.418** | | | | | | | |
| **FUNDED ERWM PROJECTS:** | | | | | | | | | | | |
| Hazardous Waste Handling Facility** | 1,198 gsm (12,900 gsf) | 12.625 | 12.454 | 0.171 | | | | | | | |
| **SUBTOTAL - FUNDED ERWM PROJECTS** | | **12.625** | **12.454** | **0.171** | | | | | | | |
| **TOTAL FUNDED** | | **74.745** | **42.572** | **14.173** | **5.500** | | | | | | |
| **BUDGETED MEL-FS PROJECTS (KG)** | | | | | | | | | | | |
| Sanitary Sewer Restoration, Phase 1 | 1,036 m (3,400 ft) | 2.400 | | 2.400 | | | | | | | |
| **TOTAL FUNDED and BUDGETED** | | **77.145** | **42.572** | **16.573** | **5.500** | | | | | | |
| **PROPOSED PROGRAM RELATED PROJECTS:** | | | | | | | | | | | |
| ALS Roadmap (KC) | 1,877 gsm (20,200 gsf) | 61.5 | | | 6.0 | 13.4 | 20.0 | 16.2 | 7.2 | | |
| NCEM Electron Beam Microchar Facility (KC) | 900 gsm (10,000 gsf) | 17.9 | | 0.9 | 4.7 | 2.3 | 0.6 | 0.0 | | | |
| **TOTAL - PROPOSED PROGRAM RELATED** | | **79.4** | | **0.9** | **10.7** | **15.7** | **20.6** | **16.2** | **7.2** | | |
| **PROPOSED MEL-FS PROJECTS:*** | | | | **96** | **97** | **98** | **99** | **00** | **01** | **02** | **03** |
| No Funding Available | | | | | | | | | | | |
| Childcare Facility | 595 gsm (6,400 gsf) | 2.8 | | | | 1.0 | 1.8 | | | | |
| Elec Sys Rehab, Ph IV - BBC Swch Sta Replc | | 7.4 | | | | 0.9 | 4.5 | 2.0 | | | |
| Upgrade Radio Communication System | | 3.1 | | | | | 0.8 | 2.2 | | | |
| Mechanical Utilities Upgrade, Ph 1 | | 4.1 | | | | | 0.7 | 2.5 | 0.9 | | |
| Seismic Safety, Phase 1 | | 4.2 | | | | | | 0.7 | 2.0 | 1.5 | |
| Upgrade Building Systems (B62/83) | | 6.7 | | | | | | 0.9 | 3.9 | 1.9 | |
| Fire and Life Safety Upgrade, Ph 2 | | 5.3 | | | | | | | 0.8 | 2.4 | 2.1 |
| Sanitary Sewer Restoration, Phase 2 | | 3.4 | | | | | | | 0.9 | 1.6 | 1.1 |
| Roadway Safety, Phase 1 | | 7.2 | | | | | | | | 0.6 | 2.6 |
| Upgrade Building Systems, B50 | | 4.9 | | | | | | | | 0.8 | 2.0 |
| Seismic Safety, Phase 2 | | 2.8 | | | | | | | | | 0.3 |
| Operations Central Addition, 50E/50F | 1,709 gsm (18,400 gsf) | 8.7 | | | | | | | | | 0.7 |
| **SUBTOTAL - PROPOSED MEL-FS PROJECTS** | | **60.6** | | **0.0** | **0.0** | **1.9** | **7.8** | **8.3** | **8.5** | **8.2** | **8.8** |
| **TOTAL FUND, BUDGT & PROP MEL-FS PROJECTS** | | **72.3** | **6.9** | **4.8** | **0.0** | **1.9** | **7.8** | **8.3** | **8.5** | **8.2** | **8.8** |

* This list has been significantly changed from the list presented in the previous plan. As MEL-FS funds had been available for only a single new project for FY 1994 through FY 1997, the former plan required significant revision to ensure that the most urgent among the many urgent needs were appropriately prioritized. LBNL has reviewed all MEL-FS needs to develop this list. The individual high-priority items that comprise this list will be reviewed further through January 1996, and the TECs may be adjusted during this process.




**Proposed major construction projects (FY 1996-2001).**

# COMMUNICATIONS AND TRUST

A key element of LBNL's strategic plan (discussed in Section III) is a broad initiative to strengthen communications at all levels and to build a trusting relationship with the Laboratory's public and private constituents. This effort focuses on enhanced internal communications, improved communications with DOE and federal and industrial partners, and a strengthened identity in the community and the region. LBNL has prepared an initial report defining communications issues and potential strategies, and has established a Communications Task Force and Advisory Council to address these needs.

## Strengthening Communication

Strengthening communications at all levels, internal and external, to build trust with the public and LBNL employees is among the key elements of the LBNL Strategic Plan. This emphasis parallels the Department of Energy's goal to change its culture to one of openness, communication, and trust.

LBNL's history has been one of excellent science and outstanding research achievement, but its public persona has been less clearly recognized. As the public and government demand more accountability for scientific investments and increase their scrutiny in areas of environmental responsibility and safety, improved relationships with local, regional, and national constituencies become necessary. Institutions such as LBNL must deal honestly and fairly with the public they serve, to increase knowledge about their mission and activities, and to reduce unwarranted fears. Habits that encourage communication and trust must become part of LBNL's culture.

To do this, LBNL commissioned an initial report in the Fall of 1993, defining communications issues and potential strategies for improving current programs and developing new ones. In 1994, two committees were established to address communications needs—the Communications Advisory Council, a management-level group which serves as counsel to the Director; and the Laboratory Communications Task Force, a working group charged with developing a Laboratory-wide LBNL Communications Plan.

### *Identity and Image*

The LBNL strategic plan clearly elucidates a mission and priorities for the Laboratory and thus provides the foundation for development of unifying and consistent written and graphic symbols of LBNL's identity. A program that clearly identifies the elements that make LBNL unique will assist in its overall recognition among its many constituencies. One manifestation of the identity program will be a more welcoming and negotiable campus. Consistent graphics and publications guidelines will also lend a sense of unity and familiarity to LBNL products and vehicles. Consistent with the mandate of the strategic plan, LBNL's identity will evolve from that of an institution of great science to an institution that provides value and relevance in the pursuit of national problems.

### *On-site Communications*

A heightened image and visibility for LBNL must begin with a positive and informed community on-site. This includes vertical as well as horizontal communications. LBNL will continue to enhance two-way interactions between management and the workforce through training programs for Laboratory leadership, increased opportunities for employee development and feedback, and improved communication mechanisms and programs. To strengthen the sense of community, programs are being designed to encourage participation and involvement among all segments of the Laboratory—educational, social, and recreational—throughout the year.

Integration of electronic communications systems and networks will be essential for effective linkage of LBNL personnel and programs, and the development of new and innovative technologies to share

information will be among the Laboratory's top planning priorities. A well-informed Laboratory citizenry leads to a more rewarding and safe workplace that nurtures creativity, rewards achievement, and is results-oriented and enjoyable.

# Public Information

How LBNL is perceived by its most important external constituencies—Bay Area communities, Congress and the Department of Energy, the general and scientific news media, the University of California, and prospective business partners—will be essential to the fulfillment of its mission. LBNL is developing an aggressive program of publicity and promotion to heighten the Laboratory's profile and broaden understanding of and appreciation for its work.

Primary audiences include the Bay Area communities, in particular the neighborhoods of Berkeley and Oakland; the undefined "public" reached via the general news media; elected officials and regulatory agencies; the Department of Energy; the University of California; prospective business clients in technology and industry; and members of various scientific communities, reached through professional affiliations or the science press. Prospective employees, especially from minority and underrepresented communities, are particularly important targets to reach as LBNL strives to achieve its diversity goals. LBNL's continuing relationships with educators in the promotion of science in the schools will be highlighted, as will the many other special partnerships upon which the Laboratory's future successes depend.

In addition to the messages of relevance that will spotlight applied science in the core competencies and their applications to real-world needs, LBNL will convey the excitement and value of fundamental research. Basic science has been the foundation of the Laboratory's record of achievement and reputation, and it continues to reflect the creativity and the pioneering spirit of discovery that underlies the continuing quest to solve the riddles of the universe. The nation's taxpayers, as shareholders in these endeavors, must be kept informed of the benefits of their investments in scientific advancement. LBNL's communications goal—through the use of print, electronic, and visual media—is to make the American people aware of this world-class treasure in order to encourage their continuing support.

# Community Relations and Outreach

Being a "good neighbor" and a valued member of the surrounding community has never been more important to LBNL, and thus its communications and interactions with local government, agencies, citizens' groups, schools, the news media, and other stakeholders will be enhanced. This includes continuing efforts to cooperate in the planning of all projects that might involve environmental and cultural impacts on the city and county within which LBNL exists.

A comprehensive and effective community relations program requires regular interactions between the citizens of LBNL and the external environment. These connections, involving administrators, scientists, and staff members at the Laboratory, will be encouraged through the Speakers' Bureau, the participation of employees in community-based projects and service groups, and the development of a more welcoming Laboratory environment. Visitor programs, special events, and targeted communications vehicles will be developed and promoted to project an inviting, cooperative, user-friendly image of openness and honesty. Goals of the Community Relations Program are identified as follows:

- Integration of community relations activities within the scientific divisions with the overall LBNL community relations effort, so that all issues of public concern may be addressed in a coordinated program.
- Continuation of a two-way communication with the public.

In particular, the local community is active in many environmental issues. Opportunities for public involvement are built into regulations, but LBNL will expand these opportunities by encouraging the public to participate in discussions at local community meetings about pertinent issues. Another, more focused goal is:

- Providing the community with accurate and timely information to increase the level of understanding of LBNL programs.

The local community, including elected officials, staff, LBNL employees, and site neighbors, is very interested in receiving more information about LBNL. Several vehicles to orient the public about LBNL programs are: site tours and open houses, information repositories, mailing lists, fact sheets and summaries of technical documents, a speakers bureau, and meetings and presentations. The purpose of these is to:

- Respond to the different information requirements of specific groups, including elected officials, city staff, site neighbors, and employees. Activities include: briefings for elected officials, attendance at local community meetings, and an electronic mail notification system for neighboring facilities, including a fax notification system.
- Respond to the changing needs of the community.

LBNL's efforts to assist in the delivery of science education in the schools through regional partnerships, participation in special in-school programs, and development of student exchange agreements with other institutions will be maintained and enhanced. Its commitment to the encouragement of science as a career for women and minorities will continue to be a priority in its fulfillment of educational outreach goals. And the communication of these efforts to the greater public audience is essential to LBNL's recognition as a valued national and regional citizen.

LBNL values its relations with local communities and is committed to an expanding outreach effort. The benefits of a good community relations program can be seen in the burgeoning partnerships LBNL is now forming with the surrounding cities of Berkeley and Oakland. For example, LBNL has become an active participant in the city of Berkeley's Environmental Affairs Commission Meetings and its Earth Day celebration. The Laboratory is also a prominent member of a county-wide coalition to formulate a reconversion plan for the Alameda Naval Air Station, which has been scheduled for closure. LBNL will bring its scientific and technological expertise to bear on the effort to restore the environment around the base and create new jobs in place of those that will be lost.

Operating under the philosophy that every LBNL employee is an ambassador for the Laboratory, the community relations program is directed internally as well. Noon-time lectures and films, nature walks around the Laboratory's scenic premises, ecology fairs, and other activities are held throughout the year, and all employees are encouraged to attend.

# VI. RESOURCE PROJECTIONS

Resource projections for the Institutional Plan provide a description of the budget authority to implement the research programs. The resource tables also indicate actual FY 1994 BA and estimated FY 1995 BA for comparison. These tables include:

- Resource Summaries (page 6-2);
- Secretarial Level Resources (pages 6-3 and 6-4);
- Program Office Resources (pages 6-5 through 6-8);
- Work for Others Resources (page 6-9); and
- Subcontracting and Procurement (page 6-10).

The FY 1996 estimate is based on FY 1996 DOE budget guidance, the President's Request, and assessments by LBNL Divisions. For fiscal years 1997 and beyond, operating cost projections are in FY 1997 dollars and construction costs are in actual-year dollars (as indicated in the DOE guidance). For FY 1997 to FY 2001, the growth assumptions in program areas as tabulated range from 0% to 1.5% per year. These growth assumptions are based on the general direction indicated by DOE program personnel. Specific trend levels were established within each program activity.

The resource projections that follow include all funded and budgeted construction projects, the projected MEL-FS program, the approved Environmental Restoration and Waste Management program funding and construction, and operational costs for the Advanced Light Source. The new initiative costs are indicated in Section IV. Construction project costs are provided in Section V. The distribution of direct and indirect full-time equivalents is integrated with ES&H staffing planning, but is insufficient for full support of the 5-year ES&H Plan and Corrective Action Plan (see Section V), both of which require additional program support for full implementation.

**Funding Summary (Fiscal Year Budget Authority, $M)**

| Category | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| DOE Operating | 184.5 | 177.5 | 186.3 | 189.3 | 192.3 | 192.7 | 193.1 | 193.5 |
| WFO Operating | 42.5 | 39.9 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 |
| **Total Operating** | **227.0** | **217.4** | **234.6** | **237.6** | **240.6** | **241.0** | **241.4** | **241.8** |
| Capital Equipment | 34.5 | 21.7 | 24.0 | 24.2 | 24.2 | 24.2 | 24.2 | 24.2 |
| Program Construction | 8.6 | 29.4 | 17.0 | 11.0 | 10.1 | 10.1 | 9.8 | 5.3 |
| MEL/FS-Revitalization | 5.0 | 5.0 | 2.8 | 0.0 | 1.9 | 7.8 | 8.3 | 8.5 |
| Environmental Restoration | 5.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| General Plant Projects | 3.4 | 3.4 | 4.0 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| General Purpose Equipment | 1.9 | 1.9 | 3.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| **Total Lab Funding** | **286.0** | **279.4** | **284.3** | **279.2** | **283.2** | **289.5** | **290.1** | **286.2** |

**Personnel Summary (Fiscal Year FTE)**

| Category | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| DOE Effort | 1487 | 1473 | 1444 | 1435 | 1443 | 1443 | 1443 | 1443 |
| WFO | 361 | 349 | 362 | 372 | 372 | 372 | 372 | 372 |
| **Total Direct** | **1848** | **1822** | **1806** | **1807** | **1815** | **1815** | **1815** | **1815** |
| **Total Indirect** | **782** | **776** | **768** | **768** | **768** | **768** | **768** | **768** |
| **Total Lab Personnel** | **2630** | **2598** | **2574** | **2575** | **2583** | **2583** | **2583** | **2583** |

**Secretarial Office Funding Summary (Fiscal Year Budget Authority, $M)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| Office of Energy Research | | | | | | | | |
| Operating | 129.7 | 127.9 | 134.9 | 138.2 | 139.3 | 139.4 | 139.5 | 139.6 |
| Capital Equipment | 22.6 | 14.4 | 17.0 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 |
| Construction | 15.9 | 37.7 | 22.8 | 14.5 | 15.5 | 21.4 | 21.6 | 17.3 |
| **Total** | **168.2** | **180.0** | **174.7** | **169.6** | **171.7** | **177.7** | **178.0** | **173.8** |
| Energy Efficiency and Renewable Energy | | | | | | | | |
| Operating | 24.6 | 20.8 | 21.6 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 |
| Capital Equipment | 1.4 | 0.5 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| **Total** | **26.0** | **21.3** | **22.3** | **22.9** | **22.9** | **22.9** | **22.9** | **22.9** |
| Fossil Energy | | | | | | | | |
| Operating | 3.4 | 2.0 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| **Total** | **3.4** | **2.0** | **1.9** | **1.9** | **1.9** | **1.9** | **1.9** | **1.9** |
| Civilian Waste Management | | | | | | | | |
| Operating | 3.8 | 3.6 | 3.6 | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 |
| Capital Equipment | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **4.0** | **3.6** | **3.6** | **3.7** | **3.7** | **3.7** | **3.7** | **3.7** |
| Environmental Management | | | | | | | | |
| Operating | 12.5 | 14.8 | 12.0 | 11.0 | 12.9 | 13.2 | 13.5 | 13.8 |
| Capital Equipment | 0.9 | 0.5 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Construction | 5.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **19.0** | **15.9** | **12.0** | **11.3** | **13.2** | **13.5** | **13.8** | **14.1** |
| Environment, Health and Safety | | | | | | | | |
| Operating | 1.7 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| **Total** | **1.7** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** |
| Human Resource and Administration | | | | | | | | |
| Operating | 0.7 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Construction | 1.1 | 0.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Total** | **1.8** | **0.2** | **1.3** | **1.3** | **1.3** | **1.3** | **1.3** | **1.3** |
| Policy, Planning, and Program Evaluation | | | | | | | | |
| Operating | 0.5 | 0.3 | 1.0 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| **Total** | **0.5** | **0.3** | **1.0** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** |
| Science, Education, and Tech. Information | | | | | | | | |
| Operating | 2.6 | 2.7 | 2.8 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| **Total** | **6** | **2.7** | **2.8** | **2.5** | **2.5** | **2.5** | **2.5** | **2.5** |
| Work for Other DOE Contractors | | | | | | | | |
| Operating | 5.0 | 4.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Capital Equipment | 6.3 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **Total** | **11.3** | **8.1** | **11.0** | **11.0** | **11.0** | **11.0** | **11.0** | **11.0** |
| Total DOE | | | | | | | | |
| Operating | 184.5 | 177.5 | 186.3 | 189.3 | 192.3 | 192.7 | 193.1 | 193.5 |
| Capital Equip. (inc.GPE) | 31.4 | 19.4 | 21.7 | 21.9 | 21.9 | 21.9 | 21.9 | 21.9 |
| Construction (inc. MEL) | 22.6 | 38.4 | 23.8 | 15.5 | 16.5 | 22.4 | 22.6 | 18.3 |
| **Total** | **238.5** | **235.3** | **231.8** | **231.8** | **226.7** | **230.7** | **237.0** | **233.7** |
| Work for Others | 47.5 | 44.1 | 52.5 | 52.5 | 52.5 | 52.5 | 52.5 | 52.5 |
| **Total Lab Funding** | **286.0** | **279.4** | **284.3** | **280.8** | **283.0** | **289.0** | **297.9** | **296.0** |

**Personnel By Assistant Secretary Level Office (Fiscal Year FTE)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| Office of Energy Research | 1101 | 1094 | 1078 | 1072 | 1080 | 1080 | 1080 | 1080 |
| Energy Efficiency & Renewable Energy | 150 | 148 | 143 | 142 | 142 | 142 | 142 | 142 |
| Fossil Energy | 16 | 15 | 12 | 12 | 12 | 12 | 12 | 12 |
| Civilian Waste Management | 23 | 23 | 22 | 22 | 22 | 22 | 22 | 22 |
| Environment, Health and Safety | 14 | 15 | 14 | 14 | 14 | 14 | 14 | 14 |
| Environmental Management | 70 | 70 | 60 | 58 | 58 | 58 | 58 | 58 |
| Human Resource & Administration | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Policy, Planning and Program Evaluation | 5 | 5 | 6 | 7 | 7 | 7 | 7 | 7 |
| Science, Education and Tech. Information | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Other DOE Contractors | 90 | 85 | 90 | 90 | 90 | 90 | 90 | 90 |
| **Total DOE** | **1487** | **1473** | **1444** | **1435** | **1443** | **1443** | **1443** | **1443** |
| Work for Others | 361 | 349 | 362 | 372 | 372 | 372 | 372 | 372 |
| **Total Direct** | **1848** | **1822** | **1806** | **1807** | **1815** | **1815** | **1815** | **1815** |
| **Total Indirect** | **782** | **776** | **768** | **768** | **768** | **768** | **768** | **768** |
| **Total Personnel** | **2630** | **2598** | **2574** | **2575** | **2583** | **2583** | **2583** | **2583** |

**Office of Energy Research Funding and Personnel (FY BA, $M)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| AT Fusion Energy | | | | | | | | |
| Operating | 3.8 | 6.0 | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 | 3.6 |
| Capital Equipment | 0.7 | 0.2 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Construction | 0.0 | 0.0 | 3.6 | 4.8 | 4.8 | 4.8 | 4.5 | 0.0 |
| **Total** | **4.5** | **6.2** | **7.4** | **8.7** | **8.8** | **8.9** | **8.7** | **4.3** |
| Direct FTE | 31 | 35 | 20 | 20 | 20 | 20 | 20 | 20 |
| KA High Energy Physics | | | | | | | | |
| Operating | 19.6 | 19.6 | 20.2 | 20.8 | 20.8 | 20.8 | 20.8 | 20.8 |
| Capital Equipment | 2.2 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| Construction | 2.8 | 6.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **24.6** | **28.3** | **22.1** | **22.7** | **22.7** | **22.7** | **22.7** | **22.7** |
| Direct FTE | 160 | 160 | 159 | 158 | 158 | 158 | 158 | 158 |
| KB Nuclear Physics | | | | | | | | |
| Operating | 22.1 | 17.2 | 18.5 | 19.1 | 19.1 | 9.1 | 19.1 | 19.1 |
| Capital Equipment | 8.4 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 |
| Construction | 3.6 | 3.6 | 4.2 | 4.9 | 5.0 | 5.0 | 5.0 | 5.0 |
| **Total** | **34.1** | **25.4** | **27.3** | **28.6** | **28.7** | **28.7** | **28.7** | **28.7** |
| Direct FTE | 210 | 190 | 169 | 167 | 167 | 167 | 167 | 167 |
| KC 02 Materials Sciences | | | | | | | | |
| Operating | 37.8 | 36.8 | 45.4 | 46.8 | 46.8 | 46.8 | 46.8 | 46.8 |
| Capital Equipment | 5.3 | 2.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| Construction | 1.8 | 1.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| **Total** | **44.9** | **41.5** | **54.1** | **55.5** | **55.5** | **55.5** | **55.5** | **55.5** |
| Direct FTE | 337 | 337 | 365 | 365 | 365 | 365 | 365 | 365 |
| KC 03 Chemical Sciences | | | | | | | | |
| Operating | 8.7 | 7.9 | 7.8 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Capital Equipment | 2.5 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| **Total** | **11.2** | **9.2** | **9.1** | **9.3** | **9.3** | **9.3** | **9.3** | **9.3** |
| Direct FTE | 82 | 80 | 71 | 70 | 70 | 70 | 70 | 70 |
| KC 04 Engineering, Math and Geosciences | | | | | | | | |
| Operating | 2.4 | 2.0 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Capital Equipment | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Total** | **2.7** | **2.1** | **1.4** | **1.4** | **1.4** | **1.4** | **1.4** | **1.4** |
| Direct FTE | 24 | 20 | 14 | 14 | 14 | 14 | 14 | 14 |
| KC 05 Advanced Energy Projects | | | | | | | | |
| Operating | 0.5 | 0.8 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Capital Equipment | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **0.6** | **0.9** | **0.7** | **0.5** | **0.5** | **0.5** | **0.5** | **0.5** |
| Direct FTE | 3 | 4 | 4 | 0 | 0 | 0 | 0 | 0 |
| KC 06 Energy Biosciences | | | | | | | | |
| Operating | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Capital Equipment | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Total** | **1.2** | **1.1** | **1.2** | **1.2** | **1.2** | **1.3** | **1.3** | **1.3** |
| Direct FTE | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |

**Office of Energy Research Funding and Personnel (FY BA, $M) (continued)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| KC 07 Applied Math Sciences | | | | | | | | |
| Operating | 7.8 | 3.6 | 3.4 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Capital Equipment | 0.3 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Total** | **8.1** | **3.6** | **3.5** | **3.6** | **3.6** | **3.6** | **3.6** | **3.6** |
| Direct FTE | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 |
| KC Basic Energy Sciences (Total) | | | | | | | | |
| Operating | 58.3 | 52.1 | 39.6 | 61.3 | 61.3 | 61.3 | 61.3 | 61.3 |
| Capital Equipment | 8.6 | 4.5 | 6.6 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 |
| Construction | 1.8 | 1.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| **Total** | **68.7** | **58.4** | **70.0** | **71.6** | **71.6** | **71.6** | **71.6** | **71.6** |
| Direct FTE | 482 | 476 | 490 | 485 | 485 | 485 | 485 | 485 |
| KG Multiprogram Energy | | | | | | | | |
| Operating | 0.3 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Capital Equipment | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 5.0 | 5.0 | 2.8 | 0.0 | 1.9 | 7.8 | 8.3 | 8.5 |
| **Total** | **5.4** | **6.2** | **3.8** | **1.0** | **2.9** | **8.8** | **9.3** | **9.5** |
| Direct FTE | 28 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| KP Biological and Environmental Research | | | | | | | | |
| Operating | 21.2 | 21.1 | 21.0 | 22.0 | 23.0 | 23.0 | 23.0 | 23.0 |
| Capital Equipment | 2.6 | 3.1 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |
| Construction | 2.7 | 20.5 | 8.4 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **26.5** | **44.7** | **32.6** | **26.2** | **26.2** | **26.2** | **26.2** | **26.2** |
| Direct FTE | 170 | 170 | 171 | 174 | 182 | 182 | 182 | 182 |
| KT Science, Education, and Tech. Information | | | | | | | | |
| Operating | 2.6 | 2.7 | 2.8 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| **Total** | **2.6** | **2.7** | **2.8** | **2.5** | **2.5** | **2.5** | **2.5** | **2.5** |
| Direct FTE | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| KU Laboratory Technology Transfer | | | | | | | | |
| Operating | 4.4 | 10.8 | 11.5 | 10.9 | 10.9 | 10.9 | 10.9 | 10.9 |
| **Total** | **4.4** | **10.8** | **11.5** | **10.9** | **10.9** | **10.9** | **10.9** | **10.9** |
| Direct FTE | 20 | 30 | 35 | 35 | 35 | 35 | 35 | 35 |
| Total OER | | | | | | | | |
| Operating | 129.7 | 127.9 | 134.9 | 138.2 | 139.3 | 139.4 | 139.5 | 139.6 |
| Capital Equipment | 22.6 | 14.4 | 17.0 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 |
| Construction | 15.9 | 37.7 | 22.8 | 14.5 | 15.5 | 21.4 | 21.6 | 17.3 |
| **Total** | **168.2** | **180.0** | **174.7** | **169.6** | **171.7** | **177.0** | **178.0** | **173.8** |
| Direct FTE | **1101** | **1094** | **1078** | **1072** | **1080** | **1080** | **1080** | **1080** |

**Energy Efficiency and Renewable Energy Funding and Personnel (FY BA, $M)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| AK Electric Energy Systems | | | | | | | | |
| Operating | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| **Total** | **0.3** | **0.3** | **0.3** | **0.3** | **0.3** | **0.3** | **0.3** | **0.3** |
| Direct FTE | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| EB Solar Energy | | | | | | | | |
| Operating | 0.2 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| **Total** | **0.2** | **0.9** | **0.9** | **0.9** | **0.9** | **0.9** | **0.9** | **0.9** |
| Direct FTE | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| EC Building Sector | | | | | | | | |
| Operating | 16.4 | 14.8 | 14.8 | 15.2 | 15.2 | 15.2 | 15.2 | 1.52 |
| Capital Equipment | 1.1 | 0.4 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **Total** | **17.5** | **15.2** | **15.4** | **1.58** | **15.8** | **15.8** | **15.8** | **15.8** |
| Direct FTE | 114 | 110 | 106 | 105 | 105 | 105 | 105 | 105 |
| ED Industrial Sector | | | | | | | | |
| Operating | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **Total** | **1.1** | **0.6** | **0.6** | **0.6** | **0.6** | **0.6** | **0.6** | **0.6** |
| Direct FTE | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| EE Transportation Sector | | | | | | | | |
| Operating | 5.4 | 2.4 | 3.8 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 |
| Capital Equipment | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Total** | **5.7** | **2.5** | **3.9** | **4.0** | **4.0** | **4.0** | **4.0** | **4.0** |
| Direct FTE | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| EK Utility Sector | | | | | | | | |
| Operating | 1.3 | 1.8 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| **Total** | **1.3** | **1.8** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** |
| Direct FTE | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Total Energy Efficiency and Renewable Energy | | | | | | | | |
| Operating | 24.6 | 20.8 | 21.6 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 |
| Capital Equipment | 1.4 | 0.5 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| **Total** | **26.0** | **21.3** | **22.3** | **22.9** | **22.9** | **22.9** | **22.9** | **22.9** |
| Direct FTE | 150 | 148 | 143 | 142 | 142 | 142 | 142 | 142 |

**Fossil Fuel and Other DOE Program Funding and Personnel (FY BA, $M)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| AA Coal | | | | | | | | |
| Operating | 1.0 | 0.9 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| **Total** | **1.0** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** |
| Direct FTE | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| AB Gas | | | | | | | | |
| Operating | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Total** | **0.5** | **0.6** | **0.5** | **0.5** | **0.5** | **0.5** | **0.5** | **0.5** |
| Direct FTE | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| AC Petroleum | | | | | | | | |
| Operating | 1.9 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| **Total** | **1.9** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** |
| Direct FTE | 7 | 8 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total Fossil | | | | | | | | |
| Operating | 3.4 | 2.0 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| **Total** | **3.4** | **2.0** | **1.9** | **1.9** | **1.9** | **1.9** | **1.9** | **1.9** |
| Direct FTE | 16 | 15 | 12 | 12 | 12 | 12 | 12 | 12 |
| DB Civilian Waste Management | | | | | | | | |
| Operating | 3.8 | 3.6 | 3.6 | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 |
| Capital Equipment | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **4.0** | **3.6** | **3.6** | **3.7** | **3.7** | **3.7** | **3.7** | **3.7** |
| Direct FTE | 23 | 23 | 22 | 22 | 22 | 22 | 22 | 22 |
| HA Environmental Safety & Health | | | | | | | | |
| Operating | 1.7 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| **Total** | **1.7** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** |
| Direct FTE | 14 | 15 | 14 | 14 | 14 | 14 | 14 | 14 |
| EX Environmental Management | | | | | | | | |
| Operating | 12.5 | 14.8 | 12.0 | 11.0 | 12.9 | 13.2 | 13.5 | 13.8 |
| Capital Equipment | 0.9 | 0.5 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Construction | 5.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **19.0** | **15.9** | **12.0** | **11.3** | **13.2** | **13.5** | **13.8** | **14.1** |
| Direct FTE | **70** | **70** | **60** | **58** | **58** | **58** | **58** | **58** |
| WB Human Resource and Administration | | | | | | | | |
| Operating | 0.7 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Construction | 1.1 | 0.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Total** | **1.8** | **0.2** | **1.3** | **1.3** | **1.3** | **1.3** | **1.3** | **1.3** |
| Direct FTE | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| PE Policy Planning | | | | | | | | |
| Operating | 0.5 | 0.3 | 1.0 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| **Total** | **0.5** | **0.3** | **1.0** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** |
| Direct FTE | 5 | 5 | 6 | 7 | 7 | 7 | 7 | 7 |
| Work for Other DOE Contractors | | | | | | | | |
| Operating | 5.0 | 4.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Capital Equipment | 6.3 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **Total** | **11.3** | **8.1** | **11.0** | **11.0** | **11.0** | **11.0** | **11.0** | **11.0** |
| Direct FTE | 90 | 85 | 90 | 90 | 90 | 90 | 90 | 90 |

**Work for Others Funding and Personnel (FY BA, $M)**

| Office/Program | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| Other Federal Agencies | | | | | | | | |
| AID | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Direct FTE | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Defense | 9.1 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 |
| Direct FTE | 65 | 58 | 55 | 55 | 55 | 55 | 55 | 55 |
| EPA | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Direct FTE | 9 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| DOI | 0.5 | 0.5 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Direct FTE | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| NASA | 2.7 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| Direct FTE | 20 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| NIH | 14.7 | 14.8 | 22.9 | 22.9 | 22.9 | 22.9 | 22.9 | 22.9 |
| Direct FTE | 117 | 114 | 130 | 140 | 140 | 140 | 140 | 140 |
| Other | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Direct FTE | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Total Other Federal Agencies | | | | | | | | |
| Operating | 25.1 | 26.4 | 34.8 | 34.8 | 34.8 | 34.8 | 34.8 | 34.8 |
| Capital Equipment | 4.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| **Total** | **29.1** | **28.4** | **36.8** | **36.8** | **36.8** | **36.8** | **36.8** | **36.8** |
| Direct FTE | 223 | 221 | 234 | 244 | 244 | 244 | 244 | 244 |
| State/Private | | | | | | | | |
| Operating | 17.4 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 |
| Capital Equipment | 1.0 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| **Total** | **18.4** | **15.7** | **15.7** | **15.7** | **15.7** | **15.7** | **15.7** | **15.7** |
| Direct FTE | 138 | 128 | 128 | 128 | 128 | 128 | 128 | 128 |
| Total Work for Others | | | | | | | | |
| Operating | 42.5 | 39.9 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 |
| Capital Equipment | 5.0 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 |
| **Total** | **47.5** | **44.1** | **52.5** | **52.5** | **52.5** | **52.5** | **52.5** | **52.5** |
| Direct FTE | 361 | 349 | 362 | 372 | 372 | 372 | 372 | 372 |

**Subcontracting and Procurement ($M)**

| Recipient | FY 1993 | FY 1994 | FY 1995 (Projected) | FY 1996 (Projected) |
|---|---|---|---|---|
| Universities | 8.0 | 15.6 | 13.2 | 9.9 |
| All Other | 69.0 | 79.8 | 87.6 | 65.7 |
| Other DOE | 1.0 | 3.6 | 2.9 | 2.2 |
| **Total** | **78.0** | **99.0** | **103.7** | **77.8** |

**Procurement from Disadvantaged, Women Owned, and All Small Businesses**

| Business Category | FY 1993 $M (%) | FY 1994 $M (%) | FY 1995 (Projected) $M (%) |
|---|---|---|---|
| Disadvantaged | 7.0 (9) | 9.3 (12.3) | 9.5 (12.0) |
| Women Owned | 3.9 (5) | 5.0 (6.6) | 4.8 (6.0) |
| All Small | 35.8 (46) | 43.2 (57.1) | 44.4 (56.0) |

# VII. ACKNOWLEDGMENTS

Institutional planning at LBNL is conducted as an annual management activity based on technical information contributed by the Laboratory's Division Directors (see organization chart, Section II). Preparation of reporting documents is coordinated through the Office for Planning and Communications. Divisional staff coordinating information and assisting in preparation include:

| | |
|---|---|
| Accelerator and Fusion Research | Joseph Chew, Richard Gough |
| Chemical Sciences | Linda Maio |
| Earth Sciences | Ellen Klahn |
| Energy and Environment | Donald Grether |
| Engineering | Laura Slusher |
| Environment, Health and Safety | Christa Brothers |
| Information and Computing Sciences | David Stevens |
| Life Sciences | David Gilbert |
| Materials Sciences | Jeri Edgar |
| Nuclear Science | Janis Dairiki |
| Physics | Pauline Fong |
| Structural Biology | Susan Torrano |

The Deputy Directors' Offices provided review and comments, and scientific program leaders contributed to specific sections of the plan through division offices. In addition, elements of the documents are developed in conjunction with responsible support program administrators and staff:

| | |
|---|---|
| Assessment and Assurance | Jon Stanley |
| Budget and Resource Planning | Patricia Jenkins, Benjamin Shuey |
| Educational Programs | Roland Otto, Eileen Kraskouskas |
| Facilities Planning | Richard McClure |
| Laboratory Directed R&D | Todd Hansen |
| Technology Transfer | Bruce Davies |
| Workforce Diversity | Harry Reed, Christine Jue |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# VIII. ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AA | Affirmative Action |
| ACTI | Advanced Computational Technology Initiative |
| AECR | Advanced Electron Cyclotron Resonance |
| AGS | Alternating Gradient Synchrotron |
| ALS | Advanced Light Source |
| AMTEX | AMerican TEXtile Partnership |
| ARPA | Advanced Research Projects Agency |
| ATLAS | A Toroidal LHC Apparatus |
| BA | Budget Authority |
| BASTEC | Bay Area Science and Technology Education Collaboration |
| BES | Basic Energy Sciences (Office) |
| BEST | Bioremediation, Education, Science, and Technology (Program) |
| BESAC | Basic Energy Sciences Advisory Committee |
| BNCT | Boron-Neutron Capture Therapy |
| BNL | Brookhaven National Laboratory |
| CAD | computer-aided design |
| CAL-EPA | California Environmental Protection Agency |
| CAM | Center for Advanced Materials |
| CAMP | Capital Asset Management Plan |
| CAS | Condition Assessment Survey |
| CCCWG | Child Care Center Working Group |
| CDF | Collider Detector Facility at Fermilab |
| CDRL | Chemical Dynamics Research Laboratory |
| CEDR | Comprehensive Epidemiologic Data Resource |
| CEQA | California Environmental Quality Act |
| CERN | European Organization for Nuclear Research |
| CERNAC | Center for Energy Research Networking and Advanced Computation |
| CFC | chlorofluorocarbon |
| CFO | Chief Financial Officer |
| CIEE | California Institute for Energy Efficiency |
| COBE | Cosmic Background Explorer |

| | |
|---|---|
| CP | charge parity |
| CRADAs | Cooperative Research and Development Agreements |
| CSEE | Center for Science and Engineering Education |
| CXRO | Center for X-ray Optics |
| DAMA | Demand Activated Manufacturing Architecture |
| DIRC | Detection of Internally Reflected Cerenkov Light |
| DNA | deoxyribonucleic acid |
| DOD | U.S. Department of Defense |
| DOE | U.S. Department of Energy |
| DOE/EM | U.S. Department of Energy, Office of Environmental Research |
| DOE/ER | U.S. Department of Energy, Office of Energy Research |
| DOE/OAK | DOE Operations Office, Oakland |
| DOI | U.S. Department of Interior |
| DP | Office of Defense Programs |
| DRAM | dynamic random access memory |
| DTIN | DOE Technology Information Network |
| EAP | Employee Assistance Program |
| EBMF | Electron Beam Microcharacterization Facility |
| ECC | Emergency Command Center |
| ECM | extracellular matrix |
| ECR | electron cyclotron resonance |
| EEO | equal employment opportunity |
| EH&S | Environment, Health and Safety Division (LBL) |
| EM | Environmental Management |
| EPA | U.S. Environmental Protection Agency |
| EPRI | Electric Power Research Institute |
| ER | Office of Energy Research (see also OER) |
| ER-LTA | (DOE ) Energy Research Laboratory Technology Applications |
| ERWM | Environmental Restoration and Waste Management |
| ES&H | environment, safety, and health |
| ESnet | Energy Sciences Network |
| EUV | extreme ultraviolet |
| FE | Office of Fossil Energy |
| FEMP | Federal Energy Management Program |
| FNAL | Fermilab National Accelerator Laboratory |
| FTE | full-time equivalent |
| FY | fiscal year |
| GPE | General Purpose Equipment |

| | |
|---|---|
| GPO | Government Printing Office |
| GPP | General Plant Projects |
| GRETA | Gamma-Ray Energy Tracking Array |
| gsf | gross square feet |
| gsm | gross square meters |
| HEPA | high-efficiency particulate air |
| HIFAR | Heavy-Ion Fusion Accelerator Research |
| HGC | Human Genome Center |
| HVAC | heating, ventilating, and air-conditioning |
| HWHF | Hazardous Waste Handling Facility |
| I&SFP | Inactive & Surplus Facilities Program |
| IGP | Industry and Government Partnership |
| ILSE | Induction Linac Systems Experiments |
| INPA | Institute for Nuclear and Particle Astrophysics |
| IR | interaction region |
| IRM | information resources management |
| ISL | IsoSpin Laboratory |
| ITD | Institute for Technology Development |
| JAERI | Japan Atomic Energy Research Institute |
| JPL. | Jet Propulsion Laboratory |
| LANL | Los Alamos National Laboratory |
| LDRD | Laboratory Directed Research and Development Program |
| LHC | Large Hadron Collider |
| LIGA | Lithographie Galvanoformung, Abformung |
| LLNL | Lawrence Livermore National Laboratory |
| M&O | maintenance and operations |
| MBone | Multicast Backbone |
| MEL-FS | Multiprogram Energy Laboratory Facilities Support |
| MEMS | microelectromechanical systems |
| MSRI | Mathematical Sciences Research Institute |
| NASA | National Aeronautics and Space Administration |
| NCEM | National Center for Electron Microscopy |
| NEPA | National Environmental Policy Act |
| NIH | National Institutes of Health |
| NII | National Information Infrastructure |
| NMR | nuclear magnetic resonance |

| | |
|---|---|
| NOW | Network of Workstations |
| NSCORT | NASA Specialized Center for Research and Training |
| NSF | National Science Foundation |
| NTEP | National Teacher Enhancement |
| OAP | Operating and Assurance Program |
| OER | Office of Energy Research (see also ER) |
| OHER | Office of Health and Environmental Research |
| ORTP | Oil Recovery Technology Program |
| OSHA | Occupational Safety and Health Administration |
| PC | personal computer |
| PEP | Positron–Electron Project |
| PET | positron emission tomography |
| PNGV | Partnership for a New Generation of Vehicles |
| R&D | research and development |
| RHIC | Relativistic Heavy-Ion Collider |
| RNA | ribonucleic acid |
| RPM | Risk Prioritization Matrix |
| SAE | Society of Automotive Engineers |
| SDC | Solenoidal Detector Collaboration |
| SDP | Site Development Plan |
| SFI | Strategic Facilities Initiative |
| SLAC | Stanford Linear Accelerator Center |
| SLC | Stanford Linear Collider |
| SNL | Sandia National Laboratories |
| SNO | Sudbury Neutrino Observatory |
| SPECT | single photon computed tomography |
| SPS | Super Proton Synchrotron |
| SQUID | superconducting quantum interference device |
| SSC | Superconducting Super Collider |
| SSRL | Stanford Synchrotron Radiation Laboratory |
| STAR | Solenoidal Tracker at RHIC |
| SXR | soft x-ray |
| TEC | total estimated cost |
| TPC | Time Projection Chamber |
| UC | University of California |
| UCOP | University of California, Office of the President |
| VAT | Video-Audio Conferencing Tool |
| VLSI | very-large-scale integration |

| | |
|---|---|
| VOC | volatile organic compound |
| VUV | vacuum ultraviolet |
| WFO | work for others |
| YAC | yeast artificial chromosome |
| XANES | x-ray absorption near-edge structure spectroscopy |

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